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MONITORING AND EVALUATION OF MICROPOLLUTANTS IN A RIVER BASIN

by
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İZMİR

MONITORING AND EVALUATION OF MICROPOLLUTANTS IN A RIVER BASIN

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by

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İZMİR

M.Sc THESIS EXAMINATION RESULT FORM

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MONITORING AND EVALUATION OF MICROPOLLUTANTS IN A RIVER BASIN

ABSTRACT

European Water Framework Directive (WFD) focuses on providing sustainable management of water to protect water resources. The main objective of WFD is to achieve “good water status” in a water body. Inland surface, coastal and transitional waters must achieve “good ecological and chemical status” to protect water resources, natural ecosystems and biodiversity. Chemical pollution in water resources has a significant influence on achieving a good chemical status in water bodies. The main concern about this is the priority pollutants and specific pollutants. Priority pollutants to be monitored have been determined by Directive 2008/105/EC of the European Parliament of the Council. On the other hand, EU Member and candidate countries have to determine pollutants that are specific to their countries based on the industrial or domestic point as well as non-point discharges. Moreover, there is an urgent need in the determination of Environmental Quality Standards (EQS) for the listed national specific pollutants. Regarding these facts, this study was designed to determine the status of physicochemical, specific and priority pollutants in the Büyük Menderes River Basin (BMRB). The pollution level in the basin was evaluated based on the criteria given in WFD and Turkish Surface Water Quality Regulation (SWQR). The observed concentrations of the pollutants were compared with EQS of WFD and pollutants which exist in the basin at concentrations higher than EQS levels were determined. The water quality classes of each station were evaluated according to both WFD and SWQR. Finally, chemical status of the BMRB based on WFD was evaluated.

Keywords: Physicochemical pollutant, priority pollutants, specific pollutants, water framework directive, water resources, Büyük Menderes River Basin, water quality classification

YÜZEYSEL SU HAVZASINDA MİKROKİRLETİCİLERİN İZLENMESİ VE DEĞERLENDİRİLMESİ

ÖZ

Avrupa Su Çerçeve Direktifi (SÇD), su kaynaklarını korumak için sürdürülebilir su kaynaklarının yönetimini sağlamaya odaklanır ve SÇD'nin temel amacı "iyi su durumu" elde etmektir. Kıta içi yüzeysel, kıyı ve geçiş suları insan sağlığını, su kaynaklarını, doğal ekosistemleri ve biyoçeşitliliği korumak için "iyi ekolojik ve kimyasal durumu" sağlamalıdır. Su kaynaklarındaki kimyasal kirlilik, iyi bir kimyasal durum elde etmek için büyük öneme sahiptir. Kimyasal kirlenmedeki ana kaygı öncelikli kirleticiler ve spesifik kirleticilerdir. İzlenecek öncelikli kirleticiler, Avrupa Parlamentosu ve Konseyinin 2008/105/EC sayılı direktifi ile belirlenmiştir. Öte yandan, AB Üyesi ve aday ülkeler, endüstriyel deşarjlara dayanarak ülkelerine özgü kirleticileri belirlemek zorundadır. Ayrıca, listelenen belirli kirleticiler için Çevresel Kalite Standartlarının (ÇKS) belirlenmesinde acil bir ihtiyaç vardır. Bu ihtiyaçlar göz önünde bulundurularak, bu tez çalışmasında Büyük Menderes Havzası'ndaki fizikokimyasal, belirli (spesifik) ve öncelikli kirleticilerin belirlenmesi hedeflenmiştir. Havzadaki kirlilik seviyesi, SÇD ve Türkiye'deki Yerüstü Su Kalitesi Yönetmeliğinde (YSKY) verilen kriterlere göre değerlendirilmiştir. Kirleticilerin gözlenen konsantrasyonları, SÇD'nin Çevresel Kalite Standartları (ÇKS) ile karşılaştırılmış ve daha sonra ÇKS'den daha yüksek olan kirleticiler belirlenmiştir. Her bir istasyonun su kalite sınıfları hem SÇD hem de YSKY'e göre değerlendirilmiş ve son olarak, Büyük Menderes Nehir Havzasının (BMNH) SÇD'ye kimyasal durumu belirlenmiştir.

Anahtar Kelimeler: Fizikokimyasal kirletici, öncelikli kirleticiler, belirli kirleticiler, su çerçeve direktifi, su kaynakları, Büyük Menderes Nehir Havzası, su kalitesi sınıflandırması

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CHAPTER ONE
INTRODUCTION

1.1 Background Knowledge about AB-EU Water Framework Directive (WFD)

The development of technology has brought about the problem of water pollution. The significant increase in water pollution has forced the countries to take measures on this issue and as a result, policy development has emerged. Then actions were taken for sustainable water management, consequently, publication of new legislation on the subject for all EU and candidate countries. The water policy process of the European Union consists of 3 main periods. First period was between 1970 and 1980 which introduced regulations on water quality based on "public health". Second term was in the 1990s and urban wastewater treatment and nitrate directives, which was one of the largest legal regulations on water resources, were adopted based on pollution reduction. The third term is the announcement of Water Framework Directive (Directive 2000/60/EC) which came into force as a result of working on the basis of integrated water management, sustainable water use in 2000 and beyond. This directive is expected to remain valid for many years. (Akkaya, Efeoğlu, & Yeşil, 2006).

Water Framework Directive of the European Union covers the principles of River Basin Management Plans and provides a program and timetable for EU member states to constitute management plans. WFD is an umbrella directive in the field of water. It aims to gather the legislation on water directives such as Bathing Water Directive (2006/7/ EEC), Drinking Water Directive (98/83/EC), Fish Directive (2006/44/EC), Shellfish Waters Directive (2006/113/EC) and specific substances and pollution sources such as Dangerous Substances Directive (2006/11/EC), Ground Water Directive(80/68/EEC), Nitrate Directive (91/676/EEC) and Pesticide Directive (91/414/EEC) under one roof. The implementation of WFD is an issue for EU member states and candidate countries such as Turkey. WFD is also defined as an important tool for creating water management in the candidate countries (Directive

2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy, 2000).

The main objective of the WFD is to provide a framework for the protection of inland surface waters, transitional waters, coastal waters, and groundwater. It provides a way to prevent further deterioration of the status of terrestrial ecosystems and wetlands that are directly dependent on water ecosystems. The objectives of the WFD are to protect waters against to contamination, to reduce emissions of priority and hazardous substances, to control agriculture, industrial, domestic and all other sources of pollution and to implement the principle of ‘‘polluter pays’’ with water pricing, to reduce the effects of disasters such as floods and droughts, to provide balanced, clean, drinkable and good quality water, to protect regional and marine waters. It follows a water policy that prevents contamination of groundwater as well (Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy, 2000). Through all these aims, WFD aims to provide sustainable water management.

1.1.1 The Objectives, Principles and Obligations of The WFD

The main benefits of WFD are fair and sustainable use of water. In addition, international cooperation underlines the need for all partners in a basin to manage river basins in close cooperation. This means that the countries concerned should establish a common River Basin Management Plan that will meet the WFD's clear objectives at given time intervals. According to the ‘water is the subject of everyone’ principle, the water consumers for households, industry, and agriculture need to cooperate with each other. This principle also states that water is an invaluable resource. Therefore, WFD explains that sources of pollution should be prevented in its sources and a mechanism for sustainable control of all sources of pollution should be established. The Directive also protects groundwater and sets clear targets for its quality and quantity. It also sets clear ecological targets for rivers, lakes and coastal waters (Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy, 2000).

The time table for the implementation of WFD is given in Table 1.1.

Table 1.1 The time table and the articles of the WFD

Year	**Action**	**Reference**
2000	Entry into force of the Directive	Article 25
2003	To ensure compliance with national legislation Determination of River Basin Regions and Authorities	Article 23 Article 3
2004	Determination of characteristics of river basins: pressures, effects and economic analysis	Article 5
2006	Establishment of a monitoring network Start of public consultation	Article 8 and 14
2008	Submission of the draft River Basin Management Plan	Article 13
2009	Finalization of the watershed management plan including the program of measures	Article 13 and 11
2010	Establishing a pricing policy	Article 9
2012	Preparation of application programs	Article 11
2015	Achieving environmental objectives	Article 4
2021	End of the first management period	Article 4 and 13
2027	End of the second management period, the deadline for achieving the objectives	Article 4 and 13

In order to implement the WFD, many organizations should work together with the government, agricultural institutions, industries, universities and so on means that everyone should be involved. Water management planning and development should be prepared for all waters (Inland surface, coastal and marine, groundwater). In addition to the principles of polluter pays and full cost recycling, economic instruments should be developed. International cooperation is required as water usage, water pollution, water quality and quantity affect different countries (Akkaya, Efeoğlu, & Yeşil, 2006).

1.1.2 Basin Management Approach in WFD

The WFD aims to ensure that all surface waters and groundwaters within the river basin regions must achieve good water status. The directive provides guidance on how to establish and achieve environmental or ecological objectives for all water bodies. Good water quality for surface waters is determined by good ecological status and good chemical status. Ecological status is determined by biological quality elements supported by hydromorphological, physicochemical quality elements. The reference point is defined by reference conditions, which are either exposed to little or no human exposure. In addition, it requires identifying a significant and sustained upward trend in the concentration of any pollutant and reversing that trend through the program of measures. Candidate countries are required to meet WFD requirements in the accession process. A River Basin Management Plan (RBMP) is required for each river basin. Studies such as the characteristics of the river basin, the effects of human activities and the economic analysis of water use are important for achieving the objectives of these directives. River basin management also includes environmental measures to be applied on the basis of river sub-basins. To list these measures, all information about the basin must be obtained and examined carefully (Havza Koruma Eylem Planlarının Hazırlanması – Büyük Menderes Havzası, 2010). The need to achieve good water status target for Turkey is a part of the negotiations to be an EU member.

Some of the RBMP elements are characterization of river basin, summary of important pressures and impacts of human activities, identification and mapping of protected areas, map of monitoring networks, list of environmental targets, economic analysis, program of measures, listing and summarizing detailed measures, informing the public, summarizing the exchange of ideas and information sharing, the list of competent authorities. The related directives to achieve all these elements are that Directive on Treatment of Urban Wastewater (1991); (2006, Turkey), the Nitrates Directive (1991); (2004 in Turkey), the Drinking Water Directive (1998); (2005-266-2005 in Turkey TSE) Integrated Pollution Prevention and Control (IPPC)

Directive (1996); Bathing Water Quality Directive (1991); (2006, Turkey) (Havza Koruma Eylem Planlarının Hazırlanması – Büyük Menderes Havzası, 2010).

The action plans must be prepared to obtain integrated management for all goals of the WFD at a certain timetable. The main objective of WFD is to achieve a good water status for all water bodies. To ensure this objective, economic and environmental aspects should be integrated to provide the sustainable management of water resources. The methodology used to implement WFD may differ depending on water basin and economic or environmental aspects of a country. Water quality is evaluated based on ecological, chemical and hydromorphological status for surface waters and chemical and quantitative status for groundwater. WFD declares quality elements for the classification of ecological status including hydro-morphological, chemical and physicochemical elements. The ecological status comprises biological quality elements such as macro invertebrate fauna, aquatic flora, phytoplankton and fish with physicochemical quality elements (temperature, oxygenation, nutrient levels, etc.) and hydromorphological quality elements such as river continuity, flow regime, etc. (Buijs, 2005).

1.1.3 The Legislations Published in Turkey after WFD

In accordance with the Water Framework directive, significant numbers of legislations have been prepared in Turkey. Some of those regulations are listed below;

1.1.3.1 Regulation for the Quality and Treatment of Drinking Water Supply

The aim of this regulation is to determine the principles regarding the water supplied or planned to be supplied, quality criteria and the treatment classes to be determined in order to use the water as drinking water or potable water and the issues related to determination of treatment efficiency. The contents of regulation cover the quality category of the water supplied or planned to be supplied, the treatment classes to be applied according to category including the water, sampling analysis frequencies for the parameters to be monitored in the waters and the issues related to determination of the treatment efficiency of drinking water treatment plants (İçme Suyu Temin Edilen Suların Kalitesi ve Arıtılması Hakkında Yönetmelik, 2019).

1.1.3.2 Regulation for control of pollution caused by hazardous substances in water and environment

The purposes of this regulation are to detect and to prevent the pollution caused by dangerous substances in water. This regulation covers technical and administrative principles for surface water, estuarine waters and regional waters that the determination of hazardous substances, establishment of pollution reduction programs, prevention and monitoring of pollution, inventory of hazardous materials discharged into water, determination of discharge standards and quality criteria (Tehlikeli Maddelerin Su ve Çevresinde Neden Olduğu Kirliliğin Kontrolü Yönetmeliği, 2010).

1.1.3.3 Regulation for Urban Wastewater Treatment

The aim of this regulation is to protect the environment against the adverse effects of collection, treatment and discharge of urban wastewater and wastewater discharge from certain industrial sectors. The contents of regulation covers the technical and administrative principles related to the collection, treatment and urban discharges and certain industrial wastewater discharges to sewage systems as well as monitoring, reporting and auditing of wastewater discharge (Kentsel Atıksu Arıtımı Yönetmeliği, 2006).

1.1.3.4 Regulation on Waters for Human Consumption

The aim of this regulation is to regulate the procedures and principles regarding the conformity of water intended for human consumption to the technical and health conditions and to ensure the quality standards of the waters, the production, packaging, labeling, sale, inspection of spring waters and drinking water. This regulation covers the provisions concerning spring water, drinking water and drinking-potable water. However, it does not include natural mineral waters, spas and drinking waters, and medical waters (İnsani Tüketim Amaçlı Sular Hakkında Yönetmelik, 2005).

1.1.3.5 Regulation for Swimming Water Quality

The aim of this regulation is to determine the quality of the waters used for swimming and recreation in order to protect human health and the environment, and to ensure that these waters are not contaminated with any kinds of pollutants, especially microbiological ones. The regulation covers the technical and administrative principles related to the determination, monitoring, inspection and reporting of the criteria to be applied to the waters used for swimming and recreational purposes other than the waters used for health purposes and the waters in swimming pools (Yüzme Suyu Kalitesi Yönetmeliği, 2006).

1.1.3.6 Regulation for the Protection of Groundwater against Pollution and Degradation

The purpose of this regulation is to preserve the current state of groundwater in good condition, to prevent the pollution and deterioration of groundwater and to determine the necessary principles for the improvement of these waters. The content of regulation covers all groundwater except the waters subject to the Law on Geothermal Resources and Natural Mineral Waters dated 3/6/2007 and numbered 5686 (Yeraltı Sularının Kirlenmeye ve Bozulmaya Karşı Korunması Hakkında Yönetmelik, 2012).

1.1.3.7 Regulation for Surface Water Quality

The aim of this regulation is the determination of the biological, chemical, physico-chemical and hydromorphological qualities of surface waters and coastal and transitional waters, classification, monitoring of water quality and quantity, and to determine the intended use of these waters, to determine the procedures and principles for the measures to be taken to ensure the protection of good water quality. This regulation covers all surface waters, coastal and transitional waters except for the offshore (Yerüstü Su Kalitesi Yönetmeliği, 2012).

1.1.3.8 Regulation for Monitoring of Surface Waters and Groundwater

The purpose of this regulation is to determine the procedures and principles, the current status of all surface waters and groundwaters in the country in terms of quantity, quality and hydromorphological elements, to monitor the waters with an approach based on ecosystem integrity, to determine for standardization in monitoring and coordination between monitoring institutions and organizations. This regulation covers the monitoring of inland surface, underground, transitional and natural mineral waters, except geothermal resources and marine waters, including coastal waters at the points where the water resources are poured into the sea regardless of the intended use (Yüzeysel Sular ve Yeraltı Sularının İzlenmesine Dair Yönetmelik, 2012).

1.1.3.9 Regulation for Urban Wastewater Treatment and Legislation about Sensitive and Semi Sensitive Water Bodies

The purpose of this legislation is to determine the procedures and principles that urban wastewater discharges will be subject to the detection and monitoring of sensitive water areas and less sensitive water areas in accordance with the Urban Wastewater Treatment Regulation published in the Official Gazette dated 8/1/2006 and numbered 26047 (Kentsel Atıksu Arıtımı Yönetmeliği Hassas ve Az Hassas Su Alanları Tebliği, 2009).

1.1.4 Implementation of WFD in Turkey

In our country, many different projects related to WFD or for the protection of water bodies have been carried. The list of the some of the projects conducted so far is given below;

- Basin Protection Action Plans Project,
- Capacity Building Project on Water Quality Monitoring,
- Capacity Building Project for the Implementation of the Flood Directive,
- Project on Control of Hazardous Material Pollution,
- Preparation of Measure Package of Basin Protection Action Plans,
- Transformation of Basin Protection Action Plans into River Basin Management Plans,
- Some in Turkey in the basin Determination of Precision and Quality Target Areas Project,
- Basin Monitoring and Determination of Reference Points Project,
- Detection of Hazardous Substances in Coastal and Transitional Waters of Turkey and Ecological Coastal Dynamics Project,
- Determination and Classification of Quality Status of Sea and Coastal Waters,
- Project on Determination of Water Pollution Resulting from Use of Plant Protection Products and Determination of Environmental Quality Standards on the basis of Substance or Substance Group
- Determination of Environmental Quality and Targets in Surface, Coastal and Transition Waters, These are Büyük Menderes Basin Pilot Study projects.

In addition to these projects, the monitoring studies in the river basins of the Turkey are ongoing by General Directorate of Water Management of Ministry of Agriculture and Forestry in Turkey. In this context, the Basin Protection Action Plans for 11 basins were prepared by TUBITAK MAM in accordance with the Water Framework Directive (WFD). The basins were North Aegean Basin, Marmara Basin, Susurluk Basin, Küçük Menderes Basin, Büyük Menderes Basin, Burdur Basin, Yesilırmak Basin, Kızılırmak Basin, Konya Closed Basin, Seyhan Basin and Ceyhan. The aim of the project was to determine the characteristics of the surface and groundwater in the basins and the pollution status. The urban, industrial, agricultural and other economic activities were evaluated to determine the pressure and impacts on the basin. The basin-based pollution sources and loads were examined in detail. The basin infrastructure status was investigated. The short, medium and long term action plans to prevent pollution in the basin with the participation of all stakeholders in the basin were prepared with the provisions of Article 5 of the Water Pollution Control Regulation. An action plan was proposed with the 5 years interval as short, medium and long term which ends in year 2040 (Havza Koruma Eylem Planlarının Hazırlanması – Büyük Menderes Havzası, 2010).

1.1.5 The Methodology for The Water Quality Classification In WFD

The WFD suggests the classification of all surface water bodies under five ecological quality classes (high, good, medium, poor, bad) and two chemical quality classes (good and fail), and then determination of water quality status for each river basin region based on these classifications. A detailed monitoring plan is given in WFD. The monitoring process includes the sampling, analysis and evaluation of biological, hydro-morphological, physicochemical and chemical quality parameters used to determine the current ecological and chemical status of water bodies. WFD includes three types of monitoring. Surveillance monitoring is used to evaluate the long-term water quality changes in surface waters, natural conditions and human activities. Operational monitoring is used to determine the status of water bodies at risk to meet environmental objectives according to WFD. Investigative monitoring aims to find the reasons for un-achieved environmental targets and to determine the effects of pollution caused by accidents (Karaman, 2016).

Ecological status in surface waters, coastal waters and transitional waters is presented as high, good, moderate, poor and bad status. Chemical status in surface waters, coastal and transitional waters is presented as “good” and “fail”. The WFD gives a definition of what constitutes good water status, and the classification scheme for water quality includes five status classes: high, good, moderate, poor and bad. Ecological and chemical statuses together decide the status of the water body. High status, also called “reference condition”, is the best status achievable. It is defined as the biological, chemical and morphological conditions associated with no to very low anthropogenic pressure. Good ecological and chemical status would be if a water body was affected by human activity, but there was still a healthy functioning ecosystem and low pollution levels. Figure 1.1 shows the five different ecological status classes.

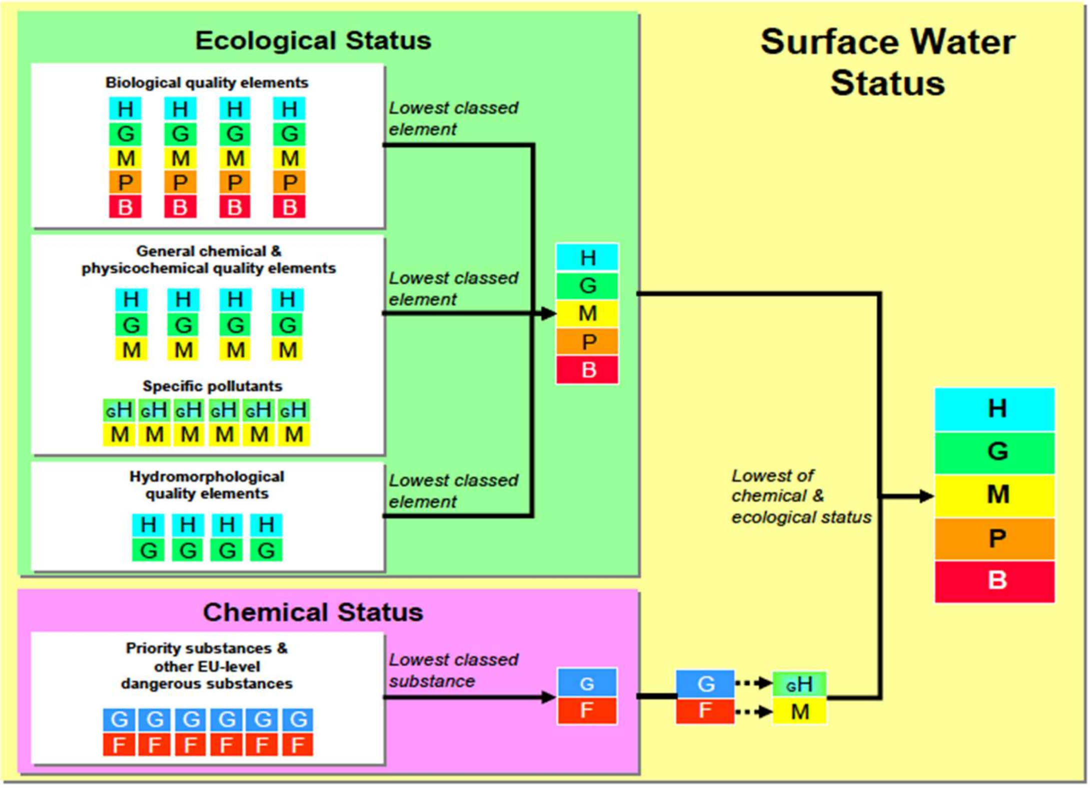

Figure 1.1 Classification of waters according to WFD ((European environment agency, 2018)

Ecological classification takes into account the other effects of human activity on the water quality, such as the physical-chemical quality of the water, the loading, as well as various manmade hydrological or structural changes, such as dams and dredging.

Water bodies are also classified according to their chemical state. Chemical status in a water body is decided through measurements of selected pollutants in water. These substances, called priority substances, include both metals such as cadmium, mercury, nickel and lead, as well as organic pollutants like pesticides. In addition, nationally identified harmful substances which are specific pollutants are noted as a part of the ecological state. There are only two status classes for chemical status: “Good” or “fail”. Good chemical status of a water body is reached when concentrations of all the priority substances are below the Environmental Quality Standard (EQS) limit values outlined in the Directive on Environmental Quality Standards (2008/105/EC). The concentration of a single substance exceeding a limit value will lead to the water body failing to achieve good chemical status (Joint water management of the Finnish-Norwegian river basin district, 2016). For priority pollutants, if the annual average pollutant concentration was below Annual Average Environmental Quality Standard (AA-EQS$_W$), it was good; Above the AA-EQS$_W$, it was considered poor. For the specific pollutants, if the annual average concentration of pollutants was below the AA-EQS$_W$ value, it was considered to be very good/good; Above the AA-EQS$_W$ it was considered as Medium.

1.1.6 The Methodology for The Water Quality Classification in SWQR

Quality classification for surface waters is made by taking into consideration the joint assessment of ecological and chemical conditions and the classes determined by the Ministry and the evaluation schemes given. The chemical status is determined by monitoring the priority substances. The ecological status is determined by monitoring and evaluating together certain pollutants, together with the biological, hydromorphological, general chemical and physico-chemical quality elements of the water body.

In the assessment of water quality monitoring results for specific pollutants and priority substances, the arithmetic average of the 1-year monitoring results by their own water body category (rivers/lakes, coastal and transitional waters) is compared with the annual average environmental quality standard (AA-EQS$_W$). In case of an emergency (accident, natural disaster, etc.), the individual monitoring data of any particular pollutant and/or priority substance is compared with the maximum permissible environmental quality standard (MAC-EQS$_W$). As a result of the evaluation, if the monitoring data is lower than both the MAC-EQS$_W$ and the AA-EQS$_W$ values, the receiving environment environmental quality standard values are provided.

The final class of water body is determined by the combined assessment of its ecological and chemical conditions. Ecological status is the determining factor in classification methodology. If the monitoring results of the chemical quality parameters exceed the environmental quality standards, the determined chemical condition reduces the ecological quality status which determines the final water quality class (Yerüstü Su Kalitesi Yönetmeliği, 2012).

According to the Regulation of Surface Water Quality Management, there are 4 water classes for surface water bodies. Class I water quality means "Very Good" water. This high quality class water is suitable for many uses such as for drinking, swimming, sporting activities, irrigation, trout farming, animal needs. Class II water quality means "Good" water. Slightly polluted water which is suitable for a few uses such as drinking, recreational or for fish breeding apart from the Trout. Class III water quality means "Moderate" water. The water is polluted and can be used by some industries and for aquaculture purposes after proper treatment. Class IV water quality means "Low" water which corresponds to very polluted water that can only be used after proper treatment (Yerüstü Su Kalitesi Yönetmeliği, 2012).

1.1.7 Büyük Menderes Basin

The Büyük Menderes River begins from in Western Anatolia, Dinar Suçıkan, a district of Afyonkarahisar and flows into the Aegean Sea in the same region. Büyük Menderes river basin is one of the most productive agricultural lands in our country. The altitude of this spring is around 880 m. It flows into the Işıklı dam and then passes through Çivril plain, Çal plain and Balkan plain. It flows from the eastern part of Çal to Bekilli and Güney. It joins with the Banaz stream within the borders of Denizli. Then flows into Sarayköy plain. Afterward, it receives the waters of Çürüksü and Gökpınar streams and proceeds to the west. It joins Akçay, which is also a big river and passes through the plains of Aydın and Söke. It joins Karpuzlu stream within the borders of Aydın. Finally, it comes to Söke and confluences the sea from Dipburun. It flows total of 584 km. There are two dams on it and these are Kemer dam and Adıgüzel dam. These dams are used for irrigation and hydroelectric production. Rafting and canoeing can be done in some parts of the river and this is one of the rare streams where sports are made.

The basin is surrounded by Samsun Mountain, Cevizli Mountain, Elma Mountain and Murat Mountain in the north, Sandıklı Mountains in the east, Madran Mountain in the south, Babadağ and Bozdağlar in the north and the Aegean Sea in the west. It has an area of approximately 2,600,967 ha.

The plains in the basin are Dinar, Dombay, Great Sincanlı, Little Sincanlı, Dazkırı, Çardak, Çivril, Baklan, Kaklik, Han-Abat, Böceli, Tavas, Saraköy, Çürüksu, Denizli Plain, Büyük Menderes, Yatağan Plain and Kayırlı Plain.

The main river in the basin is the Büyük Menderes River and its tributaries. Büyük Menderes is a river consisting of 39 main branches. The major branches of the river are Çine, Akçay, Emir, Banaz, Kufi, Dandalaz and Madran Rivers. The important stagnant waters in the basin are Çapalı Lake near Dinar, Işıklı Lake in the south of Çivril, Bafa Lake in downstream and Kemer Dam artificial lake on Akçay. Also, Karine Lake has many alluvial-set lakes (Büyük Menderes Havzası Koruma Eylem Planı, 2018).

There are 10 provinces within the borders of Büyük Menderes Basin. These provinces are Afyonkarahisar, Aydin, Burdur, Denizli, Isparta, İzmir, Kütahya, Manisa, Muğla and Uşak. Denizli, Aydın, Uşak, Afyonkarahisar and Muğla constitute the majority of the basin.

The number of people living in the basin is around 2.5 million. When the water usage in the basin is considered, 79% is Agriculture, 21% is Industrial + Domestic. Water usage for thermal facilities from geothermal sources is concentrated in the upper and middle parts of the basin. The places where geothermal resources are used for tourism are mainly around Afyon Sandıklı, Denizli Sarayköy, Pamukkale and Karahayıt districts and Aydın Buharkent and Germencik districts. Hydroelectric power plants need water usage. Energy production is done at Kemer HEPP on Akçay and Cindere HEPP on Büyük Menderes main branch. In addition, 4 hydroelectric power plants are planned on the Gökpınar and Banaz rivers. The use of geothermal for energy production purposes is concentrated around Denizli Sarayköy and Aydın Germencik and Salavatlı districts. In Büyük Menderes River Basin, water is mostly needed for agricultural irrigation. İkizdere Dam in the basin has the potential to be used as potable water. The others are Gökpınar in Denizli Province and Karacasu Pond in Aydın Province (Büyük Menderes Havzası Koruma Eylem Planı, 2018). In the Büyük Menderes Basin, groundwater is used for both drinking water supply and irrigation. The two largest groundwater water bodies in the basin are Aydın-Denizli and Uşak-Banaz-Sivaslı groundwater resources which are directly connected to Büyük Menderes River. The other two water bodies are Tavas-Kale and Muğla-Yatağan springs which are indirectly connected to the Büyük Menderes River downstream. (Büyük Menderes Havzası Koruma Eylem Planı, 2018). Since Aydın is the only province in BMRB that has borders with the sea, all sea discharges are within these borders. Bozdoğan Biological Wastewater Treatment Plant located in this region. The wastewater treatment plant belonging to the Central Municipality of Didim and the Akbük Wastewater Treatment Plant belonging to the same municipality discharge their purified water to the sea. In addition, there are lots of hotels, motels, summer houses and villages in the coastal areas. They, generally, have compact treatments plants and mostly use treated water for garden irrigation (Büyük Menderes Havzası Koruma Eylem Planı, 2018).

Approximately 44% of the basin is agricultural land. There are different climatic characteristics in coastal and inland areas. Therefore, the variety of agricultural products is high. While fruit and vegetables are cultivated in coastal areas, cereals are produced in inland areas. The most common agricultural products grown in the basin are cotton, olives, figs, chestnuts, wheat, corn, barley, sunflowers, fruits and vegetables. Agricultural activities in the basin are mostly carried out in Aydın and Denizli provinces. (Büyük Menderes Havzası Koruma Eylem Planı, 2018).

Leather, textile, food (fig processing, olive oil production) industries and mining are the main industrial activities in Büyük Menderes Basin. There are 14 organized industrial zones within the catchment area. Textile enterprises are generally located in Denizli and Uşak provinces. Leather industry is carried out in the organized industrial zones of Uşak Province and Aydın Province Karacasu. Agri-food, mining and metal are the main industries in Aydın and the industry is concentrated in and around Söke. Olive oil plants are concentrated in Aydın province and districts and there are approximately 150 olive oil production facilities. In addition, tourism in Aydın is an important source of income during the summer months. Karacasu Leather Manufacturers Association is located in the basin. Textile and ready-to-wear garments, iron and steel, electrical and electronic industries and metal industries are very developed. Industrial facilities in Uşak are concentrated in Merkez, Banaz and Eşme districts. There is a sugar factory in Uşak and leather, textile and ceramic enterprises are gathered here (Büyük Menderes Havzası Kirlilik Önleme Eylem Planı, 2016).

The Büyük Menderes basin is composed of about 67 sub-basins which are in the four districts namely Afyon, Denizli, Uşak, Muğla. Figure 1.2 shows the sub-basins of the BMR.

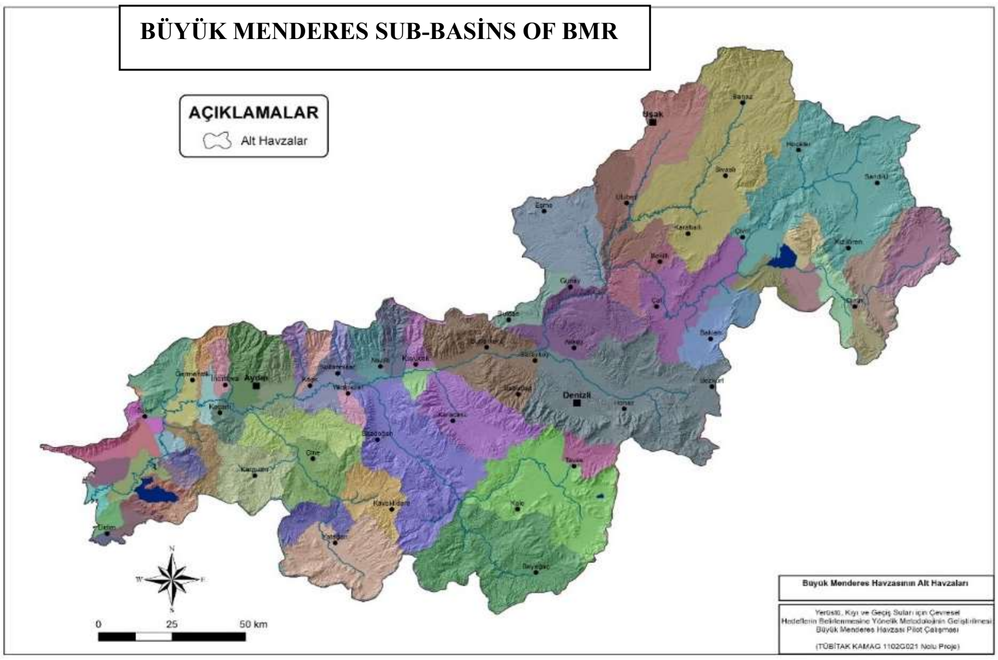

Figure 1.2 The sub-basins of the BMR (Yerüstü, Kıyı ve Geçiş Suları için Çevresel Hedeflerin Belirlenmesine Yönelik Metodolojinin Geliştirilmesi: Büyük Menderes Havzası Pilot Çalışması Projesi, 2018)

1.1.7.1 Priority and Specific Pollutants in BMRB

Economic and social activities, which produce chemicals, impact the water adversely. The main concern for chemical status is the priority and specific pollutants. The priority substances from point and non-point sources are generated through water used by urban and rural populations, industrial emissions and farming and this determinate chemical status of water. Inland, surface, coastal and transitional waters must achieve “good ecological and chemical status” to protect human health, water supply, natural ecosystems and biodiversity. Priority pollutants to be monitored have been determined by the directive 2008/105/EC of the European Parliament. EU Member and candidate countries should determine pollutants that are specific to their countries. The Ministry of Forestry and Water Affairs in Turkey carried out number of projects to identify national specific pollutants. Lists of possible specific pollutants were prepared based on i) point sources mainly industrial activities, ii) capacity reports of substances that are produced or are imported up to 1 ton/year, iii) non-point toxic hazardous substance sources such as pesticides which are either detected in the river basin or widely used ones in Turkey. As a result of three-stage evaluation, thousands of different pollutants were included in the list of possible specific pollutants that may exist in the river basins of Turkey. The selection of most dangerous or significant pollutants to monitor in the rivers basins of Turkey was conducted by using COMMPS and Total Hazard Scoring (THS) methods, as well as by applying risk code, expert assessment and bioaccumulation characteristics of substances (Şıltu, 2015). After a final evaluation, a national specific pollutant list was prepared by the Ministry. The priority and specific pollutants monitored in this study at Büyük Menderes Basin were given in Table 1.2 and Table 1.3, respectively.

Table 1.2 List of priority pollutants with EQS values monitored in BMRB

WFD No	**Priority Pollutant**	**Group**	**AA-EQS$_w$ ppb**	**MAC-EQS$_w$ ppb**
1	Alachlor	Pesticide	0.3	0.7
2	Anthracene	PAH	0.1	0.4
3	Atrazin	Pesticide	0.6	2
4	Benzene	VOC	8	50

Table 1.2 continues

WFD No	**Priority Pollutant**	**Group**	**AA-EQS$_w$ ppb**	**MAC-EQS$_w$ ppb**
5	Pentabromodiphenylether PBDE) (28, 47, 99, 100, 153,154)		0.0002	-
6	Cadmium and its compounds	Metal	0.2	0.45
7	Chloro alkane, C10-13	Chlorinated hydrocarbon	0.4	1.4
8	Chlorfenvinphos	Pesticide	0.1	0.3
9	Chlorpyrifos (Chlorpyrifos-ethyl)	Pesticide	0.03	0.1
9a	Cyclodiene pesticides:	Pesticide		
	Aldrin	Pesticide	0.01	-
	Dieldrin	Pesticide	0.02	0.93
	Endrin	Pesticide	0.01	-
	Isodrin	Pesticide	0.01	-
9 b	DDT total			
	DDT para-para- DDT	Pesticide		
	DDT-o,p	Pesticide	0.01	0.65
10	1,2-dichloroethane	VOC	10	-
11	Dichloromethane	VOC	20	-
12	Di(2-ethylhexyl)phthalate (DEHP)	Phthalate	1.3	-
13	Diuron	Pesticide	0.2	1.8
14	Endosulfan	Pesticide	0.0005	0.004
	Endosulfan I (alpha isomer)			
	Endosulfan II (beta isomer)			
	Endosulfan sulfate			
15	Fluoranthene	PAH	0.1	1
16	Hexachlorobenzene	Pesticide	0.01	0.05
17	Hexachlorobutadiene	VOC	0.1	0.6
18	Hexachlorocyclohexane	Pesticide	0.002	0.02
19	Isoproturon	Pesticide	0.3	1
20	Lead and Compounds	Metal	7.2	-
21	Mercury and Compounds	Metal	0.05	0.07
22	Naphthalene	PAH	1.2	-
23	Nickel and Compounds	Metal	20	-
24	Nonylphenol	Alkyl phenol	0.3	2
25	Octyl phenol	Alkyl phenol	0.01	-
26	Pentachlorobenzene	Pesticide	0.0007	-
27	Pentachlorophenol	Pesticide	0.4	1
28	Polyaromatic hydrocarbons	PAH		
	(Benzo(a)pyrene)	PAH	0.05	0.1

Table 1.2 continues

WFD No	Priority Pollutant	Group	AA-EQS$_w$ ppb	MAC-EQS$_w$ ppb
	(Benzo(b)fluoranthene)	PAH	0.03	-
	(Benzo(g,h,i)perylene)	PAH	0.02	-
	(Benzo(k)fluoranthene)	PAH		
	(Indeno(1,2,3-cd)pyrene)	PAH	0.002	-
29	Simazine	Pesticide	1	4
30	Tributyltin compounds	Organotin Compounds	0.0002	0.0015
31	Trichlorobenzenes	VOC	0.4	-
32	Trichloromethane (chloroform)	VOC	2.5	-
33	Trifluralin (2,4-Dinitrochlorobenzene)	Pesticide	0.03	-
34	Dicofol Dichlorobenzophenone, 4,4'- Results	Pesticide	0.000032	-
35	Perfluorooctane sulfonic acid and its derivatives	Surfactant	0.00013	7.2
36	Quinoxyfen	Pesticide	0.015	0.54
37	Dioxins and dioxin-like compounds			
38	Aclonifen	Pesticide	0.012	0.012
39	Bifenox	Pesticide	0.0012	0.004
40	Cybutryne	Pesticide	0.0025	0.016
41	Cypermethrin	Pesticide	0.000008	0.00006
	alpha-cypermethrin	Pesticide		
	beta-cypermethrin	Pesticide		
	theta-cypermethrin	Pesticide		
	zeta-cypermethrin	Pesticide		
42	Dichlorvos	Pesticide	0.00006	0.00007
43	Hexabromocyclododecanes	Pesticide	0.0008	0.05
44	Heptachlor and heptachlor epoxicde	Pesticide	0.00000001	0.00003
	Heptachlor exo-epoxide (isomer B)	Pesticide		
	Heptachlor endo-epoxide	Pesticide		
	Heptachlor	Pesticide		
45	Terbutryn	Pesticide	0.0065	0.034

Table 1.3 List of specific pollutants with EQS values monitored in BMRB

Pollutant	Group	AA-EQS$_w$ ppb	MAC-EQS$_w$ ppb
1,1-Dichloroethane	VOC	1000	10000
1,2,4,5-tetrachloro-benzen	VOC	6	24
1,2,4-Trimethylbenzene	VOC	7.4	516
1,3,5-Trimethylbenzene Mesitilen	VOC	9	150

Table 1.3 continues

Pollutant	**Group**	**AA-EQS$_w$ppb**	**MAC-EQS$_w$ppb**
1,3-Dichlorobenzene	VOC	58	599
Acenaphthene	PAH	5.53	66
Acetamiprid	Pesticide	42	42
Acetochlor	Pesticide	0.3	10.1
Aluminium	Metal	2.2	27
Antimony	Metal	7.8	102.8
Arsenic	Metal	53	53
Azoxystrobin	Pesticide	0.2	6
Copper	Metal	1.6	3.1
Barium	Metal	680	680
Beryllium	Metal	2.5	3.9
Bisphenol-A	Alkylphenol	6.5	252
Boscalid	Pesticide	19	113
Boron	Metal	707	1472
Buprofezin	Pesticide	3.5	3.5
Butralin	Pesticide	0.1	4.1
Butyl benzyl phthalate	Phthalate	2.7	44
Carbendazim	Pesticide	2.7	77
Carbofuran	Pesticide	2.3	2.3
Carbon tetrachloride	VOC	7.2	130
Chloridazon	Pesticide	6	6
Chlorobenzilate	Pesticide	6	60
Zinc	Metal	5.9	231
Clothianidin	Pesticide	1.2	1.2
Cyprodinil	Pesticide	4.3	21
Demeton –S	Pesticide	20	20
Iron	Metal	360.1	100.8
Diazinon	Pesticide	0.9	4
Diethyl phthalate	Phthalate	71.6	1919
Diflubenzuron	Pesticide	0.13	0.13
Dimethoate	Pesticide	15	15
Dimethomorph	Pesticide	3.5	61
Di-n-butyl phthalate	Phthalate	16	96
Diphenylamine	Pesticide	37	100
Epoxyconazole	Pesticide	0.8	0.8
Ethoprophos	Pesticide	0.21	6.4
Fenamıphos	Pesticide	0.01	0.08
Fenhexamid	Pesticide	28	28
Fenpropathrin	Pesticide	0.01	0.01

Table 1.3 continues

Pollutant	**Group**	**AA-EQS$_w$ppb**	**MAC-EQS$_w$ppb**
Fenthion	Pesticide	0.05	1.11
Fluazifop-P-Butyl	Pesticide	4.8	53
Flutriafol	Pesticide	25	79
Silver	Metal	1.5	1.5
Imidachloprid	Pesticide	0.14	1.4
Imizalil	Pesticide	50	73
Izopropilbenzen (Cumene)	VOC	35	260
Tin	Metal	13	13
Cobalt	Metal	0.3	2.6
Chromium	Metal	1.4	142
Linuron	Pesticide	3	7
Metalaxyl	Pesticide	17	5320
Methacrifos	Pesticide		
Methamidophos	Pesticide	0.2	0.2
Methidathion	Pesticide	42	42
Metolachlor	Pesticide	3.3	88
Monocrotophos	Pesticide	0.4	45
N-Propybenzene	VOC	0.2	1.7
O xylene	VOC	24	585
Oxadixil	Pesticide	306	306
p,p'-Dichlorodiphenyl dichloroethane (p-p' DDD)	Pesticide	0.025	0.025
PCB 101	PCB	0.25	0.25
PCB 118	PCB	0.0005	0.002
PCB 138	PCB	0.01	0.02
PCB 153	PCB	0.01	0.02
PCB 180	PCB	0.01	0.02
PCB 28	PCB	0.01	0.02
PCB 31	PCB	0.01	0.02
PCB 52	PCB	0.01	0.02
Penconazol	Pesticide	1.2	1.9
Permethrin	Pesticide	0.12	0.12
Phenanthrene	PAH	1.4	11.2
Prochloraz	Pesticide	10.81	13.23
Propamocarb	Pesticide	2240	3914
Propham	Pesticide	1	989
Propiconazole	Pesticide	0.7	50
Pyrene	PAH	0.1	0.42
Free CN	Cyanide	1.27	6

Table 1.3 continues

Pollutant	**Group**	**AA-EQS$_w$ppb**	**MAC-EQS$_w$ppb**
Silicon	Metal	1830	1830
Styrene	VOC	6.3	575
Tebuconazole	Pesticide	23	121
Terbuthylazine	Pesticide	0.2	3.5
Tetrabromobisphenol A	Alkylphenol		
Thiabendazole	Pesticide	0.5	28
Thiacloprid	Pesticide	0.13	2
Thiamethoxam	Pesticide	20	20
Thiophonate Methyl	Pesticide	42	42
Titanium	Metal	26	42
Trichloroethylene	VOC	176	8163
Vanadium	Metal	1.6	96.8
Triklosan	Personal Care Product	0.12	11
Diclofenac	Pharmaceutical		
Total Hydrocarbongrubune	The limit values for these substances have not yet been determined. Work continues.		
17-alfa-etinilestradiol			
17-beta-estradiol			

1.1.7.2 Point & Non-Point Sources in BMRB

The pollution sources for surface water are divided into point and non- point sources. Point-sourced pressures are based on domestic wastewater without urban wastewater treatment plants (UWTP), domestic wastewater having urban wastewater treatment plants (UWTP) and wastewater from different industrial facilities. There are total 83 WWTP (wastewater treatment plants) including 28 UWTP ones in the vicinity of the Büyük Menderes River Basin (BMRB). Discharge flows of UWTP sites in the basin were given in Figure 1.3 (Yerüstü, Kıyı ve Geçiş Suları için Çevresel Hedeflerin Belirlenmesine Yönelik Metodolojinin Geliştirilmesi: Büyük Menderes Havzası Pilot Çalışması Projesi, 2018). There are no treatment plants in 5 districts of Afyon, 13 districts in Aydın, 14 districts in Denizli, 1 district in Isparta, 4 districts in Muğla, 4 districts in Uşak (and in their towns). The wastewaters in these districts are directly discharged to the BMRB.

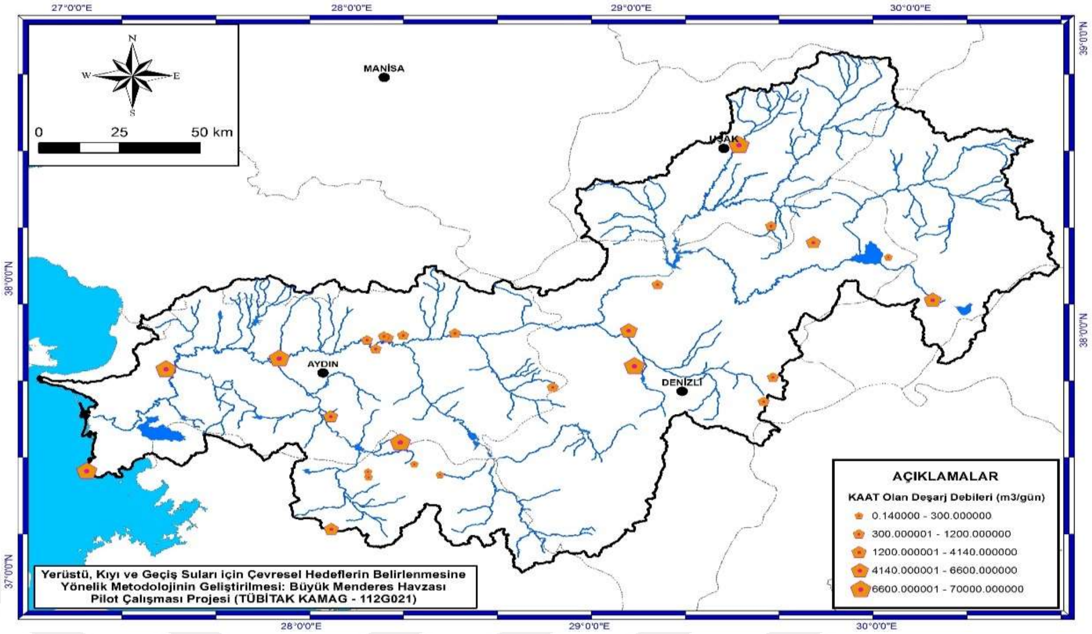

Figure 1.3 The map of UWTP discharge flows (m^3/d) in BMRB ((Yerüstü, Kıyı ve Geçiş Suları için Çevresel Hedeflerin Belirlenmesine Yönelik Metodolojinin Geliştirilmesi: Büyük Menderes Havzası Pilot Çalışması Projesi, 2018)

The number of industrial facilities identified in the basin is 77. Food, textile, metal, mine, paper, leather, drink and paper are the most common sectors in BMBR. Food industry is in the first place of the list with 19 plants, textile industry takes the second place in the list with 16 establishments and finally there are 5 metal industries in the Basin. The distribution of sectors operating within in the boundaries of BMRB by provinces according to water pollution control regulation is given in Figure 1.4. Considering this distribution, Denizli is the province with the highest industrial activity with 34 sectors, the other is as follows Aydın with 25 sectors, Uşak with 17 sectors and Afyonkarahisar with 1 sector.

The main industrial sectors in Aydın are food (with the number of 8), metal (with the number of 5) and textile (with the number of 2). Industrial facilities in Aydın are mostly established in the northern part of the province. Denizli has more intensive industrial activity comparing to other provinces. The main industrial sectors that exist on provincial basis are textile (with the number of 8) and food (with the number of 4). In addition, there are 1 leather and paper industries in Denizli. Different industrial activities are mostly established in Denizli center, Honaz and Sarayköy districts. The main industrial sectors in Uşak are the textile (with number of 6), food (with number of 6) and chemical (with number of 4). They are mainly around Uşak city center and in Eşme district. There is only 1 food industry in Afyonkarahisar.

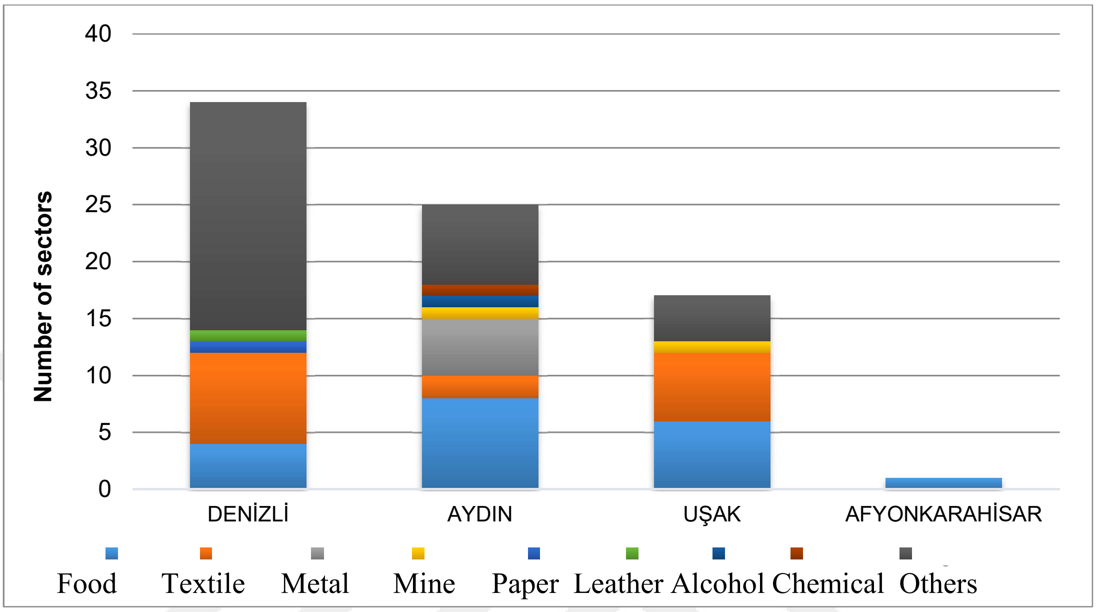

Figure 1.4 The distribution of sectors operating within in the boundaries of BMRB

There are 14 organized industrial zones (OIZ) within in the boundaries of BMRB. The active ones which are 40% occupied by the industry and have WWTPs are Aydın, Astim Ortaklar, Denizli (Honaz), Denizli Leather and Uşak Leather OIZs. The number of WWTP with advanced biological treatment plant is 6 in these OIZ. There are no WWTPs in Sandıklı, Dinar, Söke and Karahallı OIZs. Wastewater from these OIZs is collected in the septic tank. WWTP in Nazilli OIZ is not in operation, but the wastewater formed is collected through the municipal wastewater collection system and transferred to the treatment plant. The other WWTPs in Buharkent, Çine and Çardak OIZs were not in operation during the monitored period in this study due to the lack of active industrial facilities or the ongoing construction in the OIZs. The sectoral distribution (for year 2016) of active OIZs with WWTP within the boundaries of BMRB was given in Figure 1.5.

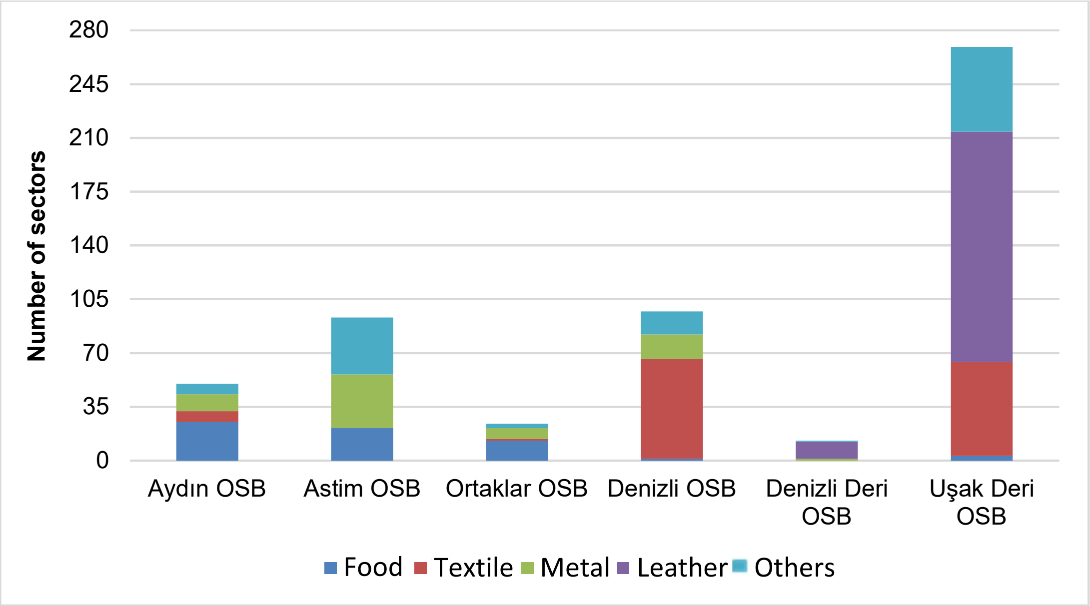

Figure 1.5 The sectoral distribution (for year 2016) of OIZs which have WWTP in BMRB

There are 4 landfill sites within the BMRB and only one of them has leachate treatment facility. The leachate from other landfills are either transferred from the holding tanks back to the site or transported to the WWTP by sewage truck.

In Afyonkarahisar province, the landfill site which is within the boundaries of Akarçay Basin is operated by ‘‘Afyonkarahisar Province Environmental Services Association’’. The other two landfill sites within the boundaries of BMRB are in Aydın. These are Central and Didim solid waste disposal sites. The site investigations revealed that there is no leachate water treatment plant in Central Solid Waste Disposal Facility, the leachate is recycled back to the landfill site. Didim landfill site has a leachate treatment plant. There is only one landfill site in Denizli and in Uşak.

There are 28 Geothermal Energy Producing companies in the Basin. 23 of them are located in Aydın, 5 of them are located in Denizli. Boron contamination is likely to occur from companies such as thermal hotels with a flow rate below 10 L/s and small GPPs (Geothermal Power Plants) that do not do reinjection back to underground.

It is stated that there are approximately 151 olive oil production facilities within the boundaries of BMRB, especially in Aydın province for year 2016. For olive blackwater, due to the fact that existing lagoons are far from the engineering designs and overflow with excessive rainfall, it causes uncontrolled blackwater discharges to surface waters.

In BMRB; agriculture, farming (livestock), leachate waters from irregular solid waste landfills and mining activities are identified as non-point source pressures.

The highest levels of nitrogen (N) fertilizer use are in Tavas, Çivril, Köşk and Aydın Söke zones in Denizli. The highest N loads from livestock activities come from Afyonkarahisar Sandıklı, Aydın Karpuzlu, Sultanhisar, Denizli Beyağaç, Kavaklıdere, Muğla Karacaören, Uşak Ulubey, Sivaslı and Banaz zones.

Marble quarries and operations exist in Muğla, in Aydın especially in Uşak within the boundaries of BMRB. Wastewater that may occur as a result of mining activities causes the risk of pollution in the basin.

Due to climate change in the basin, both water quality and water ecology can be seriously affected. As a result of climate change, the decrease in the flow rate of the river tributaries in the basin will result in lower water levels in the water bodies and increase the areas where the flow beds dry. Combining with this situation and the increase in air temperature, a significant pressure on water quality parameters and ecology in surface waters above the basin could be observed (Yerüstü, Kıyı ve Geçiş Suları için Çevresel Hedeflerin Belirlenmesine Yönelik Metodolojinin Geliştirilmesi: Büyük Menderes Havzası Pilot Çalışması Projesi, 2018).

1.1.7.3 The research projects in the BMRB

In this project, four seasons of sampling was done for physicochemical parameters. The average of each pollution parameter was calculated. The results obtained were compared with the “Very Good-Good” and “Good-Medium” water quality class ranges. The physicochemical status was defined as ‘‘Very Good’’, ‘‘Good’’ or ‘‘Moderate’’. For physical parameters such as temperature and pH, it was found appropriate to have only one “Very Good-Medium” class limit instead of “Very Good- Good” and “Good- Medium” limit values. The general physicochemical state of a water body was determined using the approach "if one is bad, all are bad”. According to this approach, the physicochemical state was determined using the worst evaluation class parameter. In the priority and specific pollutant classification approach, the annual average environmental quality standard (AA-EQS) and the maximum allowable concentration environmental quality standard (MAC-EQS) were considered. There are two categories in this classification as “Passed” (good and above) or “failed” (below good).

In the stations where three samples were taken, the classification was made by taking the average value. In the stations where two samples were taken, no classification was made as the average could not be taken. According to the results of the analysis, the water quality class for physicochemical parameters was determined as “medium quality” or ‘‘good quality” in rivers and lakes, coastal waters as “medium quality” and transitional waters as ‘‘high quality’’. Water quality was good at BMR32 (Aydın, Yukarı Çine-3), BMR 47 (Yukarı İkizdere-1), BMR 27 (Yukarı Akçay), BMR15 (Çay Kavuştu) points selected as the reference point. BMR 48 (Yukarı İkizdere-2) water quality was moderate. In the project report, the overall physicochemical evaluation was determined as “moderate" quality after taking the priority and specific pollutant status into consideration. BMR 38, which is the reference station, is the only station reported as “good quality water”.

Organic priority and specific pollutants identified as a result of the first period monitoring in the project (December-January 2013) were Bis (2-ethylhexyl) phthalate, Floranthane, Benzo (a) pyrene, Benzo (k) Floranthene, Benzene, Trichloroethylene. Priority and specific metals detected were Lead and its compounds, Nickel and its compounds, Mercury and its compounds, Barium, Arsenic, Zinc, Tin, Cobalt, Antimony, Selenium, Iron, Manganese, Total Chromium, Vanadium, Aluminum and Boron.

The second period of monitoring was carried out in March-April 2014 and Di (2-ethylhexyl) phthalate and Trichloromethane were detected in most stations, alpha-Endosulfan (0.004 ppb), Benzo (a) pyrene, Tetrachlorethylene and Trifluralin were detected in some stations. The most commonly observed metals were Barium, Antimony, Selenium, Zinc, Iron, Manganese, Vanadium, Aluminum and Boron.

The third term monitoring was completed in June 2014. Naphthalene and Trifluralin were the organic pollutants observed. The most commonly detected metals were Mercury and its compounds, Barium, Zinc, Boron, Aluminum, Vanadium, Selenium and Copper.

In the fourth and last period (September 2014) monitoring, it was found that the concentration of organic substances other than Naphthalene and Trifluralin was below the LOD. The most common metals were Barium, Zinc, Copper, Selenium, Antimony, Aluminum, Boron, Vanadium, Iron and Manganese.

According to the results of this project, PAHs, some pesticides and Bis (2-ethylhexyl) phthalate (DEHP) were the main organic pollutants observed. The organic pollution could be less severe but the metal pollution in the basin was significant (Su Kalitesi İzleme Konusunda Kapasite Geliştirme Teknik Yardım Projesi Nihai Rapor, 2015).

A basing- protection plan was prepared by TUBİTAK MAM. The project aimed to prevent pollution, to protect and improve the BMRB. The potential of water resources was determined according to point and non-point pollutant sources and the existing water quality. Then, short, medium and long term, priorities were developed and then, technologically economical, suitable and sustainable plans were made. Considering the agricultural, industrial activities, irregular storage areas and pollution from geothermal waters in the basin, Dokuzsele Creek, Banaz River, Çürüksu River, Büyük Menderes Plain, Bafa Lake, pollution-intensive rivers, dam lakes and HEPPs were identified as hot spots. For water quality classifications, measurement and analysis data obtained from DSİ covering the years 2003-2009 were used. Surface water quality classes were determined based on the quality criteria according to the Classes of Inland Water Resources given in Table 1 of the Water Pollution Control Regulation (WPCR). Where the data are available and sufficient for each DSI station, in COD, BOD_5, NH_4-N, NO_2-N and NO_3-N which are important parameters indicating organic carbon and nitrogen pollution, water quality classes (I, II, III, IV) have been determined. It was observed that COD and NH_4-N parameters entered into Class II-III, NO_2-N entered into Class IV and NO_3-N entered into Class I, in most water quality measurement stations in Büyük Menderes River and its tributaries. The classification was made separately along the basin and according to the side arms feeding the main branch. The types of products grown in the basin, the areas used, the type of fertilizer used, the amount of pesticide, the details of livestock activities, the distribution of industrial activities by sectors and provinces, detailed information about OIZs, the number of small industrial sites and the distribution by provinces were given. In addition, protected areas, water resources, ponds, power generation capacities and locations of HEPPs, drinking and potable water resources, and infrastructure for obtaining drinking water were evaluated. Point and non-point source COD, N and P pollution loads were calculated. The River Basin Management Plan (2007) prepared for the BMRB, which was selected as a pilot region by the Ministry during the European Union harmonization process, was taken as reference. Evaluations were made according to the outputs of this report. Pressure and impact assessment was made, hot spots were identified and solution suggestions were presented (Havza Koruma Eylem Planlarının Hazırlanması – Büyük Menderes Havzası, 2010).

The other project was about the determination of water pollution resulting from the use of plant protection products and determination of environmental quality standards in substance or substance groups in years from 2012 to 2014. The project was carried out and completed by TÜBİTAK MAM In this project, an inventory of the source of hazardous substances from the BMRB was made. Interviews and surveys were conducted with dealers selling plant protection products, owners of agricultural land and farmers in Afyonkarahisar, Muğla, Denizli, Uşak and Afyon provinces. The aim of these meetings was to reach the list of pesticides sold in the last 20 years and the list of pesticides used in the last 10 years. As a result of interviews with plant protection products dealers and farmers, a list of plant protection products sold on provincial and district basis was prepared. The project has been monitored for six terms and the pesticides observed in the BMR according to the project outputs; 2,4-D; (2,4-dichloro phenoxy) acetic acid, Acetamiprid, Acetamiprid, Acetochlor, Aldrin, Alpha-Cypermethrin, Atrazine, Azoxystrobin, Beta-Cypermethrin, BHC; Gamma-Hch, Bifenox, Boscalid, Bromopropylate, Captan, Carbendazim, Carbofuran, Chlorbenzylate, Chlorfenapyr, Chloridazone; Pyrazon, Chlorothalonil, Chlorpyrifos; Chlorpyrifos-Ethyl, Clopyralid, Clothianidine, Cyclanilide, Cyfluthrin; Beta-Cyfluthrin, Cyprodinil, Diazinon, Dichlorvos, Diclofenac, Dieldrin, Diflubenzuron, Diflufenican, Dimethenamide, Dimethoate, Dimethomorph, Dimethomorph, Dinobuton, Diuron, Fenamiphos, Fenitrothion, Fenpropathrin, Fluazifop-P-Butyl, Cypermethrin, Hexachlorobenzene, Imidacloprid, Isodrin, Isoproturon, Mepiquat Chloride, Metalaxyl, Methacrifos, Methamidophos, Methamidophos, Methidathion, Methomyl, Metolachlor, Metrafenone, Monocrotophos, Nicosulfuron, P, P'-DDT, Prochlorase, Prometryne, Propamocarb HCL, Terbuthylazine, Terbutryn, Thiabendazole, Thiacloprid, Thiamethoxam, Thiophanate-Methyl, Triclosan, Trifluralin, Trinexapac-Ethyl, Zeta-Cypermethrin. The most common pesticides are Acetampiride, Carbendazim, Clopyradil and Diazinon. Other pesticides were observed periodically. Triclosan; at Denizli, Afyon, Uşak and Aydın in the 24-197 ppt range predominantly detected in the fourth period of monitoring. Thiamethoxam was observed at concentrations between 0.9 ppt and 5.3 ppt especially in the 3rd period follow-up. Aldrin, which is in the list of priority pollutants, was detected at 0.4-0.5 ppt concentrations only at 4 sampling points in Denizli and Aydın and during the 5th term monitoring. Alpha-cypermethrin (3.6-0.4 ppt), Beta-cypermethrin (1.5-2.2 ppt) and Gamma-cypermethrin (1.7-1.8 ppt), which are also on the list of priority pollutants, are only used in Uşak and Aydın in 2 or 3 stations. Atrazine was detected at a single station in Uşak in the second term monitoring at concentrations of 4- 24 ppt (Bitki Koruma Ürünlerinin Kullanımı Neticesinde Meydana Gelen Su Kirliliğinin Tespiti ve Madde veya Madde Grubu Bazında Çevresel Kalite Standartlarının Belirlenmesi Projesi, 2015).

1.1.8 Implication of WFD in EU Countries

Germany is one of the countries with the most active implication of WFD in the EU. A comment on implication of WFD in Germany was reported by Arle, Mohoup & Kirst in 2016. The assessment of the ecological status/potential of surface water bodies in Germany revealed that only 8.2% of 9900 surface water bodies have actually good/very good status, while more than 90% are at moderate or worse status. It is believed that the reason for failing to reach good ecological status is based on the hydromorphological changes in streams and high nutrient loads sourced from agricultural land use.

The current chemical status for German water bodies is referred to as "not good". An explanation of this status can be given as Mercury presence in all water bodies. In half of ten river basins in Germany, 7 of 33 priority pollutants (cadmium, nickel, polycyclic aromatic hydrocarbons (PAH), tributyltin, fluoranthene, diuron and isoproturon) were higher than EQS. On the other hand, in five or less rivers basins, 18 of priority pollutants (lead, brominated diphenyl ether, 1.2Dichloorethane, Anthracene, Bis(2-ethylhexyl) phthalate, Hexachlorobenzene, Hexachlorobutadiene, Naphthalene, Nonylphenol, Octylphenol, Pentachlorobenzene, Tetrachloroethylene, Trichlorobenzene, Trichloroethene, Trichloromethane, Hexachlorocyclohexane, DDT and Chlorpyrifos) were higher than EQS.

Evaluation of the first river management plans by the European Environment Agency (EEA) reveals that half of the surface waters cannot reach "good ecological potential" currently. European rivers and transitional waters are in a worse ecological status than lakes and coastal waters.

Although assessment methods and parameters were progressed within the European Union, it still needs further development. Topics such as sufficient knowledge of chemical status, international harmonization of pollutants, interactions of natural factors and anthropogenic pressures and their effects on freshwater, effects of land use, the role of biological interactions must be investigated in detail (Arle, Mohaupt, & Kirst, 2016).

The work of the water framework directive in Europe is considerable. Most countries have come to the conclusion that they have completed the monitoring periods quickly to learn the status of their waters. In the EU member states, a number of practices and regulations have emerged, including or covering this directive. According to the basin management plans made on this subject, the results in the tables were obtained. Table 1.4 gives the total number of quality classes in rivers and lakes within the scope of river basin management plans (RBMP) of 27 European countries according to the concept of ecological status given in WFD. Table 1.5 presents the total number of quality classes in rivers, lakes, transitional and coastal waters within the scope of the river basin management plans of 27 European countries according to the chemical status concept given in the WFD (European environment agency, 2018).

Table 1.4 European water bodies status given according to ecological status in WFD ((European environment agency, 2018)

Ecological Status		**High**	**Good**	**Unknown**	**Moderate**	**Poor**	**Bad**
1. RBMP	**River**	6.067	33.047	13.674	33.194	11.917	4.693
	Lake	1.796	6.075	4.232	4.405	1.250	633
2. RBMP	**River**	11.767	34.730	5.174	40.854	13.654	5.779
	Lake	3.957	9.663	1.129	7.904	1.960	790

Table 1.5 European water bodies status given according to chemical status in WFD ((European environment agency, 2018)

Chemical Status		**Good**	**Unknown**	**Failing to the achieve good**
1. RBMP	**River**	39.042	42.539	21.011
	Lake	4.757	6.164	7.470
	Transitional water	307	576	100
	Coastal water	1259	955	727

Table 1.5 continues

Chemical Status		Good	Unknown	Failing to the achieve good
2. RBMP	River	36.193	37.261	38.504
	Lake	4.620	9.261	11.522
	Transitional water	484	321	172
	Coastal water	1662	2.424	1.142

Liefferink, Wiering, & Uitenboog (2011) make comments about the obstacles, struggles, copes and diversities in implementation of WFD in three EU countries Denmark, the Netherlands and France. WFD was named as "Europe's one of the most in influential Directive", "an ambitious Directive" and "New generation EU Directive". The report concentrates on policymaking, involving stakeholders and public, integration of directive and multi-sector governance, goal setting and formulation of standards, etc in these three countries and also mentions about limitations of "fit/misfit" hypothesis which is a well-established starting point in implementation studies. It was stated that Denmark was more ambitious to implement the Directive, the Netherlands chose a pragmatic approach, and France had already a well-established river basin management system. The three different approaches were compared and new methodology was described as "contemporary EU-directives are producing in a world colored by multi-actor, multi-level and multi-sector governance". The main difference between these three countries was the starting point as policymaking. It was stated in the report that Denmark well organized the integration of other policy sectors at the central level. However, integration of stakeholders was limited that was considered as a problem in the practical implementation. The Netherlands played a key role in policymaking and practical implementation even at sub-basin level. The obstacle in this approach was sated as that the reluctance of institutions which could lead to failure in implementation of WFD goals and targets. The situation of France was much better than the other two countries. The preexisting system had already satisfied the Directive's requirements regarding stakeholder involvement, public participation and sector integration. However, it resulted as the central level retains a fair and in fact increasing the degree of control over the process in the policy formulation phase (Liefferink, Wiering, & Uitenboog, 2011).

Squintani, Plambeck, &Rijswick (2017) evaluated the WFD implementation in the Netherlands. It was stated that they took a substantial role in development of the WFD. The approach given in WFD was quite parallel with the Dutch approach. The main feature of the Dutch water governance system for the implementation of the WFD was given as that its regional water authorities based on hydrological scales and powers to regulate decide and raise taxes for their water tasks. It was stated that the decentralized character makes the regional water authorities very efficient and effective. Therefore, the Dutch system was a kind of inspiration for EU in the development of Directive. The weakness of Duct system was presented in the paper which may be caused the weaknesses of the Directive. At the end, the Dutch experience showed that the more uncertainties appeared about the exact meaning of the obligations following from the Directive as more the implementation process proceeded (Squintani, Plambeck, & Rijswick, 2017).

1.2 Objectives and Scope of the Thesis

Büyük Menderes River is a substantially large basin and an important water resource for the region but receiving point and non-point waste discharges that threaten the biological life in the river and human health through the food chain. It needs a systematic and well-planned protection against to further pollution and improvements of the existing condition in the guidance of scientific approaches. WFD provides a framework for the protection of inland surface waters, transitional waters, coastal waters and groundwater. It is a guideline explains methodology about how to collect data from a river basin and how to evaluate those data to protect or to improve the quality of the water. WFD was can be considered as a guide for a scientific approach in order to evaluate the water quality of Büyük Menderes River and to take the measures for the improvements. By considering this fact, the main objectives of the thesis were designed as follows;

- To investigate the current pollution status of the Büyük Menderes River,
- To detect presence of organic and inorganic micropollutants listed as specific and priority pollutants,

- To determine the water quality classes for both physicochemical and chemical quality elements
- To evaluate the sediment quality which could affect the water quality,
- To develop recommendations for the measures to be taken to improve the water quality.

In this context, the basin was monitored according to the principles stated in WFD. 48 stations including the reference stations were determined in the basin and the samples were taken for 12 months. Annual averages of all monitored pollution parameters were determined. The results were evaluated according to water quality classification principles stated in WFD and SWQR. Finally, the classes of each station and then, chemical status of the basin were determined.

CHAPTER TWO
MATERIALS AND METHODS

2.1 Sampling and Monitoring

Surveillance monitoring in Büyük Menderes River Basin was conducted at 48 stations for 12 months. Table 2.1 shows the coordinates and the name of the stations and Figure 2.1 depicts the stations on the map. The water samples were collected directly from the station point at wet seasons. During the drought period, if there is no water in the station, the sample was taken from the nearest point where there was enough water for sampling. Water Frame Directive (WFD) status monitoring of physicochemical pollutants and but more important priority and specific pollutants monitoring are emphasized. Priority pollutants must be monitored for 12 months, but seasonal monitoring for specific and the physico-chemical pollutants are suggested. Seasonal sampling was conducted for the physico-chemical parameters. Despite the suggested seasonal (four times a year) monitoring for specific pollutants, they were monitored for 12 months in this study. Blank samples were taken from the field and were used to evaluate the matrix effect in the analysis of priority and specific pollutants. Samples taken from the stations were preserved according to Appendix 1, then transferred to the laboratory at 4 °C in the fridge and protected in the cooler until they are analyzed.

Table 2.1 The coordinates and the name of stations in Büyük Menderes River Basin

Station Name	Station Code	Type	Y_WGS84	X_WGS84
ISIKLI	**BML01**	Lake	38.226595	29.886688
ADIGUZEL	**BML02**	Lake	38.190122	29.223643
CINDERE-ADIGUZEL 2	**BML03**	Lake	38.117446	29.040607
KARACASU BARAJI	**BML05**	Lake	37.780214	28.596971
TAVAS-YENIDERE	**BML06**	Lake	37.606163	28.89873
KEMER	**BML07**	Lake	37.57423	28.527348
CINE ADNAN MENDERES	**BML10**	Lake	37.49512	28.129013
TOPCAM	**BML12**	Lake	37.689452	28.008499
YAYLAKAVAK	**BML13**	Lake	37.576678	27.801552
BAFA	**BML16**	Lake	37.523073	27.383493

Table 2.1 continues

Station Name	Station Code	Type	Y_WGS84	X_WGS84
IKIZDERE	**BML17**	Lake	37.889618	27.740999
YAVASLAR	**BML19**	Lake	38.526829	29.975919
KARAKUYU	**BML20**	Lake	38.054959	30.250615
ORENLER	**BML21**	Lake	38.612108	30.224311
GOKPINAR	**BML22**	Lake	37.785934	29.128115
BM RİVER-AGZI	**BMTW01**	Transitional Water	37.544755	27.174717
BM LAGUN	**BMTW02**	Transitional Water	37.585469	27.190095
BM KIYI SUYU 1	**BMCW01**	Coastal Water	37.584833	27.148131
BM KIYI SUYU 2	**BMCW02**	Coastal Water	37.410109	27.211456
BM KIYI SUYU 3	**BMCW03**	Coastal Water	37.344555	27.285342
BM KIYI SUYU 4	**BMCW04**	Coastal Water	37.390852	27.395384
YUKARI BANAZ	**BMR01**	River	38.739797	29.768536
ASAGI BANAZ-1	**BMR02**	River	38.402888	29.498929
ASAGI BANAZ-2	**BMR03**	River	38.343531	29.24029
DOKUZSELE-2	**BMR05**	River	38.380467	29.304101
KUFI-3	**BMR10**	River	38.55867	29.967309
KUFI-4	**BMR11**	River	38.244031	29.86753
YUKARI BUYUK MENDERES 1	**BMR12**	River	38.20272	29.945112
CAYKAVUSTU-2	**BMR15**	River	37.719342	29.397376
ASAGI CURUKSU-1	**BMR18**	River	37.827809	29.266643
ORTA BUYUK MENDERES	**BMR20**	River	37.954368	28.926628
ASAGI DANDALAZ	**BMR22**	River	37.87685	28.537744
YUKARI AKCAY 1	**BMR23**	River	37.561289	28.960702
YUKARI AKCAY 5	**BMR27**	River	37.446317	28.591095
ASAGI AKCAY	**BMR28**	River	37.84326	28.297443
GIRME DERESI	**BMR29**	River	37.273232	28.021417
YUKARI CINE-1	**BMR30**	River	37.426505	28.141515
YUKARI CINE-3	**BMR32**	River	37.547058	28.161884
ASAGI CINE-1	**BMR33**	River	37.595376	27.771665
ASAGI CINE-2	**BMR34**	River	37.766232	27.814306
YUKARI SARICAY	**BMR36**	River	37.678226	27.621376
YUKARI KARGIN	**BMR38**	River	37.552716	27.563502
YUKARI IKIZDERE-1	**BMR47**	River	37.928269	27.777246
YUKARI IKIZDERE-2	**BMR48**	River	37.954009	27.758918
ASAGI IKIZDERE-1	**BMR49**	River	37.878102	27.7306
ALANGULLU	**BMR52**	River	37.811174	27.616095
ASAGI BUYUK MENDERES-1	**BMR55**	River	37.803416	27.677998
ASAGI BUYUK MENDERES-2	**BMR56**	River	37.505351	27.337874

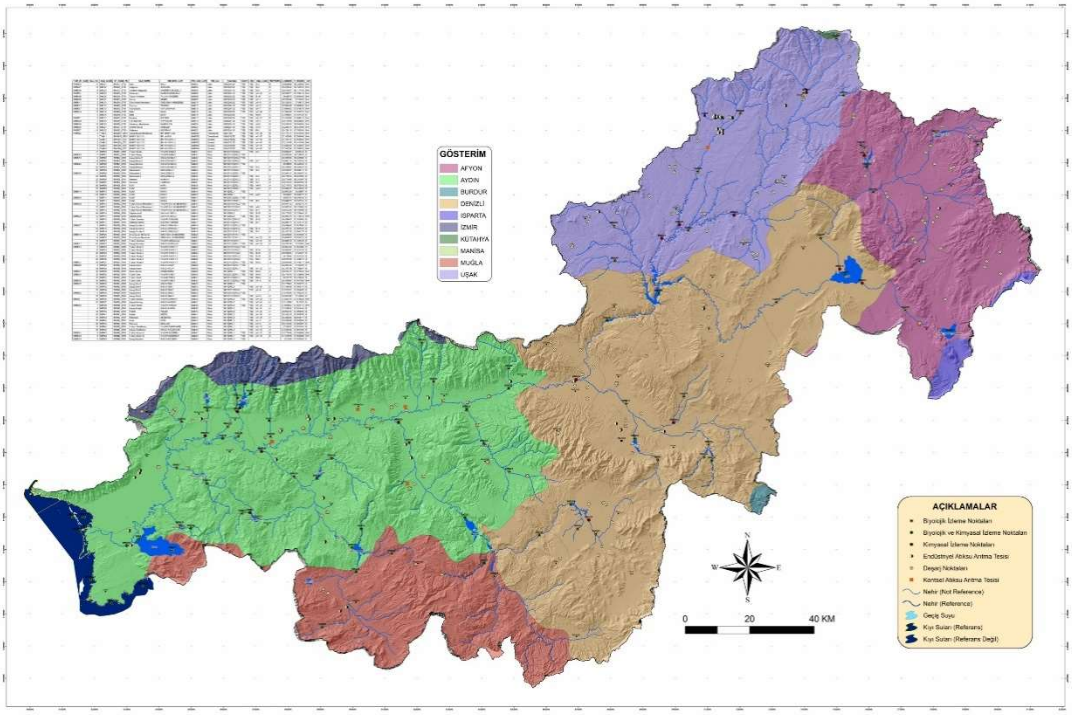

Figure 2.1 Büyük Menderes Basin Monitoring Stations (Yerüstü, Kıyı ve Geçiş Suları için Çevresel Hedeflerin Belirlenmesine Yönelik Metodolojinin Geliştirilmesi: Büyük Menderes Havzası Pilot Çalışması Projesi, 2018)

2.2 Chemical Analysis of Samples

2.2.1 Physicochemical Pollutants and Analysis

Table 2.2 indicates the monitored physicochemical parameters according to Annex 5 of the Regulation on Surface Water Quality Management published in the Official Gazette on November 30, 2012. The table also presents the analytical method used for these pollutants. The regulation was revised in August 2016 after the monitoring study of the thesis was completed. Some of the pollutants were removed from the regulation, some new ones were added and also the ranges for the classification of the water quality were revised. Table 2.2 presents the physicochemical parameters to be monitored in the previous regulation.

Physicochemical monitoring was performed seasonally in 4 periods. The analyses were carried out in DEÜ Department of Environmental Engineering Wastewater

Laboratory according to Standard Methods (Eaton, Clesceri, Rice, & Greenberg, 2005) with the method numbers given in Table 2.2. The laboratory has an accreditation certificate from Ministry of Environment and Urbanization and TURKAK ISO/17025 Experiment Laboratory. The method validation studies including Limit of Detection (LOD), Limit of Quantification (LOQ) and Uncertainty were conducted by the laboratory. Fecal and total coliform were performed in the Food Engineering Department of Süleyman Demirel University. Online measurements for Temperature (T), pH, Conductivity, Dissolved oxygen (DO) were conducted by Hach Lange HQ40d model portable multiprobe equipment.

Table 2.2 Validation results and method list for physicochemical parameters

Water Quality Parameters	**Water Quality Classes**				**LOD**	**LOQ**	**Measurement Uncertainty**	**Method**
							%	
	I	**II**	**III**	**IV**				
General conditions								
Temperature (°C)	≤ 25	≤ 25	≤ 30	> 30				SM 2550 B
pH	6.5-8.5	6.5-8.5	6.0-9.0	6.0-9.0 except	0.08	0.28	1.6	SM 2120 C SM 4500-H^+ B TS ISO 10390
Conductivity (µS/cm)	< 400	400-1000	1001-3000	> 3000	20 µS/cm	67 µS/cm	1.0 µs/cm	SM 2510 B
Color	**RES 436 nm:** 1.5	**RES 436 nm:** 3	**RES 436 nm:** 4.3	**RES 436 nm:** 5				EN ISO 7887
	RES 525 nm: 1.2	**RES 525 nm:** 2.4	**RES 525 nm:** 3.7	**RES 525 nm:** 4.2				
	RES 620 nm: 0.8	**RES 620 nm:** 1.7	**RES 620 nm:** 2.5	**RES 620 nm:** 2.8				
(A) Oxygenation Parameters								
Dissolved oxygen (mg O_2/L)^a	> 8	6-8	3-6	< 3	0.50 mg/L	1.60 mg/L	1.9	SM 4500-O C
Oxygen saturation (%)^a	90	70-90	40-70	< 40				Measured by automatic device.
Chemical oxygen demand (COD) (mg/L)	< 25	25-50	50-70	> 70	6.07 mg/L	20.24 mg/L	3.8	SM 5220 B
Biological oxygen demand (BOD_5) (mg/L)	< 4	4-8	8-20	> 20	0.83 mg/L	2.77 mg/L	6.4	SM 5210 B SM 4500-O C

Table 2.2 continues

Water Quality Parameters	**Water Quality Classes**				**LOD**	**LOQ**	**Measurement Uncertainty %**	**Method**
	I	**II**	**III**	**IV**				
B) Nutrient Parameters								
Ammonium nitrogen (mg NH_4^+-N/L)	< 0.2	0.2-1	1-2	> 2	0.018 mg/L	0.062 mg/L	0.07	SM 4500-NH_3 F
Nitrite nitrogen (mg NO_2^--N/L)	< 0.002	0.002-0.01	0.01-0.05	> 0.05	0.0002 mg/L	0.00071 mg/L	5.2	SM4500–NO_2 B Colorimetric Method
Nitrate nitrogen (mg NO_3^--N/L)	< 5	5-10	10-20	> 20	0.006 mg/L	0.020 mg/L	0.9	SM 4500-NO_3 H
Total kjeldahl-nitrogen (mg/L)	0.5	1.5	5	> 5	0.4 mg/L	1.3 mg/L	9.6	SM 4500 NorgB SM 4500-NH3 C With 250 ml sample volume
Total phosphorus (mg P/L)	< 0.03	0.03-0.16	0.16-0.65	> 0.65	0.007 mg/L	0.022 mg/L	5.5	TS EN 13346 SM 4500– P B5 ve E
C) Trace Elements (Metals)					**LOD**	**LOQ**	**Measurement Uncertainty**	**Method**
Mercury (µg Hg/L)	< 0.1	0.1-0.5	0.5-2	> 2	0.60 ppb	2.00 ppb	3.5 ppb	Internal Method DEU ASL-M01 (ICP-AES Using Hydride)
Cadmium (µg Cd/L)	≤ 2	2-5	5-7	> 7	0.36ppb	1.20 ppb	1.3 ppb	SM 3030 K SM 3120 B
Lead (µg Pb/L)	≤10	10-20	20-50	> 50	2.69 ppb	8.96 ppb	2.6 ppb	SM 3030 K SM 3120 B
Copper (µg Cu/L)	≤20	20-50	50-200	> 200	1.18 ppb	3.95 ppb	1.3 ppb	SM 3030 K SM 3120 B
Nickel (µg Ni/L)	≤20	20-50	50-200	> 200	0.65 ppb	2.18 ppb	1.6 ppb	SM 3030 K SM 3120 B
Zinc (µg Zn/L)	≤200	200-500	500-2000	> 2000	0.79 ppb	2.62 ppb	2.3ppb	SM 3030 K SM 3120 B
D) Other								
Suspended Solids					2.95	9.83	4.7	SM 2540 D
Turbidity					0.078	0.259	1.9	SM 2130 B Nephelometric Method
Alkalinity					2.87 mg/L	9.56 mg/L	4.4	SM 2320 B Titrimetric Method
Salinity					0.007 mg/L	0.023 mg/L	1.5	SM 2520 B
D) Bacteriological Parameters								
Fecal coliform (EMS/100 mL)	≤10	10-200	200-2000	> 2000				TS EN ISO 9308-1
Total coliform (EMS/100 mL)	≤100	100-20000	20000-100000	> 100000				TS EN ISO 9308-1

2.2.2 Priority and Specific Organic Pollutants Analysis

Table 2.3 and Table 2.4 depict the list of priority and the specific pollutants as well as the analytical methods used for these pollutants, respectively. Organic pollutants were analyzed by GC/MS-MS, LC/MS-MS. EPA, APHA Standard Methods and the recently developed methods in the literature were used. The validation study for these pollutants was conducted before monitoring studies. Instrument optimization, calibration curve formation, repeatability, sample preparation, determination of LOQ/ LOD/ relative standard deviation (RSD) and measurement uncertainty (U_x) were some of the studies conducted for method validation purpose.

The instrument optimization for GC/MS-MS and LC/MS-MS includes determination of the main ion for each pollutant and instrument operating conditions for MS-MS. LC/MS-MS was optimized for sheath gas pressure (SGP), ion gas pressure (ISGP), aux gas pressure (AGP), spray voltage (SV), vaporization temperature (VT) and collision gas pressure (CGP), ion source position, mobile phase composition, mobile phase gradient, flow rate, injection volume, etc. GC/MS-MS was optimized for the parent and product ions of pollutants, retention time, inlet temperature, oven temperature, Aux1 and Aux 2 temperature, source temperature, M1 Quadrapole temperature, Collison flow, Turbo speed and colon flow, etc.

In the second stage of the validation study, calibration curves with at least 5 different concentrations and at least 3 replicates at each concentration were developed by using the standard reference material. The linear range of each calibration curves was determined. In repeatability studies, a certain concentration of the pollutants was selected and then, analyzed 10 to 14 times. After that, standard deviation (SD), LOQ, LOD, RSD and U were determined for each pollutant. The approach of LOD = 3SD and LOQ = 10SD were used in LOD and LOQ determinations, respectively.

Measurement of uncertainty of the analysis was determined from uncertainties of calibration curve and repeatability. The maximum acceptable uncertainty ratio of X ± 50% was taken as the measurement uncertainty budget control value. The validation studies aimed to provide LOD value which corresponds to 30% Environmental Quality Standard (EQS) given in Water Frame Directive (WFD) or regulations declared by Ministry of Agriculture and Forestry, Department of Water Management (previously Ministry of Forestry and Water Management (MoFWM)).

Priority pollutants were monitored for 12 months. Samples were taken according to appropriate protection measures, then transferred to the laboratory at 4°C and protected in the cooler until they are analyzed. The concentration of any pollutant detected over LOD in the samples was reported. But if it is less than LOD, the result was reported as <LOD. Spikes and blanks were used for each sample period in parallel to the analyses of water samples.

The water quality classification for priority and specific pollutants was made based on Annual Average Environmental Quality Standard (AA-EQS$_W$) of the pollutants as stated in the WFD and in the Turkish Surface Water Quality Regulation (SWQR), respectively. In determining the annual average concentration of the pollutant, the LOD value of the pollutant was used if the detected concentration is less than its corresponding LOD value.

Table 2.3 The list of priority pollutants and analytical methods

WFD No	**Pollutant**	**Group**	**Device**	**Method**
1	Alachlor	Pesticide	GC MSMS	EPA 3510C ,EPA 608, EPA 525.3
2	Anthracene	PAH	GC MSMS	EPA 3510C, EPA 610
3	Atrazin	Pesticide	GC MSMS	EPA 3510C EPA 608, EPA 525.3
4	Benzene	VOC	GC MSMS	EPA 524-2
5	Pentabromodiphenylether PBDE) (28, 47, 99, 100, 153,154)		GC MSMS	EPA 527
7	Chloro alkane, C10-13	Chlorinated hydrocarbon	GC MSMS	LL extraction with DCM, P. Castells et al. / Journal of Chromatography A, 1025 (2004) 157–162.
8	Chlorfenvinphos	Pesticide	GC MSMS	EPA 3510C, EPA 608, EPA 525.3

Table 2.3 continues

WFD No	Pollutant	Group	Device	Method
9	Chlorpyrifos (Chlorpyrifos-ethyl)	Pesticide	GC MSMS	EPA 3510C,EPA 608, EPA 525.3
9a	Cyclodiene pesticides:	Pesticide	GC MSMS	EPA 3510C,EPA 608, EPA 525.3
	Aldrin	Pesticide	GC MSMS	EPA 3510C,EPA 608, EPA 525.3
	Dieldrin	Pesticide	GC MSMS	EPA 3510C,EPA 608, EPA 525.3
	Endrin	Pesticide	GC MSMS	EPA 3510C,EPA 608, EPA 525.3
	Isodrin	Pesticide	GC MSMS	EPA 3510C,EPA 608
9 b	DDT total			
	DDT para-para- DDT	Pesticide	GC MSMS	EPA 3510C,EPA 608, EPA 525.3
	DDT-o,p	Pesticide	GC MSMS	EPA 3510C,EPA 608, EPA 525.3
10	1,2-dichloroethane	VOC	GC MSMS	EPA 524-2
11	Dichloromethane	VOC	GC MSMS	EPA 524-2
12	Di(2-ethylhexyl)phthalate (DEHP)	Phthalate	LC MSMS	EPA 525.3
13	Diuron	Pesticide	LC MSMS	R. Cazorla-Reyes et al. Talanta 85 (2011) 183–196
14	Endosulfan	Pesticide	GC MSMS	EPA 3510C, EPA 608, EPA 525.3
	Endosulfan I (alpha isomer)			
	Endosulfan II (beta isomer)			
	Endosulfan sulfate			
15	Fluoranthene	PAH	GC MSMS	EPA 3510C, EPA 610
16	Hexachlorobenzene	Pesticide	GC MSMS	EPA 3510C, EPA 608
17	Hexachlorobutadiene	VOC	GC MSMS	EPA 524-2
18	Hexachlorocyclohexane	Pesticide	GC MSMS	EPA 525.3
19	Isoproturon	Pesticide	LC MSMS	R. Cazorla-Reyes et al. Talanta 85 (2011) 183–196
22	Naphthalene	PAH	GC MSMS	EPA 3510C, EPA 610
24	Nonylphenol	Alkyl phenol	LC MSMS	ASTM D7485
25	Octyl phenol	Alkyl phenol	LC MSMS	ASTM D7485
26	Pentachlorobenzene	Pesticide	GC MSMS	EPA 3510C,EPA 608
27	Pentachlorophenol	Pesticide	GC MSMS	EPA 3510C,EPA 608,EPA 525.3
28	Polyaromatic hydrocarbons	PAH		
	(Benzo(a)pyrene)	PAH	GC MSMS	EPA 3510C,EPA 610
	(Benzo(b)fluoranthene)	PAH	GC MSMS	EPA 3510C,EPA 610
	(Benzo(g,h,i)perylene)	PAH	GC MSMS	EPA 3510C,EPA 610
	(Benzo(k)fluoranthene)	PAH	GC MSMS	EPA 3510C,EPA 610

Table 2.3 continues

WFD No	Pollutant	Group	Device	Method
	(Indeno(1,2,3-cd)pyrene)	PAH	GC MSMS	EPA 3510C,EPA 610
29	Simazine	Pesticide	GC MSMS	EPA 3510C, EPA 608, EPA 525.3
30	Tributyltin compounds	Organotin Compounds	GC MSMS	Agilent and Thermo application notes (52099) Derivatization Coscolla et al. Talanta(2014) 119, 544-552
31	Trichlorobenzenes	VOC	GC MSMS	EPA 524-2
32	Trichloromethane (chloroform)	VOC	GC MSMS	EPA 524-2
33	Trifluralin (2,4-Dinitrochlorobenzene)	Pesticide	GC MSMS	EPA 3510C, EPA 608, EPA 525.3
34	Dicofol Dichlorobenzophenone, 4,4'- Results	Pesticide	GC MSMS	EPA 3510C, EPA 608
35	Perfluorooctane sulfonic acid and its derivaties	Surfactant	LC MSMS	EPA 537
36	Quinoxyfen	Pesticide	GC MSMS LC MSMS	EPA 3510C, EPA 608 R. Cazorla-Reyes et al. Talanta 85 (2011) 183
37	Dioxins and dioxin-like compounds			
38	Aclonifen	Pesticide	GC MSMS	EPA 3510C, EPA 608, EPA 619
39	Bifenox	Pesticide	GC MSMS	EPA 3510C, EPA 608
40	Cybutryne	Pesticide	GC MSMS	EPA 619
41	Cypermethrin	Pesticide	GC MSMS	EPA 3510C, EPA 608
	alpha-cypermethrin	Pesticide		
	beta-cypermethrin	Pesticide		
	theta-cypermethrin	Pesticide		
	zeta-cypermethrin	Pesticide		
42	Dichlorvos	Pesticide	GC MSMS	EPA 3510C, EPA 608, EPA 525.3
43	Hexabromocyclododecanes			
44	Heptachlor and heptachlor epoxicde	Pesticide	GC MSMS	EPA 3510C, EPA 608, EPA 525.3
	Heptachlor exo-epoxide (isomer B)	Pesticide	GC MSMS	EPA 3510C, EPA 608, EPA 525.3
	Heptachlor endo-epoxide	Pesticide	GC MSMS	EPA 3510C, EPA 608, EPA 525.3
	Heptachlor	Pesticide	GC MSMS	EPA 3510C, EPA 608, EPA 525.3
45	Terbutryn	Pesticide	GC MSMS	EPA 3510C, EPA 608, EPA 525.3

Table 2.4 The list of specific pollutants and analytical method

Pollutant	**Group**	**Device**	**Method**
1,1-Dichloroethane	VOC	GC MSMS	EPA 524-2
1,2,4,5-tetrachloro-benzen	VOC	GC MSMS	EPA 524-2
1,2,4-Trimethylbenzene	VOC	GC MSMS	EPA 524-2
1,3,5-Trimethylbenzene Mesitilen	VOC	GC MSMS	EPA 524-2
1,3-Dichlorobenzene	VOC	GC MSMS	EPA 524-2
Acenaphthene	PAH	GC MSMS	EPA 3510C EPA 610
Acetamiprid	Pesticide	LC MSMS	R. Cazorla-Reyes et al. Talanta 85 (2011) 183
Acetochlor	Pesticide	LC MSMS	R. Cazorla-Reyes et al. Talanta 85 (2011) 183
Azoxystrobin	Pesticide	LC MSMS	R. Cazorla-Reyes et al. Talanta 85 (2011) 183.
Bisfenol-A	Alkyl phenol	LC MSMS	ASTM D7485
Boscalid	Pesticide	LC MSMS	R. Cazorla-Reyes et al. Talanta 85 (2011) 183
Buprofezin	Pesticide	LC MSMS	R. Cazorla-Reyes et al. Talanta 85 (2011) 183
Butralin	Pesticide	LC MSMS	R. Cazorla-Reyes et al. Talanta 85 (2011) 183
Butyl benzyl phthalate	Phthalate	LC MSMS	EPA 525.3
Carbendazim	Pesticide	LC MSMS	R. Cazorla-Reyes et al. Talanta 85 (2011) 183
Carbofuran	Pesticide	LC MSMS	R. Cazorla-Reyes et al. Talanta 85 (2011) 183
Carbon tetrachloride	VOC	GC MSMS	EPA 524-2
Chloridazon	Pesticide	LC MSMS	R. Cazorla-Reyes et al. Talanta 85 (2011) 183
Chlorobenzilate	Pesticide	GC MSMS	EPA 525.3
Clothianidin	Pesticide	LC MSMS	R. Cazorla-Reyes et al. Talanta 85 (2011) 183
Cyprodinil	Pesticide	LC MSMS	R. Cazorla-Reyes et al. Talanta 85 (2011) 183
Demeton -S	Pesticide	GC MSMS	EPA 3510C, EPA 608
Diazinon	Pesticide	GC MSMS	EPA 3510C, EPA 608
Diethyl phthalate	Phthalate	LC MSMS	EPA 525.3
Diflubenzuron	Pesticide	LC MSMS	R. Cazorla-Reyes et al. Talanta 85 (2011) 183
Dimethoate	Pesticide	LC MSMS	R. Cazorla-Reyes et al. Talanta 85 (2011) 183
Dimethomorph	Pesticide	LC MSMS	R. Cazorla-Reyes et al. Talanta 85 (2011) 183
Di-n-butyl phthalate	Phthalate	LC MSMS	EPA 525.3
Diphenylamine	Pesticide	GC MSMS	EPA 3510C, EPA 608
Epoxyconazole	Pesticide	LC MSMS	R. Cazorla-Reyes et al. Talanta 85 (2011) 183

Table 2.4 continues

Pollutant	Group	Device	Method
Ethoprophos	Pesticide	LC MSMS	R. Cazorla-Reyes et al. Talanta 85 (2011) 183
Fenamıphos	Pesticide	LC MSMS	R. Cazorla-Reyes et al. Talanta 85 (2011) 183
Fenhexamid	Pesticide	LC MSMS	R. Cazorla-Reyes et al. Talanta 85 (2011) 183
Fenpropathrin	Pesticide	LC MSMS	R. Cazorla-Reyes et al. Talanta 85 (2011) 183
Fenthion	Pesticide	GC MSMS	EPA 3510C, EPA 608
Fluazifop-P-Butyl	Pesticide	LC MSMS	R. Cazorla-Reyes et al. Talanta 85 (2011) 183
Flutriafol	Pesticide	LC MSMS	R. Cazorla-Reyes et al. Talanta 85 (2011) 183
Imidachloprid	Pesticide	LC MSMS	R. Cazorla-Reyes et al. Talanta 85 (2011) 183
Imizalil	Pesticide	LC MSMS	R. Cazorla-Reyes et al. Talanta 85 (2011) 183
Izopropilbenzen (Cumene)	VOC	GC MSMS	EPA 524-2
Linuron	Pesticide	GC MSMS	EPA 3510C, EPA 608, EPA 525.3
Metalaxyl	Pesticide	LC MSMS	R. Cazorla-Reyes et al. Talanta 85 (2011) 183
Methacrifos	Pesticide	LC MSMS	R. Cazorla-Reyes et al. Talanta 85 (2011) 183
Methamidophos	Pesticide	LC MSMS	R. Cazorla-Reyes et al. Talanta 85 (2011) 183
Methidathion	Pesticide	LC MSMS	R. Cazorla-Reyes et al. Talanta 85 (2011) 183
Metolachlor	Pesticide	LC MSMS	R. Cazorla-Reyes et al. Talanta 85 (2011) 183
Monocrotophos	Pesticide	LC MSMS	R. Cazorla-Reyes et al. Talanta 85 (2011) 183
N-Propybenzene	VOC	GC MSMS	EPA 524
O xylene	VOC	GC MSMS	EPA 524
Oxadixil	Pesticide	LC MSMS	R. Cazorla-Reyes et al. Talanta 85 (2011) 183
p,p'-Dichlorodiphenyl dichloroethane (p-p' DDD)	Pesticide	GC MSMS	EPA 3510C, EPA 608, EPA 525.3
PCB 101	PCB	GC MSMS	EPA 3510C, EPA 610
PCB 118	PCB	GC MSMS	EPA 3510C, EPA 610
PCB 138	PCB	GC MSMS	EPA 3510C, EPA 610
PCB 153	PCB	GC MSMS	EPA 3510C, EPA 610
PCB 180	PCB	GC MSMS	EPA 3510C, EPA 610
PCB 28	PCB	GC MSMS	EPA 3510C, EPA 610
PCB 31	PCB	GC MSMS	EPA 3510C, EPA 610
PCB 52	PCB	GC MSMS	EPA 3510C, EPA 610
Penconazol	Pesticide	LC MSMS	R. Cazorla-Reyes et al. Talanta 85 (2011) 183

Table 2.4 continues

Pollutant	Group	Device	Method
Permethrin	Pesticide	GC MSMS	EPA 3510C, EPA 608, EPA 525.3
Phenanthrene	PAH	GC MSMS	EPA 3510C, EPA 610
Prochloraz	Pesticide	LC MSMS	R. Cazorla-Reyes et al. Talanta 85 (2011) 183
Propamocarb	Pesticide	LC MSMS	R. Cazorla-Reyes et al. Talanta 85 (2011) 183
Propham	Pesticide	LC MSMS	R. Cazorla-Reyes et al. Talanta 85 (2011) 183
Propiconazole	Pesticide	LC MSMS	R. Cazorla-Reyes et al. Talanta 85 (2011) 183
Pyrene	PAH	GC MSMS	EPA 3510C, EPA 610
Free CN	Cyanide	Spectrophotometric	SM 4500 CN (C ve E)
Styrene	VOC	GC MSMS	EPA 524-2
Tebuconazole	Pesticide	LC MSMS	R. Cazorla-Reyes et al. Talanta 85 (2011) 183
Terbuthylazine	Pesticide	LC MSMS	R. Cazorla-Reyes et al. Talanta 85 (2011) 183
Tetrabromobisphenol A	Alkyl phenol	LC MSMS	ASTM D7485
Thiabendazole	Pesticide	LC MSMS	R. Cazorla-Reyes et al. Talanta 85 (2011) 183
Thiacloprid	Pesticide	LC MSMS	R. Cazorla-Reyes et al. Talanta 85 (2011) 183
Thiamethoxam	Pesticide	LC MSMS	R. Cazorla-Reyes et al. Talanta 85 (2011) 183
Thiophonate Methyl	Pesticide	LC MSMS	R. Cazorla-Reyes et al. Talanta 85 (2011) 183
Trichloroethylene	VOC	GC MSMS	EPA 524-2
Total Hydrocarbon		Extraction	SM 5520 F

2.2.2.1 Polycyclic Aromatic Hydrocarbon (PAH) and Polychlorinated Biphenyls (PCB) Analysis in GC/ MS-MS

PAH and PCB analyses were conducted according to EPA 3510C (EPA, 1996). 200 mL sample was taken into the separatory funnel. The sample was diluted ½ if it is highly polluted stations such as coastal and transitional water. 20 mL of dichloromethane (DCM) was added to the funnels and then they were vigorously mixed for 2-3 minutes. The gas-phase was ventilated periodically. At least 10 minutes was allowed to separate the organic phase from the water phase. The DCM phase was taken to 40 mL of amber vial (A). The same procedure was performed by adding 10 mL of DCM for the second time and by adding 5 mL of DCM for the third time. All the organic phases (approximately 35 mL) were collected to the same amber bottle (Vial A). Sodium sulfate was added into the extract. Then, the supernatant was collected in another vial (Vial B). The particulate matter remained in the previous vial was washed with 2 mL of DCM to collect the adsorbed PAH or PCB on the salts. The liquid phase used to wash Vial A was transferred to the extract containing vial (Vial B). The solvent phase in vial B was evaporated under N_2 gas until the remaining liquid phase volume was 1 or 2 mL. Then 5 mL hexane was added, the evaporation process was continued until 1-2 concentrate was obtained. Finally, another 5 mL hexane was added and the evaporation process was repeated to obtain 0.5 mL concentrate. Extra 0.5 mL hexane was added to wash the PAHs and PCBs remained on the inner walls of the vials. 1 mL extract was transferred to the amber GC vials for the analysis.

2.2.2.2 Pesticide Analysis in GC/ MS-MS

EPA 525.3 method (EPA METHODS, 2014) was used in the analysis of non-polar pesticides. The 500 mL sample was filtered through a polyamide filter (0.45 µm). 2 mL of MeOH was added into 500 mL of filtered water and then the bottles were shaken vigorously to homogenize the MeOH in the bottle. SPE cartridges were connected to the sample feeding columns. The samples were loaded to the columns. Cartridges (Bont Elut C18 500 mg, 6 mL, 30/pk) conditioning was done by adding, in the order of, 6 mL MeOH, 6 mL Ethyl Acetate: DCM mixture (prepared at a ratio of 1:1), 6 mL MeOH and finally by adding 6 mL distilled water. SPE cartridges were protected against to drying during conditioning. The sample was passed through the cartridge immediately after conditioning at a feeding rate of 5-10 mL/min under vacuum. All samples in the sample flasks were passed through the SPE cartridge. Then, the sample flask was washed with 10 mL of distilled water and this final bottle washed sample was passed through the cartridge as well.

The SPE cartridge was dried for 2 hours under vacuum at 3 bars. After SPE cartridge was completely dried, the elution procedure was applied. Sodium sulfate cartridge was installed to SPE cartridge. A 40 mL amber vial was placed under the

SPE. Two times 5 mL Ethyl Acetate: DCM (1: 1) mixture was added to the cartridge to desorb the pesticides adsorbed on the cartridge. 10 mL elution was collected and the solvent phase was evaporated under N_2 gas until 0.5 mL extracts were obtained. Then, 5 mL of hexane was added to the extract and evaporated under N_2again to obtained 0.5 mL volume. This procedure was repeated 2 times to sweep the pesticide adsorbed on inside of the vials. The final volume of the extract was 0.5 mL, the volume was raised to 1 mL after washing the vials with hexane. Then the whole extract (1 mL) was transferred to the GC vials for the analysis of pesticide.

2.2.2.3 Chloroalkane Analysis in GC/ MS-MS

Chloroalkane analysis was conducted according to the method developed by P. Castells (Castells, Santos, & Galceran, 2004). A 500 mL sample was filtered through a polyamide filter (0.45 µm). The sample was poured into the SPE separating columns. SPE cartridges were connected to the sample feeding columns and then, the samples were loaded to the columns. Cartridge (Bont Elut C18 500 mg, 6 mL, 30/pk) conditioning was done by adding, in the order of, 2 mL MeOH and 2 mL distilled water. SPE cartridges were protected against to drying during conditioning. The sample was passed through the cartridge immediately after conditioning at a feeding rate of 5-10 mL/min under vacuum. All samples in the sample flasks were passed through the SPE cartridge. The SPE cartridge was dried for 2 hours under vacuum at 3 bars. After SPE cartridge was completely dried, the elution procedure was applied. Sodium sulfate cartridge was installed to SPE cartridge. A 40 mL amber vial was placed under the SPE. Two times 3 mL cyclohexane at a flowrate of2 ml/min was added to the cartridge to desorb the chloroalkane adsorbed on the cartridges. The solvent phase was evaporated under N_2 gas until 0.5 mL extracts were obtained. The final volume of the extract was 0.5 mL, the volume was raised to 1 mL after washing the extract vials with cyclohexane. Then the whole extract (1 mL) was transferred to the GC vials for the analysis of chloroalkanes.

2.2.2.4 Polybrominated Diphenyl Ethers (PBDE) Analysis in GC/ MS-MS

PBDE Analysis was conducted according to the method “Analyzing Wastewater Effluents for PAH’s and PBDE’s Using the Agilent 7000 Triple Quadrupole GC/MS” (Pinchin, Verik, & Brady, 2012). The PBDEs analyzed in the study were PBDE 15, BPDE28, PBDE47, PBDE99, PBDE100, PBDE153, PBDE154. For the analysis of PBDE, 140 µL of NH_3 (25%), 200 mL of distilled water and 20 mL of hexane was added into 200 mL sample. The sample was placed in an orbital horizontal shaker with 70 rpm shaking speed for at least 12 hours at room temperature. 10 mL of hexane phase which contains PBDE was collected. The 10 mL of hexane phase was taken to 40 mL amber vial. It was evaporated to 0.5 mL under N_2. The 40 mL amber vial walls were washed by hexane and the washing solvent was added to the PBDE containing extract. The total volume of the extract was adjusted to 1 mL. Then the whole extract (1 mL) was transferred to the GC vials for PBDE analysis.

2.2.2.5 Organotin Compound Analysis in GC/ MS-MS

The method developed by Coscolla (Coscollà, Requena, Yusa, & Olivares, 2014) was used in organotin compound analysis in GC/MS-MS. The standard solutions were prepared as follows; 1mL acetate buffer and 50 µL derivatization agent were added to the 1 mL of the references standard solution. The mixture was shaken for 30 minutes in an orbital shaker and then, 5 mL of distilled water and 1 mL of hexane were added. It was shaken for another 30 seconds to homogenize the mixture. The hexane phase was collected from the top and it was transferred to amber vial to be analyzed in GC/ MS-MS. Acetate Buffer was prepared by dissolving 82 g of acetate in 1 L distilled water. The pH is adjusted to 4.5 with acetic acid. Derivatization agent was prepared daily by dissolving 0.2 g of $NaBEt_4$ in 1 mL ethanol.

The organotin compound analysis in the sample was conducted as follows; 10 mL sample was taken and it was mixed with 5 mL MeOH. The mixture was stirred for 10 minutes. After that, 2 mL acetate buffer and 200 µL derivatization agent were added.

The mixture was shaken for 30 minutes in an orbital shaker and then, 1 mL hexane was added into the mixture. It was shaken another 30 seconds. After that, the hexane phase was collected from the top, Na_2SO_4 was added to capture the water remained in the sample. It was filtered through a 0.45 membrane syringe filter. The analysis was carried out on GC/ MS-MS.

2.2.2.6 Pesticide, Phthalate and PFOS Analysis in LC/ MS-MS

Polar pesticide and PFOS/Phthalate analysis were conducted according to the Single solid phase extraction method (Cazorla-Reyes, Moreno, González, Frenicha, & Vidal, 2011). The 500 mL sample was filtered through a membrane filter (0.45 µm Hv). The pH of the sample was adjusted to 7. Then, 1 mL MeOH was added into 500 mL of filtered water. SPE cartridges (HLB) were connected to the sample feeding columns. Cartridges (Bont Elut Plexa 500 mg, 6 mL, 30/pk) conditioning was done by adding, in the order of, 4 mL MeOH and 8 mL distilled water. SPE cartridges were protected against to drying during conditioning. The sample was passed through the cartridge immediately after conditioning at a feeding rate of 5-10 mL/min under vacuum. All samples in the sample flasks were passed through the SPE cartridge. The SPE cartridge was dried for 2 hours under vacuum at 3 bars. After SPE cartridge was completely dried, the elution procedure was applied. Sodium sulfate cartridge was installed to SPE cartridge. A 40 mL amber vial was placed under the SPE. Two times 4 mL MeOH were added to the cartridge to desorb the pesticides and PFOS/Phthalate adsorbed on the cartridges. 8 mL elution was collected and the all solvent phase was completely evaporated under N_2 gas. 1 mL mobile phase was added to the vials. The extract was divided into two with 0.5 mL volume. Each 0.5 mL extract was placed into different vials for pesticide and PFOS/ Phthalate analysis in LC/ MS-MS. The instrument was run with corresponding mobile phases given below.

Mobile phase for pesticide analysis was as follows; Mobile phase A was made up of 95% Water, 5% MeOH, 400 µL Ammonium Format solution (1 M) and 0.1% Formic acid. Mobile phase B; 95% MeOH, 5% Water, 400 µL Ammonium Format solution (1 M) and 0.1% Formic acid. Washwater contained 40% water + 60%MeOH.1 M Ammonium Format solution was prepared by dissolving0.67 g of tart in 10 mL water. The standard solution for the calibration curve was prepared by adding the mobile phase on to the standard solution in a ratio of Mobile phase A/ Mobile phase B= 1/1.

Mobile phase for PFOS/ Phthalate analysis was prepared according to the method developed by Addressing the Challenges of Analyzing Trace Perfluorooctanoic Acid (PFOA) and Perfluorooctane Sulfonate (PFOS) Using LC/QQQ (D. Voyksner & Meng, 2008). Mobile phase A was made up of 1000 µL from 1 M Ammonium acetate solution and 100 mL Water. Mobile phase B was made up of Acetonitrile (AcN). Wash water contained 50% water and 50% MeOH.1 M Ammonium Format solution was prepared by dissolving 0.77 g of tart in 10 mL water. The standard solution for the calibration curve was prepared by MeOH.

2.2.2.7 Alkylphenol Analysis in LC/ MS-MS

ASTM D7485 (ASTM Standards, 2017) method was used in the analysis of alkylphenol. The pH of the filtered sample from 500 mL membrane filter (0.45 µm Hv) was adjusted to 2 by formic acid. 1 mL of MeOH was added into 500 mL of filtered water and then the bottles were shaken vigorously to homogenize the MeOH in the bottle. SPE cartridges were connected to the sample feeding columns. The samples were loaded to the columns. Cartridges (Bont Elut C18 500 mg, 6 mL, 30/pk) conditioning was done by adding, in the order of, 5 mL MeOH and 3 mL MeOH/water with formic acid mixture (1:1). SPE cartridges were protected against to drying during conditioning. The sample was passed through the cartridge immediately after conditioning at a feeding rate of 5-10 mL/min under vacuum. All samples in the sample flasks were passed through the SPE cartridge. The SPE cartridge was dried for 2 hours under vacuum at 3 bars. After SPE cartridge was completely dried, the elution procedure was applied. Sodium sulfate cartridge was installed to SPE cartridge. A 40 mL amber vial was placed under the SPE. A mixture of 5 mL (MeOH / DCM) (1: 1) was added to the cartridge to desorb the alkylphenol adsorbed on the cartridges. 5 mL elution was collected and the all solvent phase was completely evaporated under N_2 gas. 1 mL of methanol was added in the 40 ml amber vials to wash the adsorbed compounds on the vial walls. The 40 mL amber vial was shaken well and this phase was taken up in 2 mL vials, in which the sample dissolved was introduced into the LC/ MS-MS device. The instrument was run with corresponding mobile phases given below.

Mobile phase for alkylphenol analysis was as follows; Mobile phase A was made up of 0.1% Ammonia Water, 2.155 mL NH_3 and 500 mL water. Mobile phase B; 0.1% Ammonia MeOH, 500 mL MeOH, 2.155 mL NH_3. Wash water contained 40% water + 60%MeOH.MeOH Water with formic acid was prepared mixed 20 mL of MeOH and with 20 mL of water adjusted to pH 2 with formic acid.

2.2.2.8 Volatile Organic Compounds (VOC) Analysis in GC/ MS-MS

A 10 mL sample was taken and placed in 20 mL headspace vial. It was shaken for at least two minutes. The vial was placed to autosampler. VOC analysis was performed at GC/MS-MS by headspace according to methods EPA524.2 (Munch, 1995).

2.2.3 Metal Analysis

Table 2.5 depicts the list and analytical method applied for metal pollutants. Metal analysis was carried out in DEU Environmental Engineering Department Air Pollution Laboratory. The laboratory has an accreditation certificate from Ministry of Environment and Urbanization and TURKAK ISO/17025 Experiment Laboratory. Metal analyses were performed at ICP-MS or ICP-OES.

SM 3120 B and SM 3125 B (Eaton, Clesceri, Rice, & Greenberg, 2005) were used in the analysis of metal. Samples were taken in 250 ml PFTA plastic containers and acidified with HNO_3. Then, they were filtered through 0.45 µm filters to separate particulate matter. Samples with high salinity, such as coastal and transitional water, were diluted with a ratio of 1/100.

Table 2.5 The list of metals and analytical methods

Pollutant	Group	Device	Method
Cadmium and its compounds	Metal	ICP OES, ICP MS	SM 3030 K, SM 3120 B, SM 3125 B
Lead and its compounds	Metal	ICP OES, ICP MS	SM 3030 K, SM 3120 B, SM 3125 B
Mercury and its compounds	Metal	ICP OES, ICP MS	SM 3030 K, SM 3120 B, SM 3125 B
Nickel and its compounds	Metal	ICP OES, ICP MS	SM 3030 K, SM 3120 B, SM 3125 B
Antimony	Metal	ICP OES, ICP MS	SM 3030 K, SM 3120 B, SM 3125 B
Arsenic	Metal	ICP OES, ICP MS	SM 3030 K, SM 3120 B, SM 3125 B
Copper	Metal	ICP OES, ICP MS	SM 3030 K, SM 3120 B, SM 3125 B
Barium	Metal	ICP OES, ICP MS	SM 3030 K, SM 3120 B, SM 3125 B
Beryllium	Metal	ICP OES, ICP MS	SM 3030 K, SM 3120 B, SM 3125 B
Boron	Metal	ICP OES, ICP MS	SM 3030 K, SM 3120 B, SM 3125 B
Bromur	Katyon	ICP OES, ICP MS	SM 4110 B-D
Zinc	Metal	ICP OES, ICP MS	SM 3030 K, SM 3120 B, SM 3125 B
Iron	Metal	ICP OES, ICP MS	SM 3030 K, SM 3120 B, SM 3125 B
Silver	Metal	ICP OES, ICP MS	SM 3030 K, SM 3120 B, SM 3125 B
Tin	Metal	ICP OES, ICP MS	SM 3030 K, SM 3120 B, SM 3125 B
Cobalt	Metal	ICP OES, ICP MS	SM 3030 K, SM 3120 B, SM 3125 B
Silisium	Metal	ICP OES, ICP MS	SM 3030 K, SM 3120 B, SM 3125 B
Titanium	Metal	ICP OES, ICP MS	SM 3030 K, SM 3120 B, SM 3125 B
Vanadium	Metal	ICP OES, ICP MS	SM 3030 K, SM 3120 B, SM 3125 B
Alumium	Metal	ICP OES, ICP MS	SM 3030 K, SM 3120 B, SM 3125 B
Calcium	Metal	ICP OES, ICP MS	SM 3030 K, SM 3120 B, SM 3125 B
Chromium	Metal	ICP OES, ICP MS	SM 3030 K, SM 3120 B, SM 3125 B
Sodium	Metal	ICP OES, ICP MS	SM 3030 K, SM 3120 B, SM 3125 B

2.3 Sediment Samples

Sediment samples were taken only in May 2017 for a 12-month monitoring period. The sediments were collected form mainly from lakes, coastal and transitional waters. Beside to sediment sampling, three water samples like surface, middle deep and from the deep along the water column were taken. The same physicochemical, priority and specific pollutant analysis were performed in water samples as they were done on the regular water samples. Both the water and sediment samples were transported to the laboratory at 4 °C and preserved in the fridge until they are analyzed. Table 2.7 depicts the list and analytical methods applied for the measurement of pollutants in the sediment. Some of the priority and specific pollutant analysis in sediment were performed in DEU Environmental Engineering Department Air Pollution Measurement Laboratory. A significant number of these parameters have accreditation certificates. The available LOD values were used for non-accreditation certificate.

There is a limited number of quality guidelines used to evaluate sediment quality in surface waters. The sediment quality assessment system applied in Canada was used in the study (Fletcher, Welsh, & Fletcher , 2008). (Table 2.8). The classification for the quality of the sediment was conducted regarding to the 14 PAHs, 7 pesticides, 10 heavy metals and 3 different types of conventional pollutants like TOC, TKN and TP.

Table 2.6 The list of the pollutants and the analytical method applied for sediment quality

Pollutant Parameter	**Method**
Total nitrogen	TS 8337 ISO 11261
Kjeldahl Nitrogen	SM 4500 Norg B, SM 4500 NH_3 C
Total Organic Carbon	TS 12089 EN 13137
Nitrite Nitrogen	TS EN 12457-4, SM 4500 NO_2-B
Nitrate Nitrogen	TS EN 12457-4, SM 4500 NO_3-H
Ammonia Nitrogen	TS EN 12457-4, SM 4500-NH_3-B, SM 4500-NH_3-C
PAH	EPA 3540C, EPA 8270D
Pesticide	EPA 3540C, EPA 8081B
Metal analysis	SM 3120B, SM 3125B

Table 2.7 Canada sediment quality directive quality criteria table (Fletcher, Welsh, & Fletcher , 2008)

Parameter	**Ontario Sediment Standards (ppm)**		**Canadian Freshwater Sediment Directive (µg/kg)**	
	Lowest Impact Level (LEL)	**Severe Impact Level (SEL)**	**Temporary Sediment Quality Directive (ISQG)**	**Possible Impact Level (PEL)**
Acenaphthene	*Bkz.* PAH	*Bkz.* PAH	6.71	88.9
The Asenaftel	*Bkz.* PAH	*Bkz.* PAH	5.87	128
Aldrin	0.002	8		
Ammonia				
Anthracene	0.22	370	46.9	245
Arsenic	6	33	5.9 mg/kg	17 mg/kg
Benzo (A) Anthracene	0.32	1480	31.7	385
Benzo (A) Pyrene	0.37	1440	31.9	782
Benzo (G, H, İ) Perylene	0.17	320		
Benzo (K) Fluoranthene	0.24	1340		
Cadmium	0.6	10	0.6 mg/kg	3.5 mg/kg
Carbon, Total Organic (Toc)	1%	10%		
Chlordane	0.007	6	4.5	8.87
Chromium	26	110	37.3 mg/kg	90 mg/kg
The Kris	0.34	460	57.1	862
Cobalt				
Virgin	16	110	35.7 mg/kg	197 mg/kg
The Cyanide				
DDD (P, P- And O, P-)	0.008	6	3.54	8.51
DDE (P, P- And O, P-)	0.005	19	1.42	6.75
DDT (Total)	0.007	12	1.19	4.77
Dibenzo (A, H) Anthracene	0.06	130	6.22	135
The Dieldrin	0.002	91	2.85	6.67
Endrin	0.003	130	2.67	62.4
Flouranthene	0.75	1020	111	2355
Floren	0.19	160	21.2	144
Heptachlor Epoxide	0.005	5	0.6	2.74
Hexachlorobenzene	0.02	24		
Indo (1,2,3-C, D) Pyrene	0.2	320		
Iron	2%	4%		
Bullet	31	250	35 mg/kg	91.3 mg/kg
Linden			0.94	1.38
Manga	460	1100		
Mercury	0.2	2	0.17 mg/kg	0.486 mg/kg
Methylnaphthalene, 2- (1-)			20.2	201
Mirex	0.007	130		
Naphthalene	*Bkz.* PAH	*Bkz.* PAH	34.6	391
Nickel	16	75		
Nitrogen (Total Kjeldal) (Tkn)	550	4800		
Nonylphenol and Ethoxylates			1.4 mg/kg	
Oil And Grease				
PAH (Total)	4	10000		
Phenanthrene	0.56	950	41.9	515

CHAPTER THREE
RESULTS AND DISCUSSIONS

3.1 Specific and Priority Pollutants Monitoring

3.1.1 Pesticide Pollution in Büyük Menderes River

The pesticides monitored in Büyük Menderes River Basin were the pesticides listed in WFD and the ones in the national specific pollutants list. 90 pesticides from priority / specific groups are analyzed within the scope of the project. Pesticides whose chromatograms were observed as a result of twelve-month monitoring in the basin were 2,4'-DDE, 2,4'-DDT, 4,4'-DDD, 4,4'-DDT, Alachlor, Aldrin, Acetachlor, Acetamipride, Atrazine, Azoxystrobin, Boscalide, Buprofezin, Butraline, Diazinone, Diphenylamine Diflubenzuron, Dicofol, Dimethoate, Dimethomorph, Diuron, Endosulfan Sulphate, Endrin, Epoxiconazole, Etoprofos, Fenamiphos, Fenxamide, Fenpropatrin, Fluazifop-P-Butyl, Flutriafol, Hexachloro-Benzene (HCB), Imazalyl, Imidacloprid, Isoproturon, Carbendazimide, Carbofuran, Chlorophenazon, Carbofuran, Chlorophen, Chlorpyrifos, Clotianidine, Lindane, Metalaxyl, Methamidophos, Methidation, Metolachlor, Monocrotophos, Oxadixyl, Penconazole, Pentachloro-Benzene, Profam, Prochlorase, Propamocarb, Propiconazole, Simazine, Cypermethrin, Cyprodinyl, Simazin, Cypermethrin, Cyprodinyl, Tebuconazole, Terbuthylazine, Terbutryn, Thiacloprid, Thiabendazole, Thiamethoxam, Thiophanate-Methyl, Trifluralin, α-HCH (α-BHC), β-HCH (β-BHC), δ-HCH (δ-BHC). The level of the pesticide pollution in the basin were evaluated based on the Maximum Allowable Concentration Environmental Quality Standards (MAC-EQS$_W$) and the Annual Average Concentration Environmental Quality Standards (AA-EQS$_W$) values given in WFD or in the national specific pollutants list of SWQR. The detected pesticide concentrations in the basin based on the stations and sampling month were given in Figures between Figure 3.1 and Figure 3.67.

DDT is one of the well-known pesticides in worldwide. It was banned about three decades ago due to its irreversible adverse effects on the environment and organisms. It is a long-lasting one in the environment. In other words, its derivatives and degradation products remain in the soil and then, all they are transferred to the waters. It is an ongoing process due to its persistence in the nature. Therefore, it is considered as one of the hazardous pollutants in EU, and its derivatives like 2,4'-DDT, 4,4'-DDD and 4,4'-DDT received significant attention in WFD.

2,4' -DDE is one of the derivatives of DDT. It is not included in the list of either priority or national specific pollutants. The analytical method was available at the DEÜ and therefore, it was included in the monitoring study. For this reason, MAC-EQS$_w$ and AA-EQS$_w$ values are not available. 2,4'-DDE was detected above the LOD value at stations BML01, BML02, BML05, BML10 in lake waters, BMTW02 transitional water, BMCW02 in coastal water and BMR56 river water. The concentration ranged between 0.0011 ppb-0.008 ppb. The maximum concentration of 0.008 ppb was observed, interestingly, at coastal water (BMCW02) in July 2016 (Figure 3.1).

2,4'-DDT as a derivative of DDT and It is must be monitored. Unfortunately, the MAC-EQS$_w$ and the AA-EQS$_w$ values were not determined in WFD due to probably insufficient data about its toxicity level. 2,4'-DDT was observed in the range of 0.0014-0.044 ppb in December 2015 and February, April, June, July 2016 sampling periods at the stations mainly lake like, BML01, BML05, BML10 and transition water as BMTW02 or coastal one, BMCW02. The maximum concentration of 0.044 ppb BML01 was obtained in lake water (Figure 3.2).

4,4'-DDD is another derivative of DDT and it is included in the national specific pollutants list of the Ministry. The MAC-EQS$_w$ water value was determined as 0.025 ppb. The maximum concentration of 4,4'-DDD in the basin was 0.0102 ppb in December 2015 at BML01 lake station where 2.4'-DDT was detected as well. The observed concentration was close to MAC-EQS$_w$ but did not exceed this limit value (Figure 3.3).

4,4'-DDT is a pesticide on the list of priority pollutants and it is a derivative of DDT. It was observed in the concentrations of 0.0087 ppb and 0.0034 ppb in

BML01, BML10 lake waters, and 0.005-0.007 ppb in BMTW02 transition water and BMCW02 coastal water, respectively. BMR05 is a river station at which there is industrial discharge. The concentration of 4,4'-DDT was 0.0047 ppb at this station. The coastal/transitional waters, rivers/lakes MAC-EQS$_w$ water values are 0.01 ppb and 0.1 ppb, respectively. The concentrations determined are below both MAC-EQS$_w$ values. (Figure 3.4).

Alachlor is used to control the growth of large leaves of corn and other crops. The degree of toxicity is moderate. It has been proven to be carcinogenic by the US EPA. Alachlor can be degraded by microbial processes, adsorption, photolysis, ozonation and gamma radiolysis. It is not only a residue in vegetables and fruits that could pose a health risk, but it is also toxic to the biological systems through the soil and the groundwater. Its half-life in the soil is more than 70 days and it decomposes in water for more than 30 days. Alachlor is in the priority pollutant group and the MAC-EQS$_w$ value is 0.7 ppb for all types of water bodies. The highest alachlor concentration observed in the basin was 0.12 ppb at BML21 lake water. The relatively high concentrations of alachlor, which is below MAC-EQS$_w$, were obtained in March 2016 in BML21 lake, BMTW02 transition water, BMCW04 coastal water and BMR29, BMR32 river waters (Figure 3.5). Although alachlor receives considerable attention in the EU due to its toxic effects, it is not a significant pesticide to be considered in the BMRB.

Aldrin is a chlorinated insecticide. It is classified as a moderately persistent chemical. It is used to protect against insects in the soil, cotton insects, corn rootworms, or may worm maggots, and to protect materials made up of wood from ants. It can be easily adsorbed in soil. Its half-life is 20-100 days and it is listed as a priority pollutant in WFD. Aldrin concentration observed in the basin for the twelve-month monitoring period varied between 0.003 ppb-0.06 ppb. It was most frequently observed in January and February 2016 (Figure 3.6).

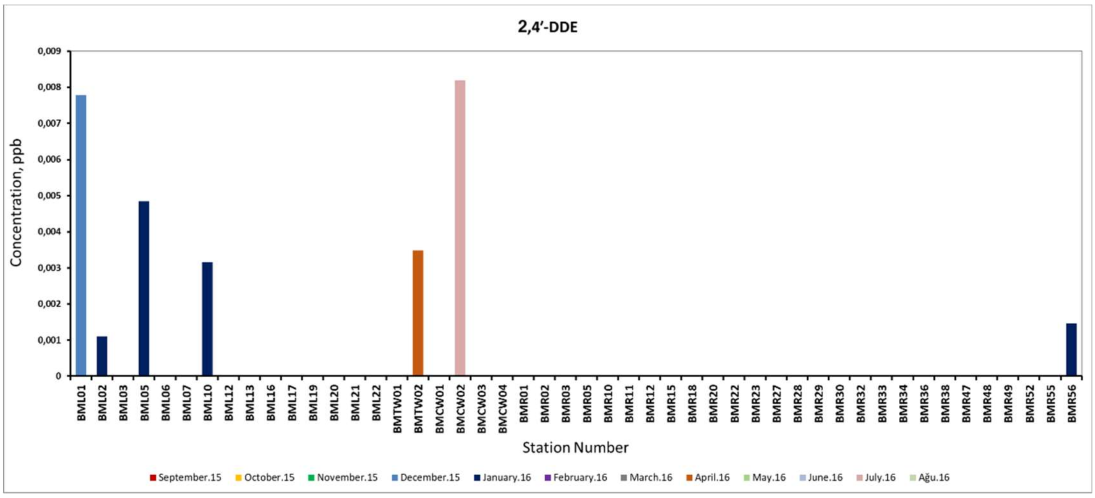

Figure 3.1 The observed 2,4'-DDE concentrations at the station of BMRB for the monitored period

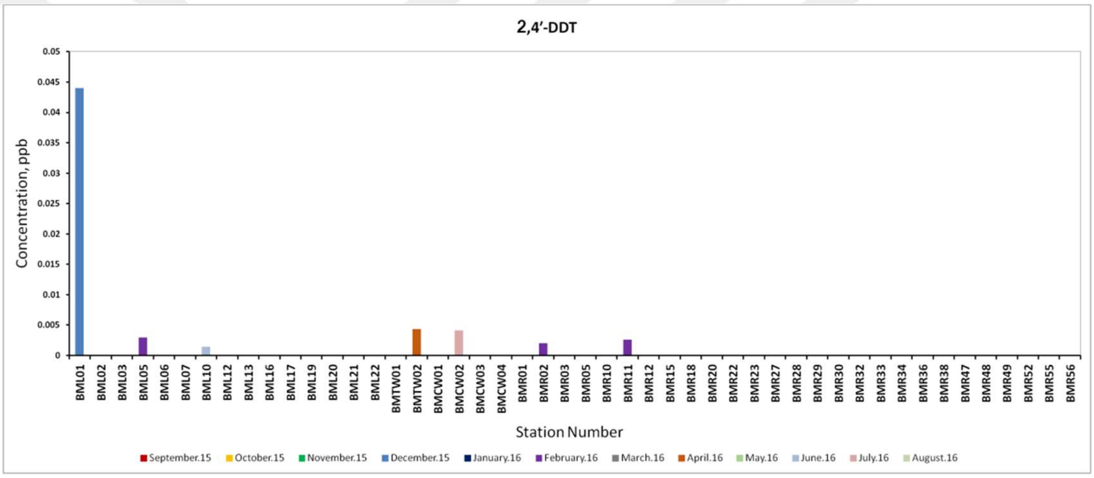

Figure 3.2 The observed 2,4'-DDT concentrations at the station of BMRB for the monitored period

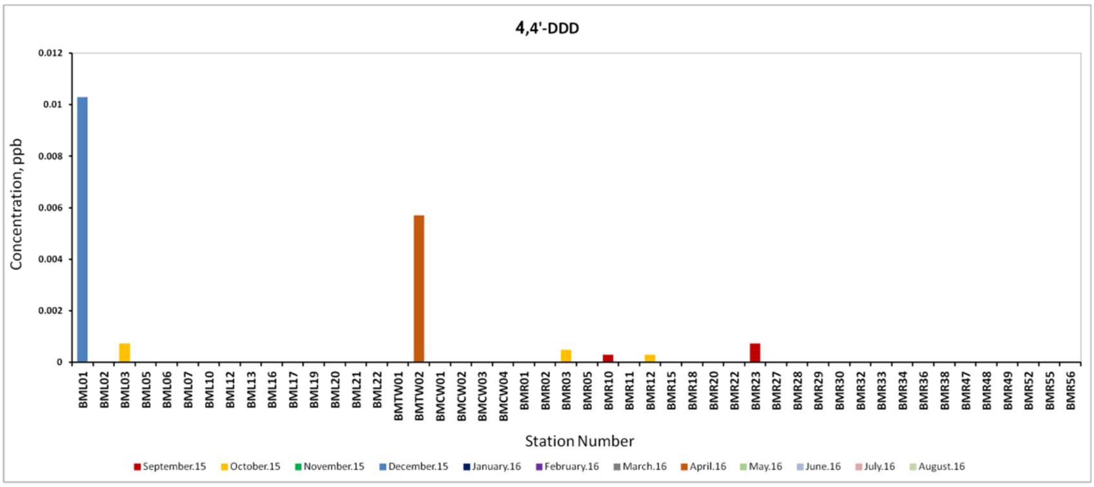

Figure 3.3 The observed 4,4'-DDD concentrations at the station of BMRB for the monitored period

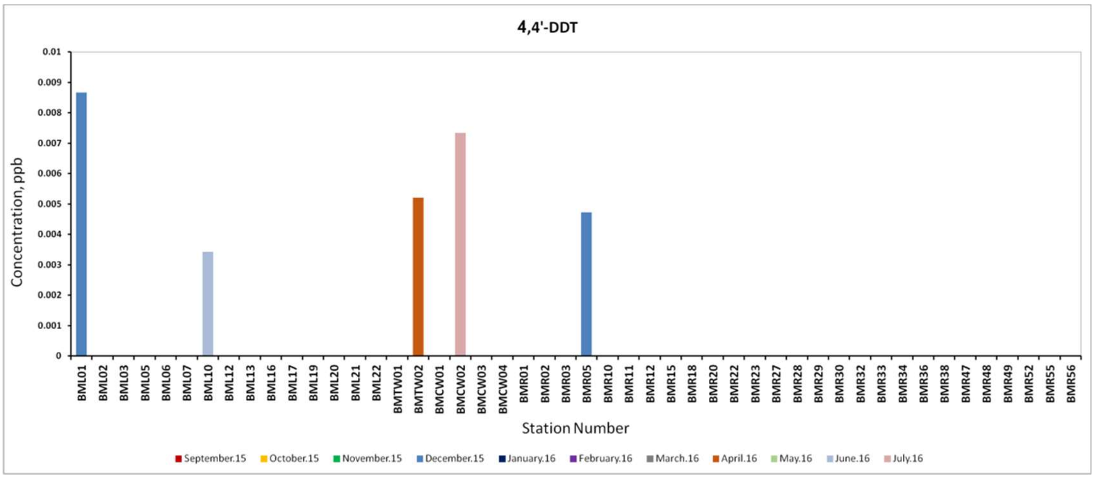

Figure 3.4 The observed 4,4'-DDT concentrations at the station of BMRB for the monitored period

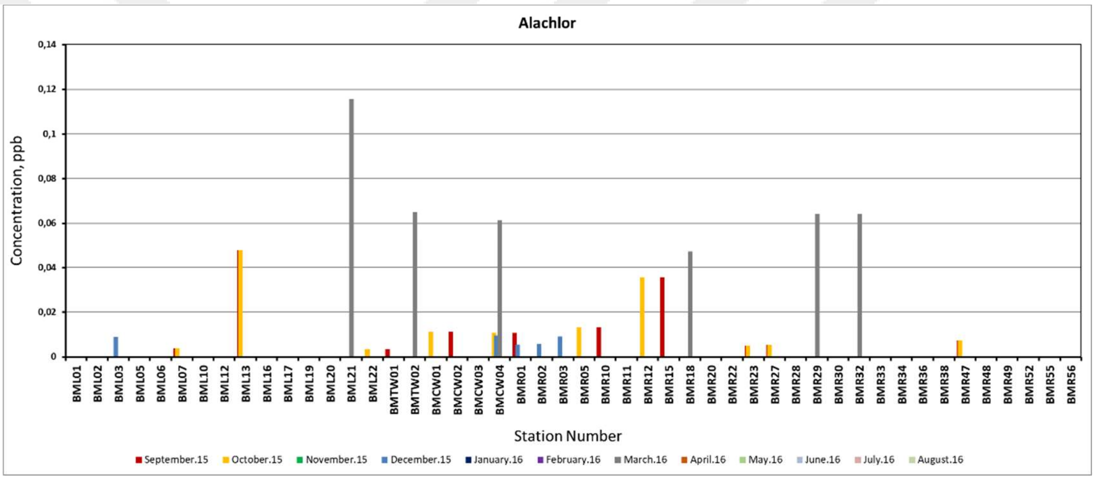

Figure 3.5 The observed Alachlor concentrations at the station of BMRB for the monitored period

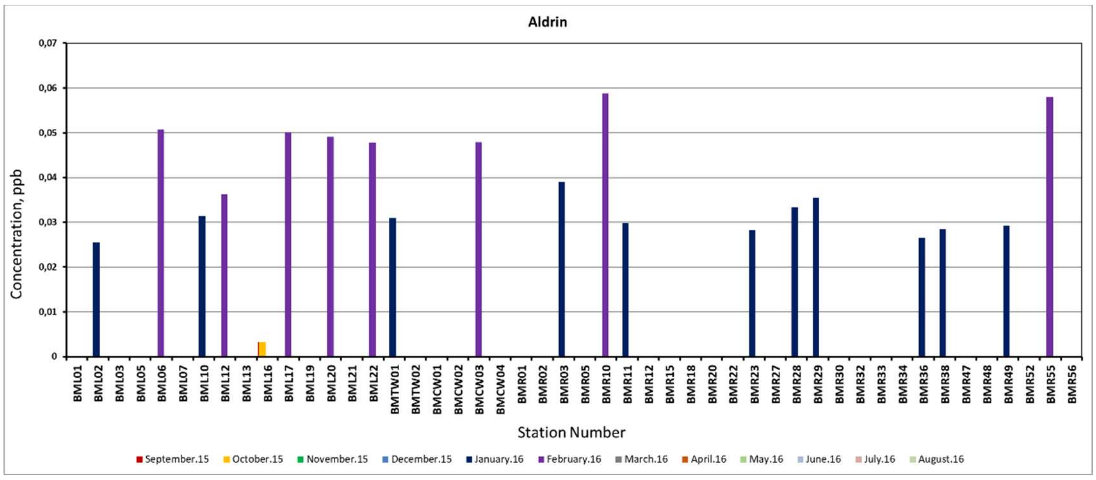

Figure 3.6 The observed Aldrin concentrations at the station of BMRB for the monitored period

Acetochlor is a pesticide in the specific pollutants list of the Ministry. It is one of the most widely detected pesticides for the monitoring period. The maximum observed concentration is 0.18 ppb which is observed at BMR05. Fortunately, the observed concentration is below the MAC-EQS_w value (Figure 3.7).

Acetamiprid was observed only during September-October 2015. The maximum concentration was determined at the transitional water station BMTW01 with 1.93 ppb which was far below MAC-EQS_w= 42 ppb (Figure 3.8).

Atrazine is an herbicide from the triazine group. It is in the list of priority pollutants. It is a pesticide widely used in the field to combat broadleaf or herbaceous plants before planting or after harvest. It is classified as an endocrine-disrupting chemical. It is an important pollutant for surface water, rainwater, sea and groundwater due to its high degree of persistence in nature. Under laboratory conditions, the half-life in the soil was reported as 50 days, but in real conditions and depending on the type of soil, the half-life extended up to 125 days. Despite its low solubility in water, it is a potential groundwater contaminant. It is a pollutant with high mobility in the soil since its adsorption occurs at low levels. Atrazine has a long-term pollutant nature when it reaches surface waters by rainwater or irrigation due to its low biodegradability. During the monitoring process, atrazine was observed in BML01 and BML03 stations, which are lake water, in February 2016 and mostly in river water stations in May 2016. The maximum detected concentration was 0.004 ppb at BML03 and it is below the MAC-EQS_w value (Figure 3.9).

Azoxystrobin is a specific pollutant. The maximum concentration (0.06 ppb) was detected in BMR03 at which there is industrial discharge. In addition, approximately 0.02 ppb azoxystrobin was detected in BML03, BML06 and BML07 lake waters. These concentrations are below MAC-EQS_w = 6 ppb (Figure 3.10).

Boscalid is listed as a specific pollutant. It was detected at stations BML05, BML20, BML21, BML22 in the range of 0.002 ppb-0.009 ppb in lake waters. It was observed more frequently in river waters and the concentrations were between 0.002 ppb and 0.04 ppb. The maximum concentration observed was 0.043 ppb in BMR52. The MAC-EQS$_w$ values determined for Boscalid are 113 ppb for rivers and lakes. The all observed concentrations are well below this value (Figure 3.11).

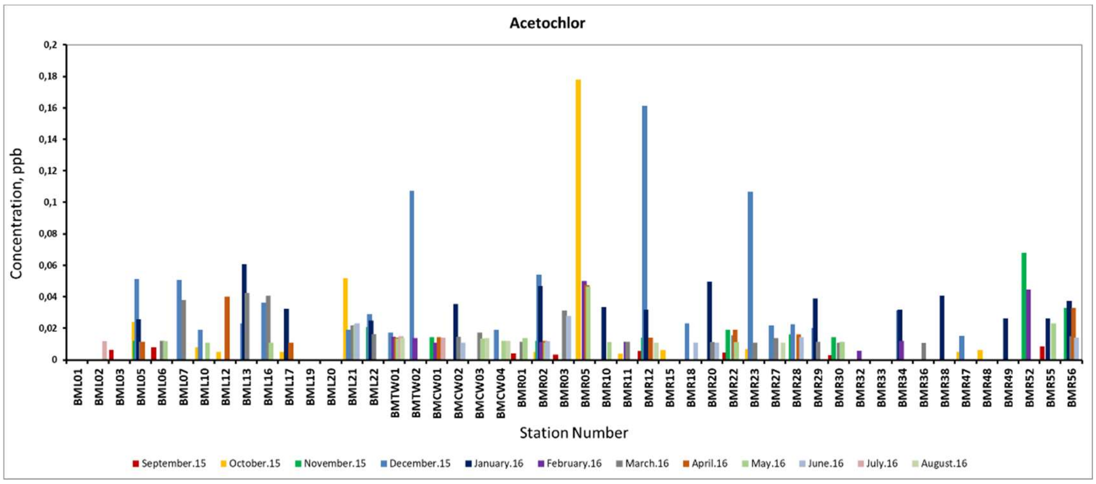

Figure 3.7 The observed Acetochlor concentrations at the station of BMRB for the monitored period

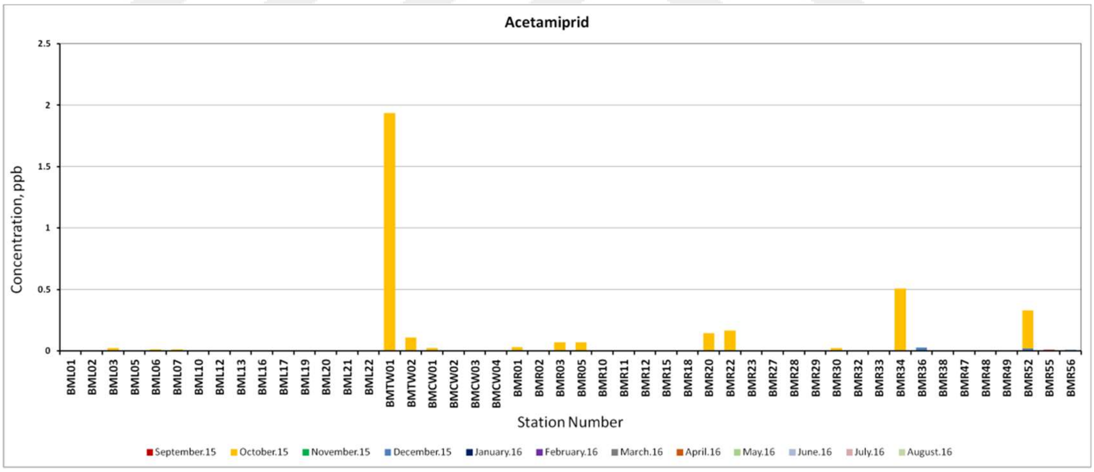

Figure 3.8 The observed Acetamiprid concentrations at the station of BMRB for the monitored period

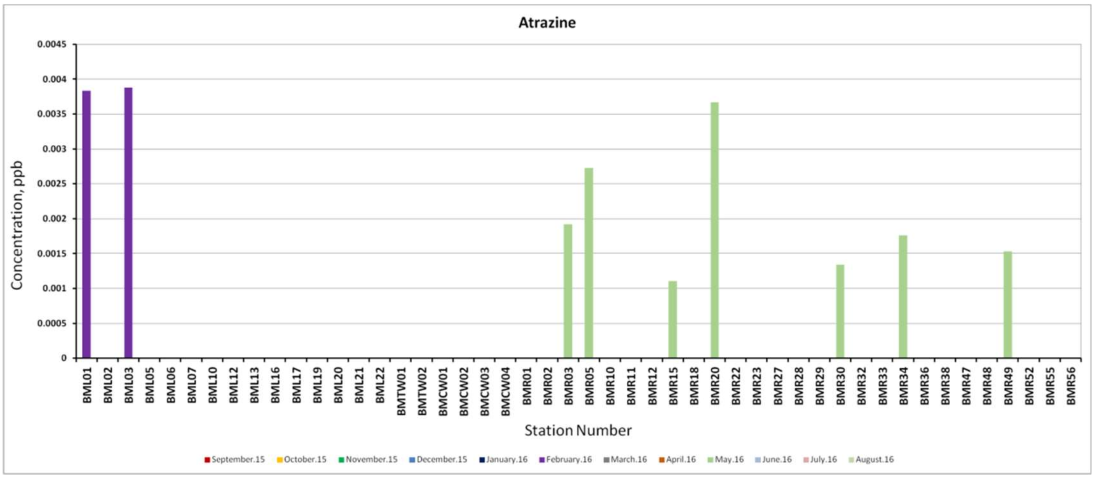

Figure 3.9 The observed Atrazine concentrations at the station of BMRB for the monitored period

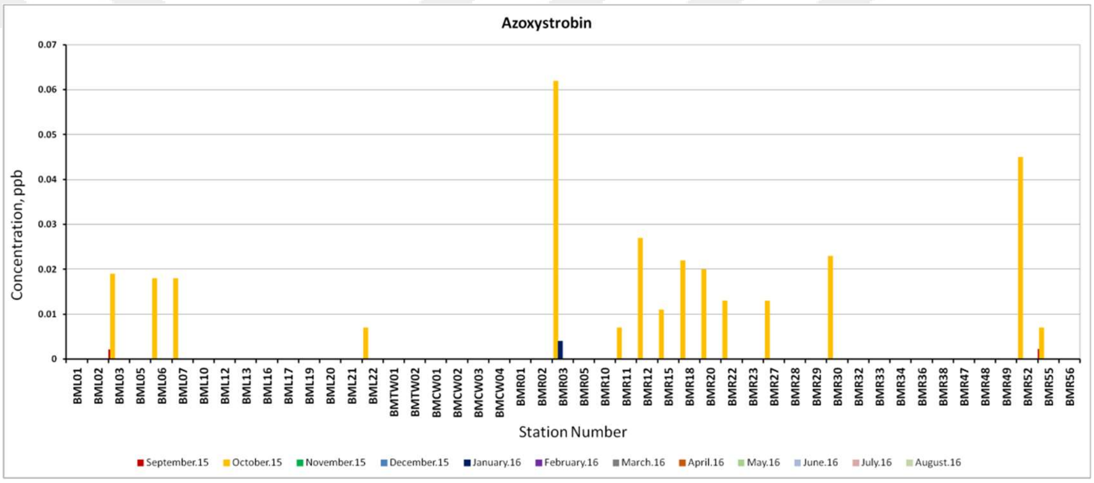

Figure 3.10 The observed Azoxystrobin concentrations at the station of BMRB for the monitored period

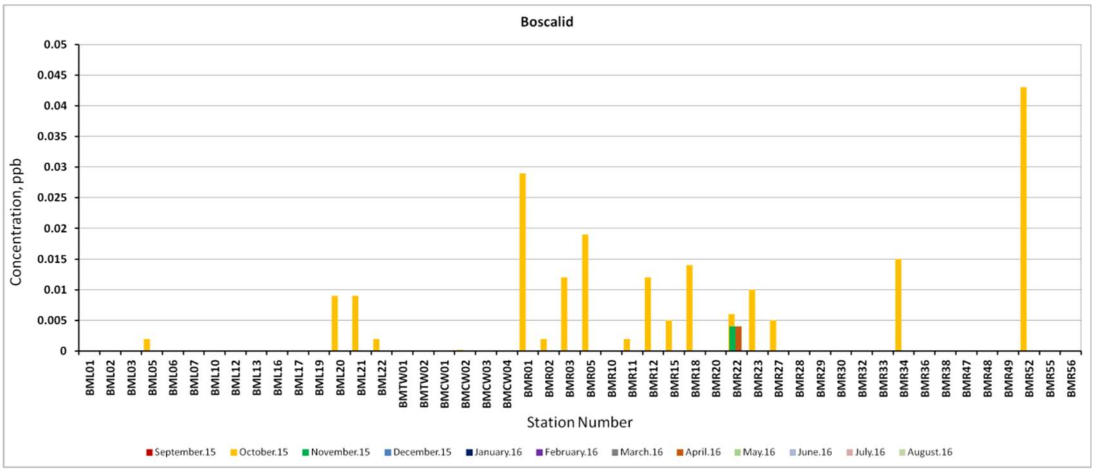

Figure 3.11 The observed Boscalid concentrations at the station of BMRB for the monitored period

Buprofezin was not detected in lakes, transitional waters and coastal waters during the monitoring process. However, it was observed that the river water stations BMR02, BMR05, BMR18, BMR22, BMR28 were slightly contaminated with Buprofezin at the concentrations between 0.001-023 ppb. It reaches the maximum concentration (0.023 ppb) in BMR05 station where there is industrial discharge. However, the concentrations determined were lower than MAC-EQS$_w$ = 3.5 ppb (Figure 3.12). Therefore, it can be concluded that Buprofezin is not a significant pollutant to be considered in the basin.

The concentrations of Butralin were in the range of 0.006 ppb-0.007 ppb in the basin. It was mainly observed in the coastal station BMCW01, lake station BML05, BML06, BML12. The average concentration in all stations can be presented as 0.006 ppb. These concentrations are less than MAC-EQS$_w$ = 4.15 ppb (Figure 3.13). These results show that Butralin is not a contaminant in the basin.

Diazinon was commonly observed in BMR03 and BMR05. It is a specific pollutant listed, too. The maximum observed concentration was around 0.16 ppb in BMR05 and this concentration is less than MAC-EQS$_w$ = 4 ppb (Figure 3.14).

MAC-EQS$_w$ for Diphenylamine is 100 ppb for rivers and lakes and 440 ppb for coastal and transitional waters. Diphenylamine was detected during the monitoring period only in November 2015 in lake stations BML10, BML16 and BML21, river water stations BMR05, BMR28, BMR32 and BMR36. The maximum observed concentration was 0.106 ppb which is less than MAC-EQS$_w$ = 100 ppb (Figure 3.15).

Diflubenzuron is in specific pollutant group. It was detected in September 2015-April 2016 monitoring period in different stations. The MAC-EQS$_w$ value for rivers and lakes is 0.13 ppb. The maximum concentration of 0.18 ppb in lakes and 0.38 ppb in rivers were determined. In coastal waters, diflubenzuron was observed at a maximum concentration of 0.08 ppb which is above the limit value of 0.002 ppb (Figure 3.16).

Dicofol is a priority pollutant. It is released to the environment through wide range of utilization for fruits, vegetables and ornamental plants. Degradation in soil is moderately slow. It has a half-life of 30 to 60 days and has a high affinity to be accumulated in lipids. MAC-EQS$_W$ values were not determined in the directives or in the national regulations. The results revealed that dicofol concentration varies in the range of 0.00053 ppb-0.00143 ppb in BMRB. In December 2015 monitoring period, its concentration increased to 0.01 ppb, ones, in BML01 (Figure 3.17).

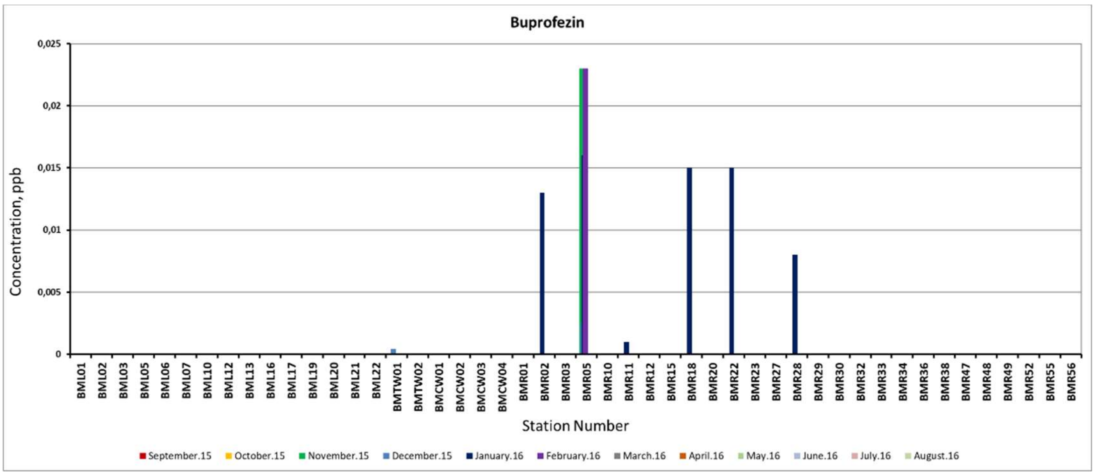

Figure 3.12 The observed Buprofezin concentrations at the station of BMRB for the monitored period

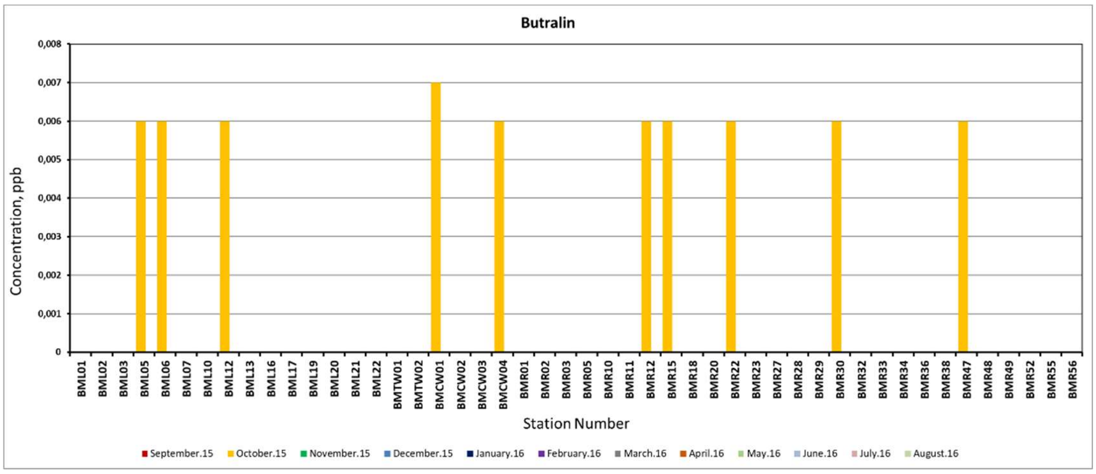

Figure 3.13 The observed Butralin concentrations at the station of BMRB for the monitored period

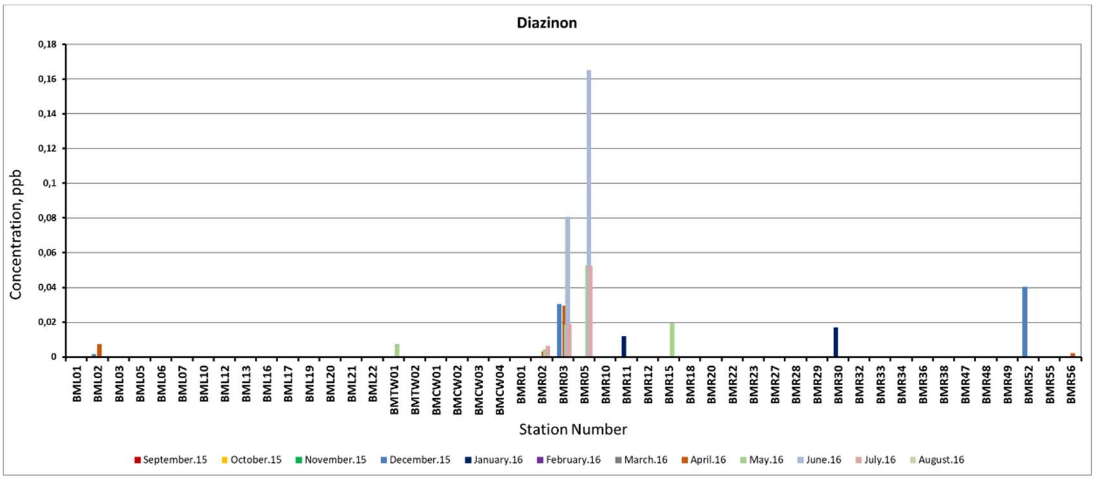

Figure 3.14 The observed Diazinon concentrations at the station of BMRB for the monitored period

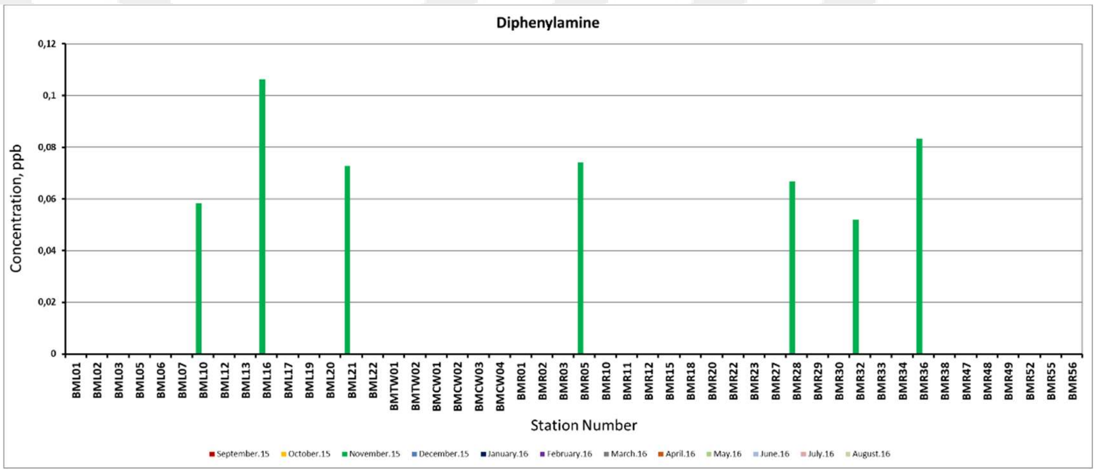

Figure 3.15 The observed Diphenylamine concentrations at the station of BMRB for the monitored period

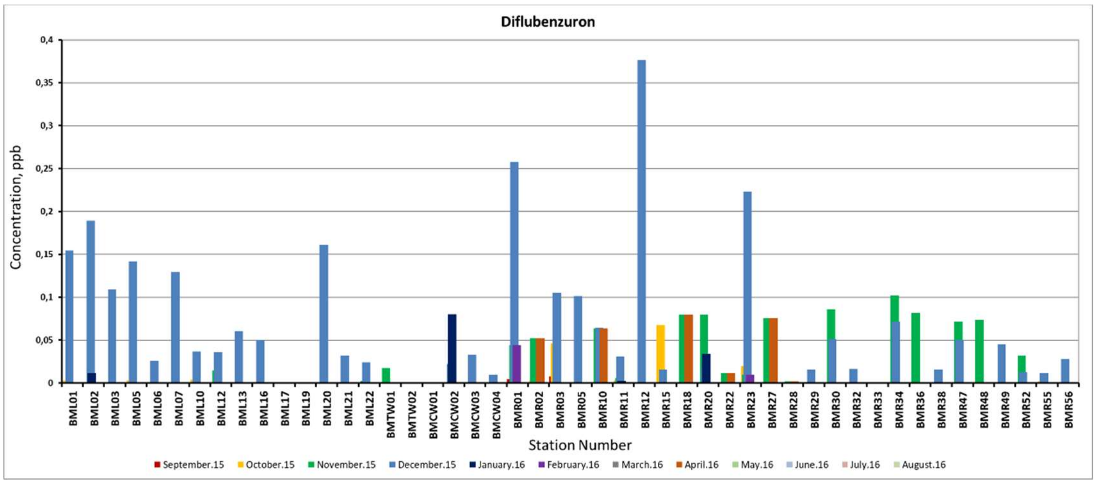

Figure 3.16 The observed Diflubenzuron concentrations at the station of BMRB for the monitored period

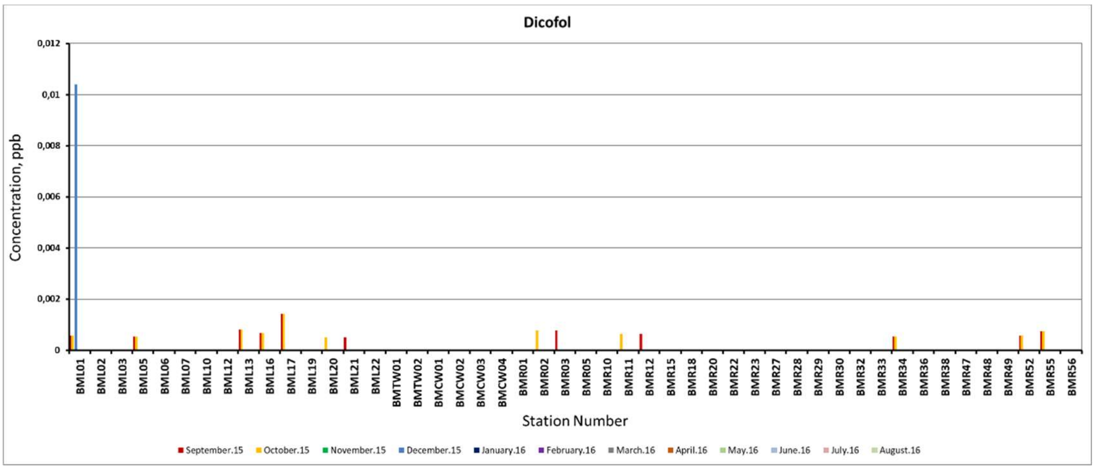

Figure 3.17 The observed Dicofol concentrations at the station of BMRB for the monitored period

The detected concentrations of Dimethoate are given in Figure 3.18. The MAC-EQS_w for both Lake / River and Coastal / Transitional water bodies for dimethoate is 15 ppb. This pesticide was observed at concentrations as high as 1.34 ppb in October 2015, in November 2015 and in January 2016. Even though relatively high dimethoate concentration, it is still lower than the MAC-EQS_w (Figure 3.18).

Dimethomorph was observed in lakes, coastal water and river water stations in the concentrations ranges between 0.007 ppb-0.01 ppb, especially, during October 2015. However, the concentrations determined were significantly lower than the MAC-EQS_w value of 61 ppb (Figure 3.19).

Diuron is an herbicide from the organonitrogen group which is on the list of priority pollutants. It is a pesticide used to combat broad-leaved plants and weeds in the field before planting or after harvest. Hydrolysis in water varies depending on the pH value. The half-life by hydrolysis at pH = 5 can last up to 1490 days, while at pH = 9 it can last to 2020 days. However, its half-life in the soil is 90-180 days. It is a highly persisting pesticide in water due to the long half-life. The disintegration product has higher toxicity than diuron. The limit value for rivers and lakes is 1.8 ppb. The results from the monitoring study in BMRB showed the maximum concentration of 0.26 ppb at BMR05 river water station. No limit values have been determined for coastal and transitional waters. However, a concentration of 1.2 ppb was observed at BMTW02 transition water station in October 2015, (Figure 3.20).

This is very close to the MAC-EQS$_w$ for rivers. Therefore, this pesticide could be considered as an important one to be taken into consideration.

Epoxiconazole is a specific pollutant and its MAC-EQS$_w$ values is 0.8 ppb for rivers/lakes and 0.3 ppb for coastal and transitional waters. It was observed in BMRB at the stations such as BML12, BMTW02 and BMR12 in December 2015 and January 2016 periods. The maximum concentration was 0.11 ppb in BMR12. The observed concentration is lower than MAC-EQS$_w$ (Figure 3.21).

Ethoprophos is a pesticide in the specific pollutant group. MAC-EQS$_w$ values are 6.4 ppb for rivers/lakes and 0.35 ppb for coastal and transitional waters. It was observed in October 2015 at the BML01, BML05, BML10, BML12, BML22 stations with the maximum concentration of 0.007 ppb. The sample taken in December 2015 at BMR20 resulted in higher Ethoprophos concentration as 0.015 ppb. Even though these are the highest concentrations observed in the basin, they are lower than MAC-EQS$_w$ (Figure 3.22).

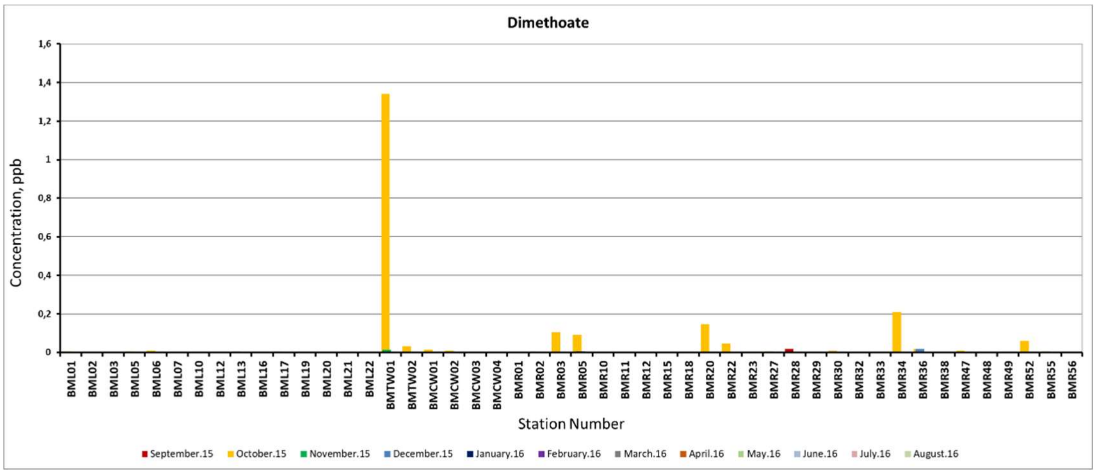

Figure 3.18 The observed Dimethoate concentrations at the station of BMRB for the monitored period

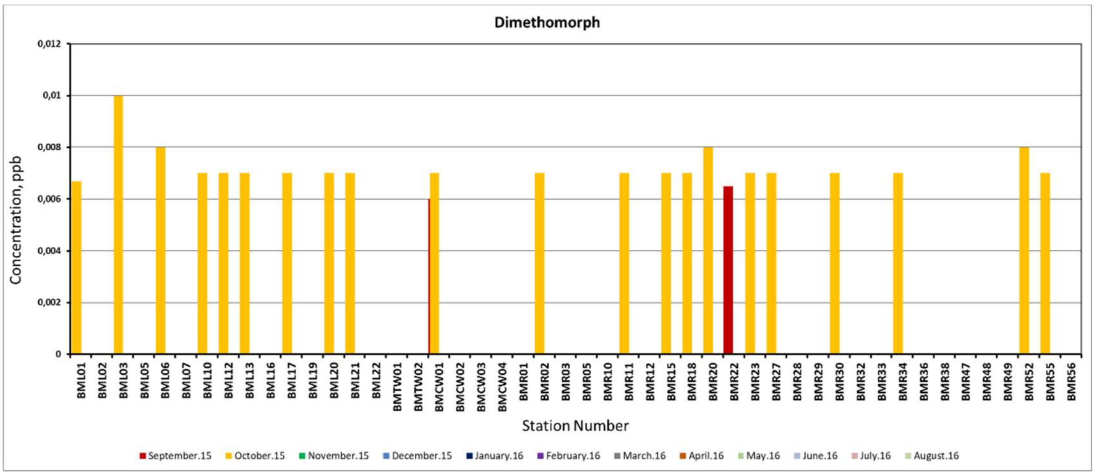

Figure 3.19 The observed Dimethomorph concentrations at the station of BMRB for the monitored period

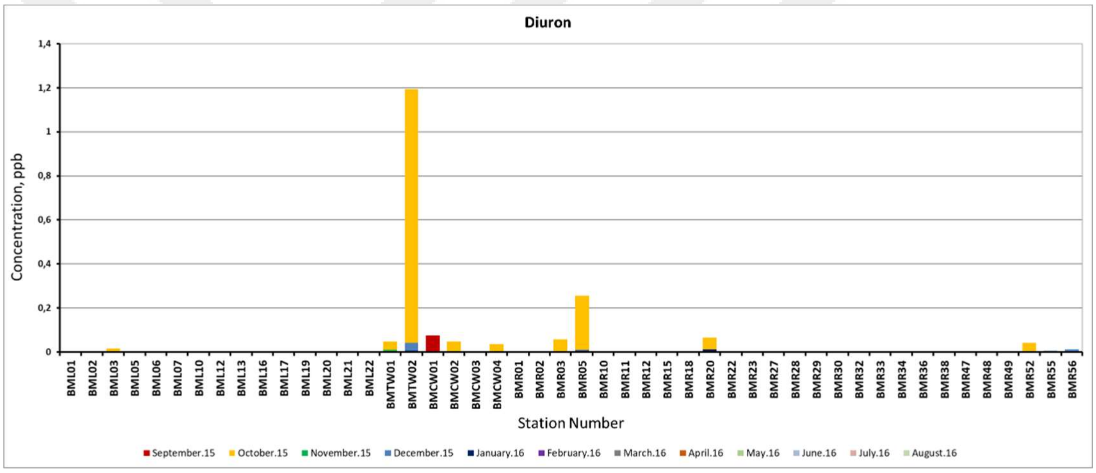

Figure 3.20 The observed Diuron concentrations at the station of BMRB for the monitored period

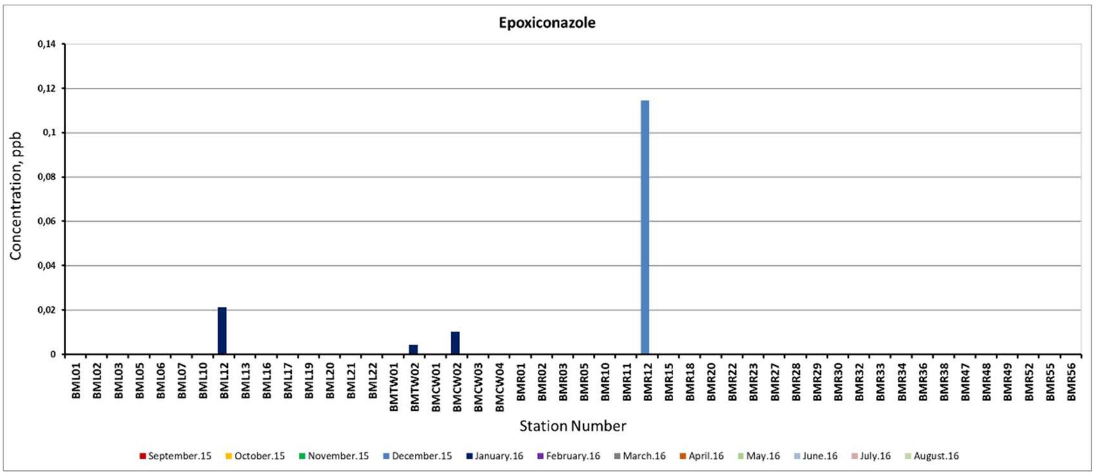

Figure 3.21 The observed Epoxiconazole concentrations at the station of BMRB for the monitored period

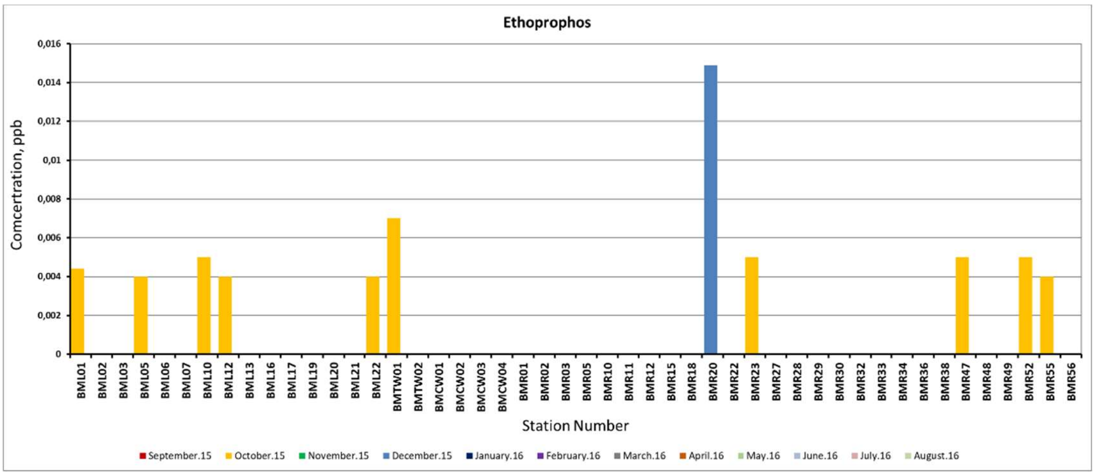

Figure 3.22 The observed Ethoprophos concentrations at the station of BMRB for the monitored period

Some of the pesticides in the specific pollutants listed were commonly detected in the BMRB. The results of these pesticide were presented in corresponding figures as Asfenamiphos (Figure 3.23), Fenhexamid (Figure 3.24), Fenpropathrin (Figure 3.25), Fluazifop-P-Butyl, Flutriafol (Figure 3.26), Imazalil (Figure 3.28), Isoproturon (Figure 3.30), Carbofuran (Figure 3.32), Clotianidine (Figure 3.37), Metalaxyl (Figure 3.39), Methamidophos (Figure 3.40), Metidation (Figure 3.41), Oxadixyl (Figure 3.44), Penconazole (Figure 3.45), Propiconazole (Figure 3.50), Thiacloprid (Figure 3.57), Thiophanate-Methyl (Figure 3.60), are particularly common pesticides In the BMRB during the October 2015 monitoring period. The maximum concentrations of these pesticides were as follows; Fenamiphos = 0.019 ppb, Feneksamid = 0.018 ppb, Flutriafol = 0.004 ppb, Imazalil = 0.01 ppb, Isoproturon = 0.018 ppb, Carbofuran = 0.016 ppb, Clotianidine = 0.017 ppb, Metalaxyl = 0.061 ppb, Methamidophos = 0.028 ppb, Metidation = 0.005 ppb, Oxadixyl = 0.02 ppb, Penconazole = 0.009 ppb, Carbendazim = 0.31 ppb, Propiconazole = 0.012 ppb, Thiaclopyrid = 0.52 ppb, Thiophanate-Methyl = 0.006 ppb. These concentrations were lower than MAC-EQS$_w$ value of the corresponding pesticide.

Hexachlorobenzene (HCB) was observed especially in December 2015 and February 2016, the highest value of 0.007 ppb was measured at BMR05 station in January 2016. (Figure 3.27)

Imidacloprid has been detected relatively often in lake stations and in BMR03 and BMR05, where there was industrial discharge. The highest concentration was observed as 0.54 ppb at BMTW01 station which is transition water. This concentration is less than MAC-EQS$_w$ = 1.4 ppb determined for coastal and transitional waters (Figure 3.29).

Carbendazim was only observed in September 2015 at BML03 station with the highest value of 0.31 ppb (Figure 3.31). The concentration of carbendazim at BML06, BMTW02, BMR03, BMR52 stations was in the range of 0.001 to 0.05 ppb. It was not detected in other months.

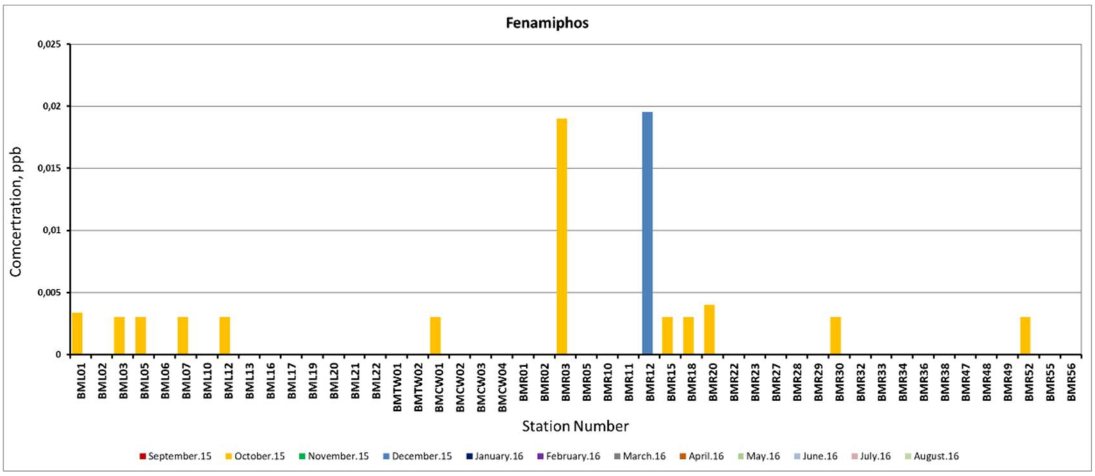

Figure 3.23 The observed Fenamiphos concentrations at the station of BMRB for the monitored period

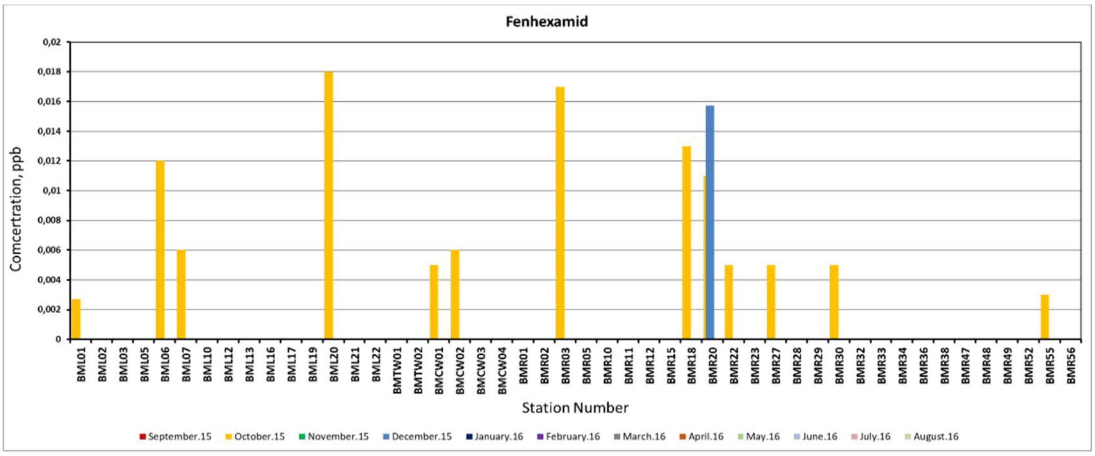

Figure 3.24 The observed Fenhexamid concentrations at the station of BMRB for the monitored period

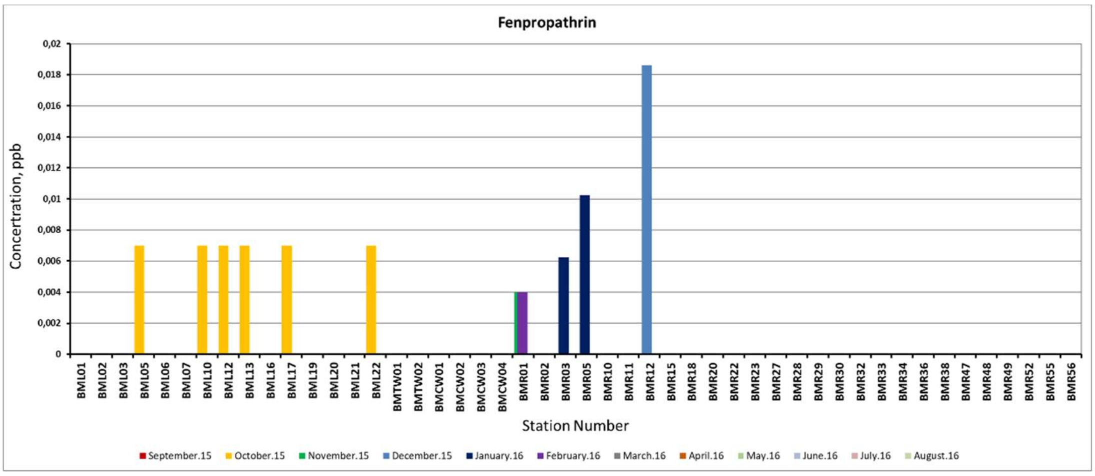

Figure 3.25 The observed Fenpropathrin concentrations at the station of BMRB for the monitored period

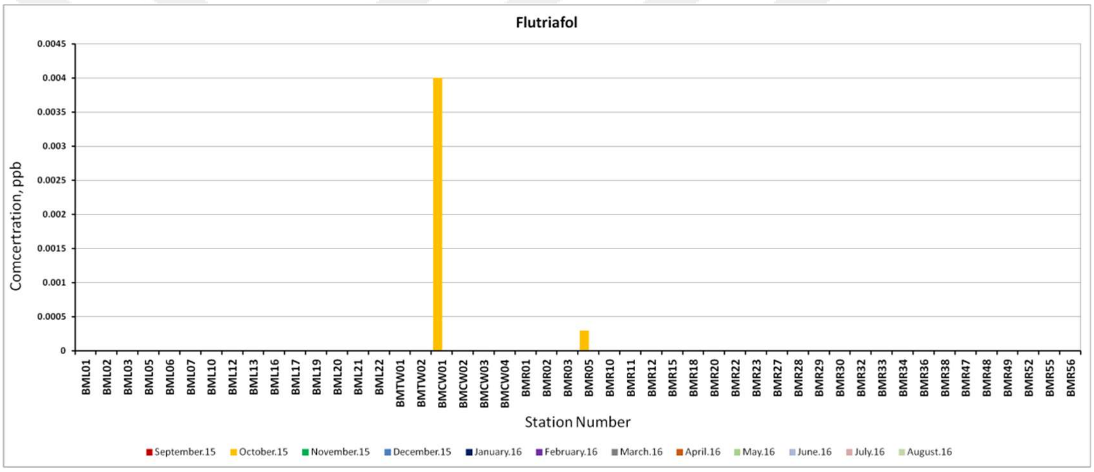

Figure 3.26 The observed Flutriafol concentrations at the station of BMRB for the monitored period

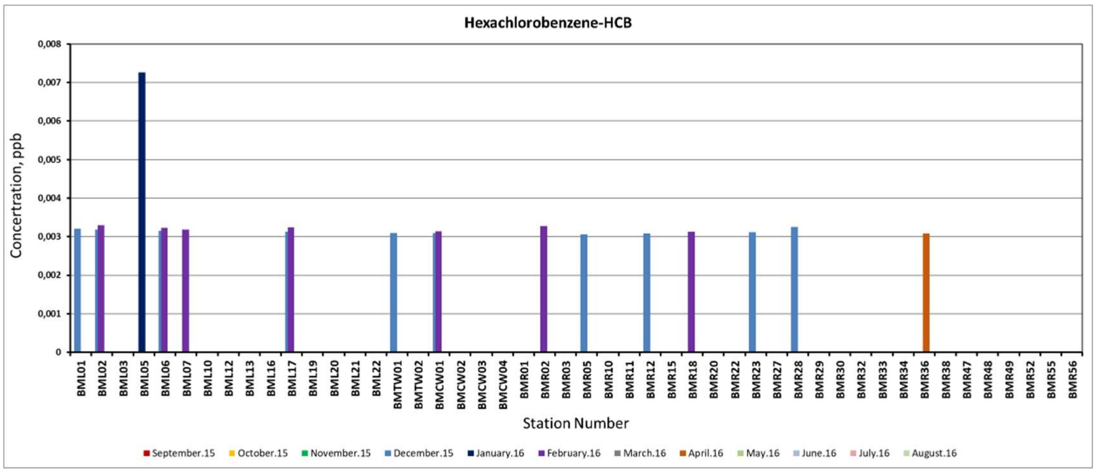

Figure 3.27 The observed Hexachlorobenzene (HCB) concentrations at the station of BMRB for the monitored period

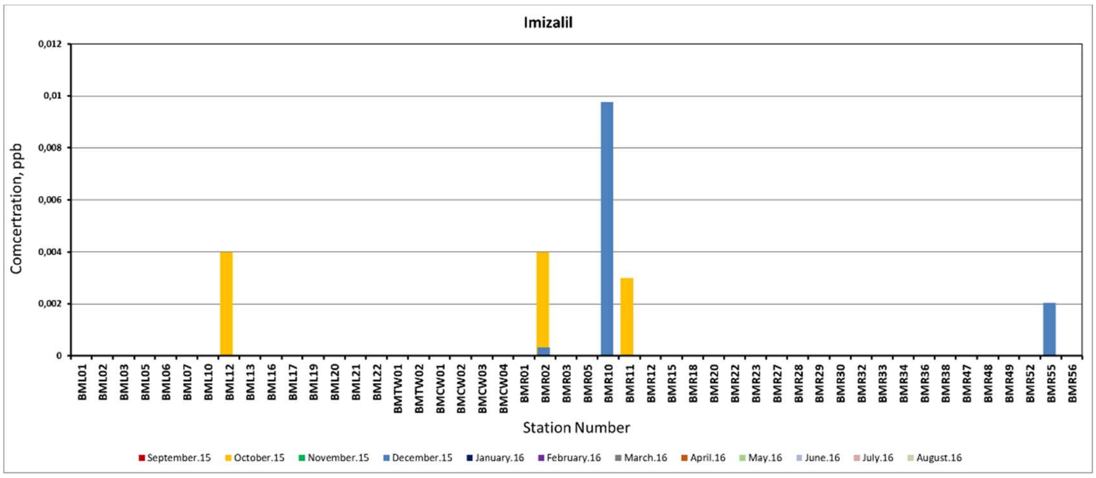

Figure 3.28 The observed Imizalil concentrations at the station of BMRB for the monitored period

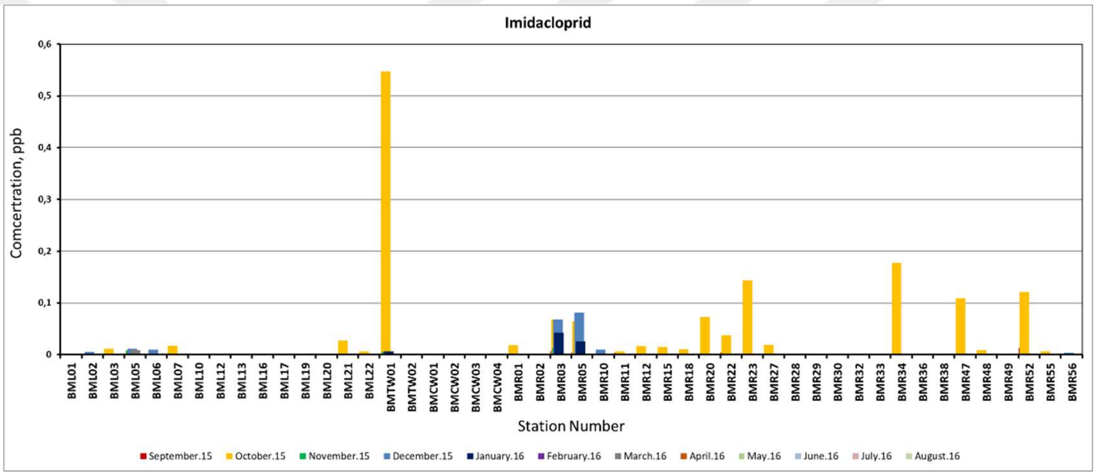

Figure 3.29 The observed Imidacloprid concentrations at the station of BMRB for the monitored period

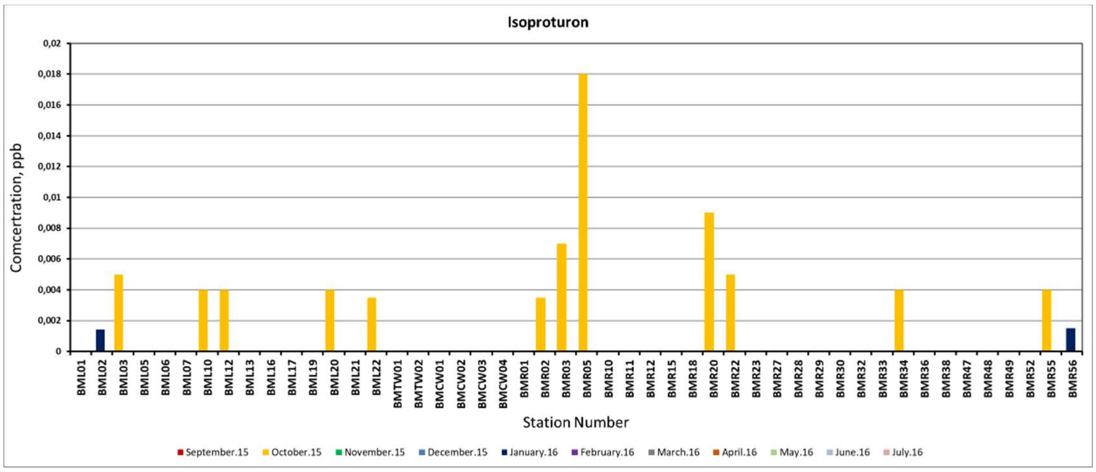

Figure 3.30 The observed Isoproturon concentrations at the station of BMRB for the monitored period

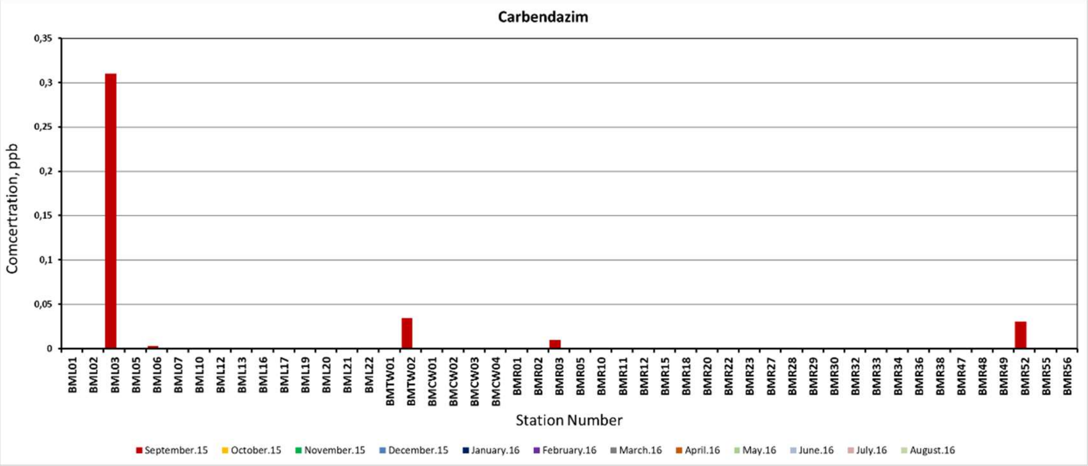

Figure 3.31 The observed Carbendazim concentrations at the station of BMRB for the monitored period

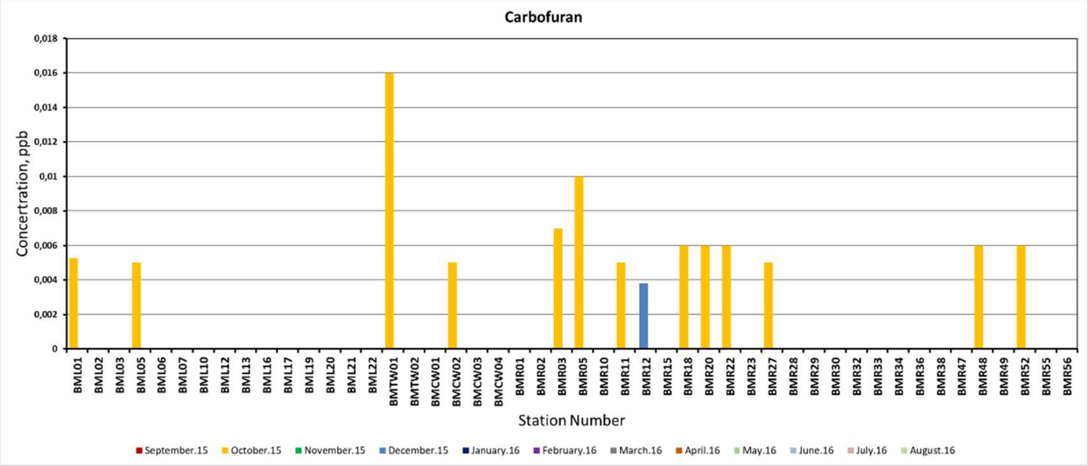

Figure 3.32 The observed Carbofuran concentrations at the station of BMRB for the monitored period

Quinoxyfen is a pesticide listed as a priority pollutant. It is used as a fungicide preservative in agricultural products such as grapes, hops, stone fruits, strawberries, melons, squash and lettuce. It is very toxic to the aquatic ecosystem. The toxic effect of concentration is not fully determined due to its chemical properties. The residues break down rapidly by photolysis. Due to its low solubility in water, it is strongly bound to the water sediment. This pesticide was only observed once in July 2016 at the BMR28 station at a concentration of 0.0014 ppb. It is a concentration below the LOD value. Since the chromatogram was determined, it was given as a concentration. The concentration determined is below the MAC-EQS$_w$ values (Figure 3.33).

Chloridazon is a specific pollutant detected in the basin during January 2016 monitoring period at BML01, BML12, BMTW01, BMTW02, BMR12 and BMR47. The maximum observed concentration was 0.18 ppb in BMR12 and it is lower than the MAC-EQS$_w$ = 6 ppb for rivers and lakes (Figure 3.34).

Chlorobenzilate was detected at BMTW02, BMR03, BMR15, BMR22, BMR29 and BMR48 in January 2016. The maximum observed concentration was 0.0019 ppb and it is again below the LOD value and MAC-EQS$_w$ (60 ppb) (Figure 3.35).

Chlorpyrifos (chlorpyrifos-ethyl) is one of the priority pollutants. It is an organophosphorus insecticide. It is soluble in benzene, acetone, chloroform, carbon disulfide, diethyl ether, xylene, methylene chloride, isooctane and methanol. Moderately harmful to human health. Chlorpyrifos can adsorb on sediment, but, also volatile in the water away. It cannot easily be biotransformed. Its half-life in soil is more than 30 days and it decomposes in water within more than 80 days. Chlorpyrifos was detected in September 2015, October 2015 and February 2016. Its concentration reached to maximum level as 0.04 ppb at BMR03 and BMR05, but this value is less than MAC-EQS$_w$ of 0.1 ppb (Figure 3.36).

Lindane (γ-bhc, 1α, 2α, 3β, 4α, 5α, 6β-hexachlorocyclohexane) is an organochlorinated insecticide which is widely used to combat insects that live in plants and feed on plants. It is also used in the form of lotions, creams or shampoos for the control of insects such as fleas, lice and ticks. Technical lindane, hexachlorocyclohexane, is briefly the gamma isomer of HCH. There are five different isomers of Lindan. The gamma isomer constitutes major one with 99% among the others and it is the most effective isomer. Its half-life is approximately 15 months. Since its adsorption property is low, it can be transported from soil to water phase. Therefore, it is one of the pesticides that could cause major groundwater pollution. Lindane is on the list of priority pollutants. It was detected in BML10 and BMR23 stations in February 2016, in BMR56 station in January 2016 and in BMTW02 station in June 2016 at BMRB. The maximum concentration of 0.024 ppb was observed in BMR23. This concentration is below MAC-EQS$_w$ = 4 ppb for river and lake waters, and MAC-EQS$_W$ = 1.4 ppb for coastal and transitional waters (Figure 3.38).

Metolachlor is a specific pollutant. The MAC-EQS$_W$ value for this pesticide is 88 ppb. The highest concentrations were observed as 0.16 ppb and 0.03 ppb in BMR52 during the monitoring periods of November 2015 and December 2015, respectively. Even the maximum observed concentration is significantly below the MAC-EQS$_W$ (Figure 3.42).

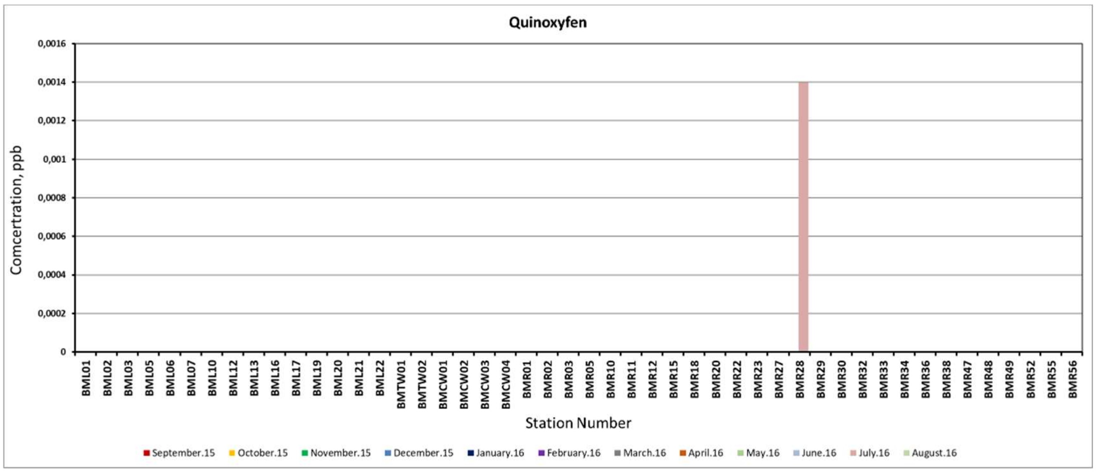

Figure 3.33 The observed Quinoxyfen concentrations at the station of BMRB for the monitored period

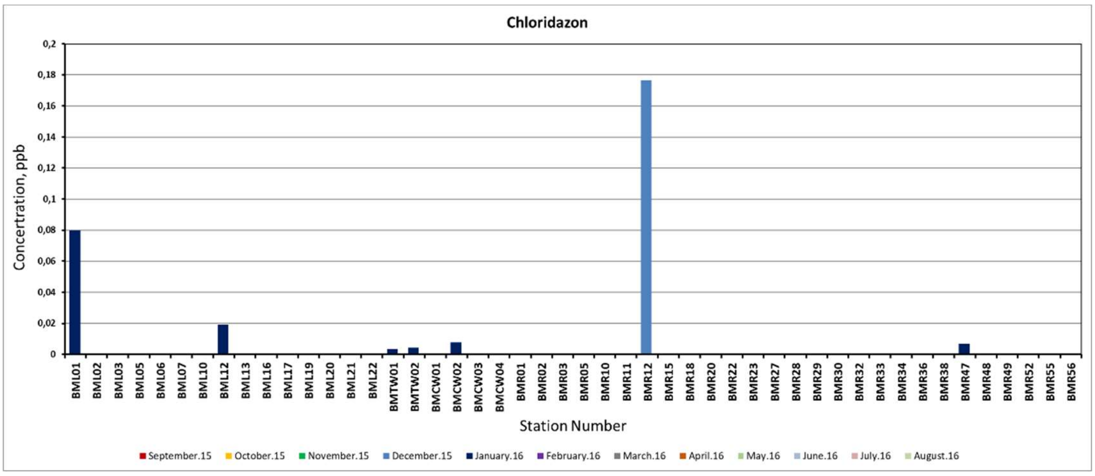

Figure 3.34 The observed Chloridazon concentrations at the station of BMRB for the monitored period

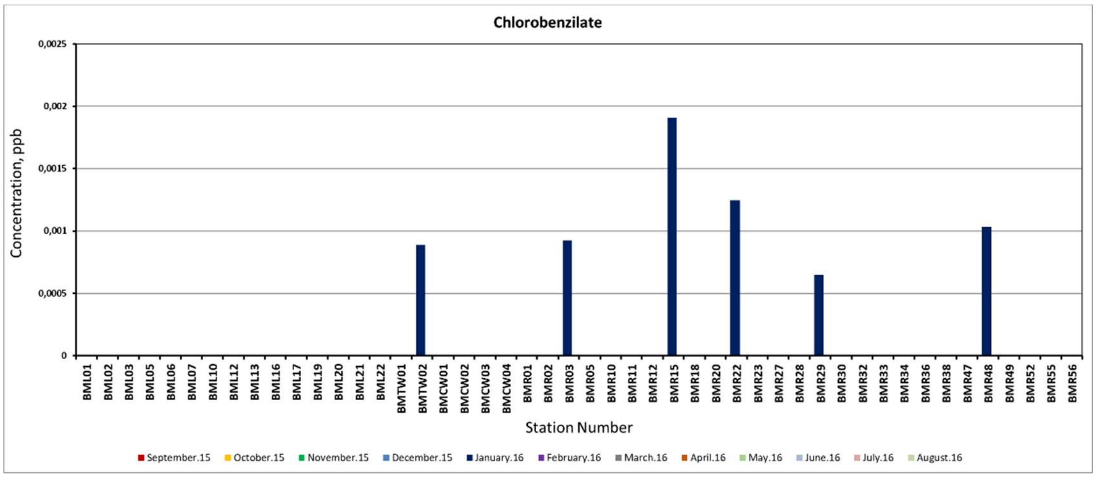

Figure 3.35 The observed Chlorobenzilate concentrations at the station of BMRB for the monitored period

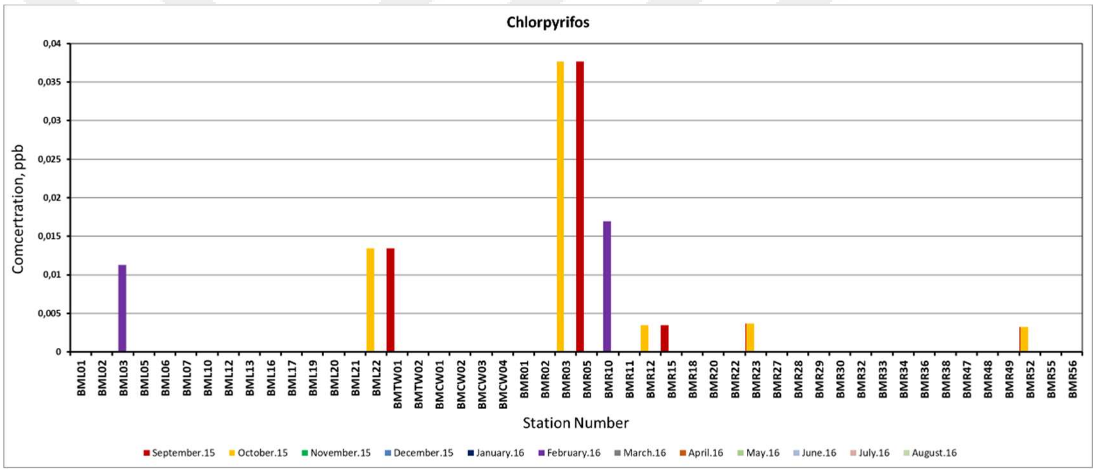

Figure 3.36 The observed Chlorpyrifos concentrations at the station of BMRB for the monitored period

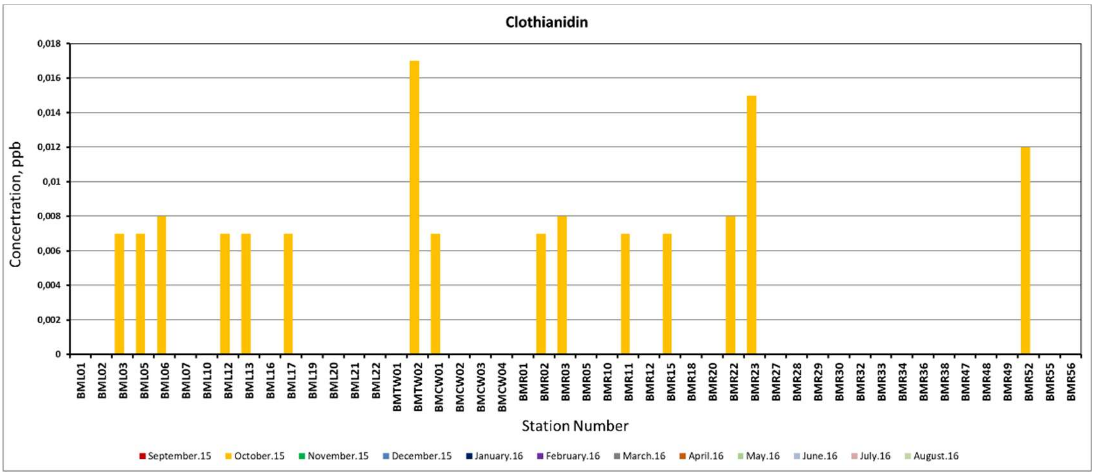

Figure 3.37 The observed Clothianidin concentrations at the station of BMRB for the monitored period

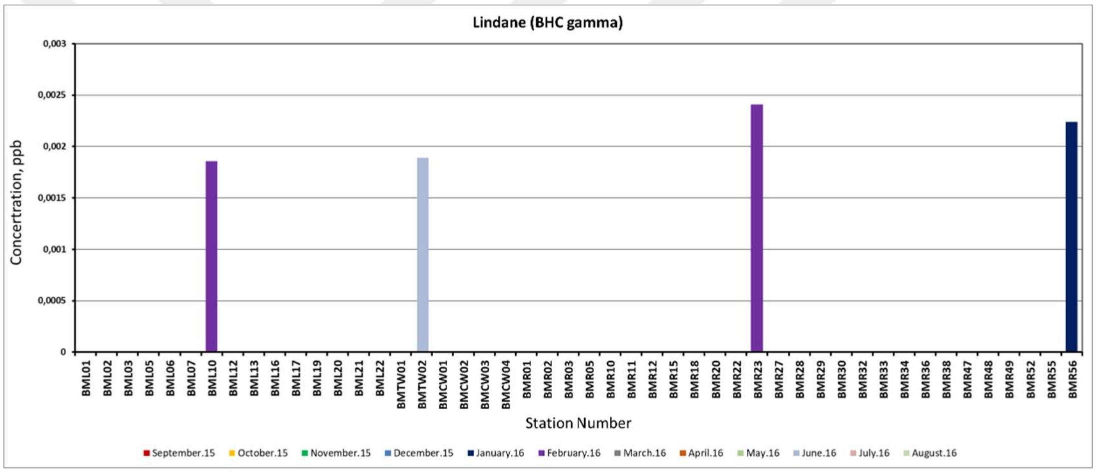

Figure 3.38 The observed Lindane concentrations at the station of BMRB for the monitored period

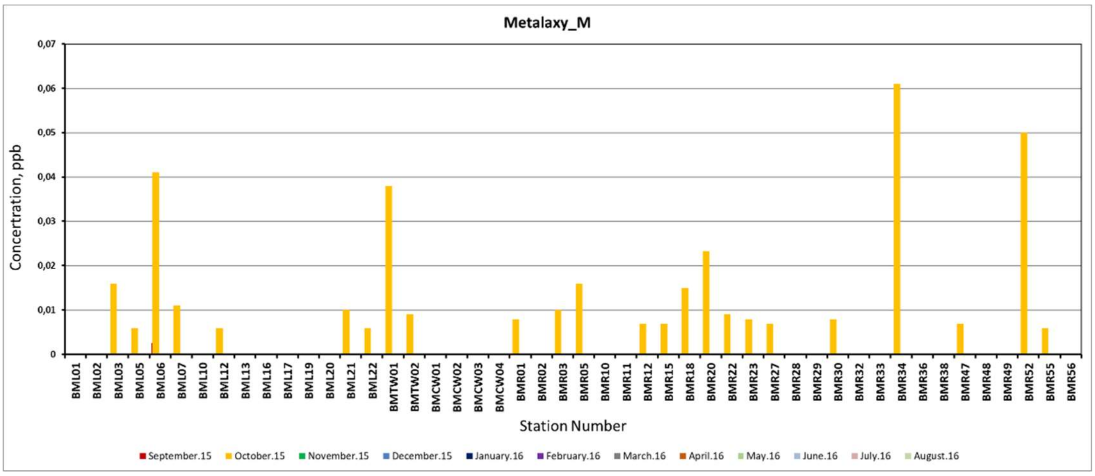

Figure 3.39 The observed Metalaxy-M concentrations at the station of BMRB for the monitored period

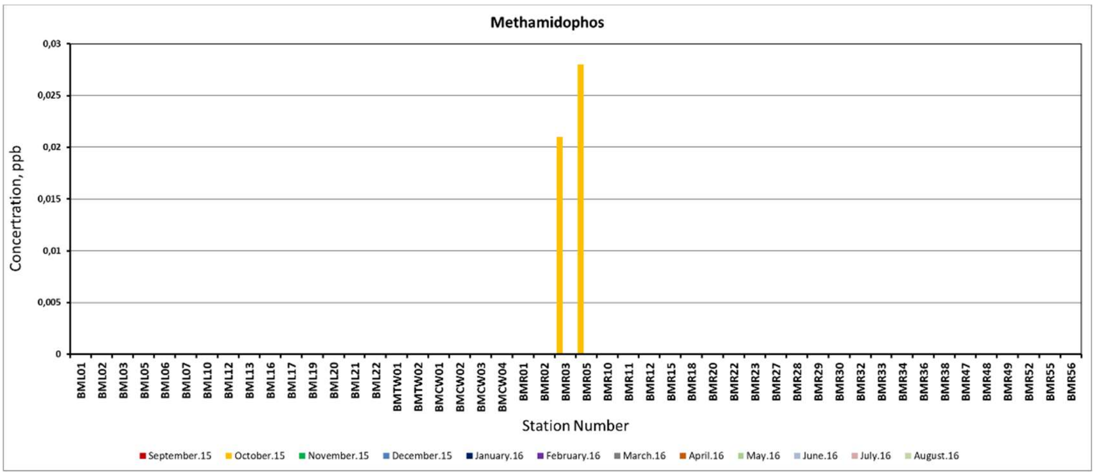

Figure 3.40 The observed Methamidophos concentrations at the station of BMRB for the monitored period

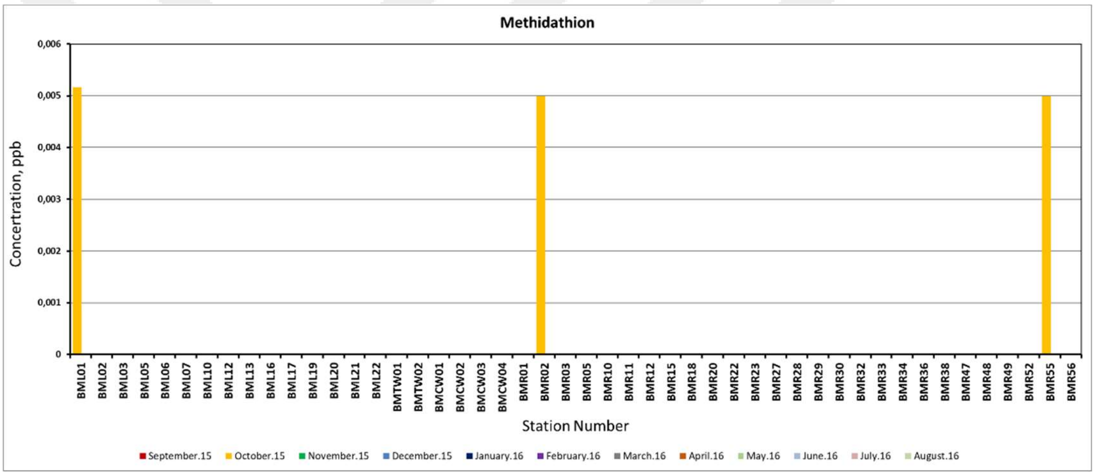

Figure 3.41 The observed Methidathion concentrations at the station of BMRB for the monitored period

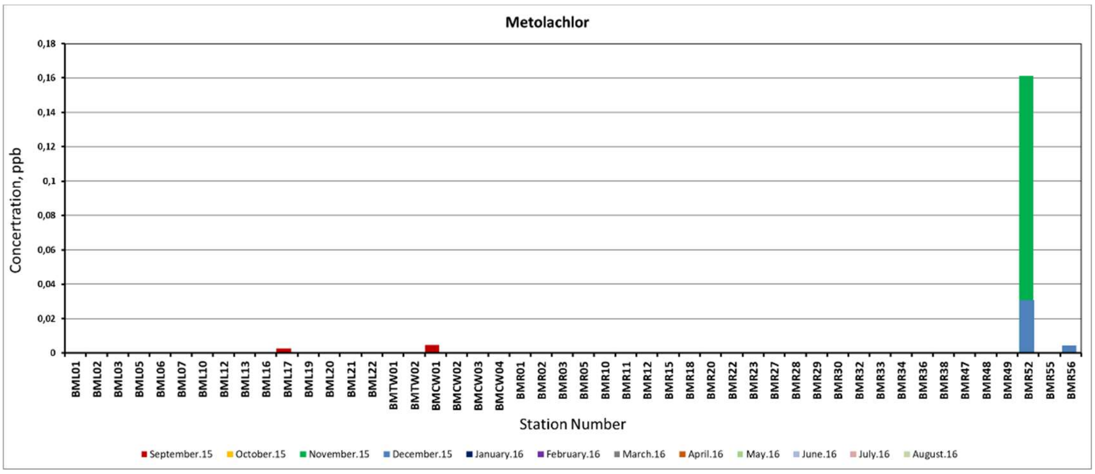

Figure 3.42 The observed Metolachlor concentrations at the station of BMRB for the monitored period

Monocrotophos is a specific pollutant detected in September 2015 and October 2015 periods. The maximum concentration of 0.06 ppb was detected at BMR05 station. These values are far below the MAC-EQS$_w$ = 45 ppb (Figure 3.43).

Penta-chlorobenzene is on the list of priority pollutants. It is used as a fungicide and as a chemical in electrical equipment in the form of mixture with chlorobenzene. It is resistant to degradation or stable in the natural environment. It evaporates from the water bodies and soils. Its accumulation in fishes is high. No MAC-EQS$_w$ value was reported in the directives or national regulations. However, AA-EQS$_w$ values are as low as 0.007 ppb in rivers/lakes and 0.0007 ppb in coastal/ transitional waters. It was observed in the basin in the range of 0.004-0.007 ppb in December 2015, in January 2016, in February 2016 and in May 2016 periods (Figure 3.46).

Propham is a specific pollutant. It was observed during the monitoring periods of October 2015, January 2016 and July 2016. Although the detected concentrations are below the LOD value, the measured concentrations in GC MSMS were presented in the thesis, since their chromatograms were too clear to be ignored. The highest concentration was found as 0.46 ppb at BMR55 station in March 2016. However, even concentration is below the MAC-EQS$_w$ value of 989 ppb (Figure 3.47). It means that Propham is not a significant pollutant in the basin.

Prochloraz is a relatively common specific pollutant detected in the basin in September 2015 and October 2016. It was especially observed in the coastal waters in October 2015 period with the maximum concentration of 0.02 ppb (Figure 3.48). This value is again lower than the allowable concentrations (13 ppb). Similarly, propamocarb is a specific contaminant that is frequently detected in the basin. Although, the maximum concentration in the basin was 0.04 ppb, it does not pose a contamination risk due to its extremely high MAC-EQS$_w$ given as 3914ppb (Figure 3.49).

Simazine is a priority pollutant. It is used as a selective herbicide for the control of weeds. It is in the same class as the herbicide atrazine. It has got low adsorption property on organic matter or solid surface. It can easily adsorb on clay particle surfaces and hence, can be transported to the groundwater, simultaneously. Its volatility and the accumulation potential in the fishes is low. During the monitoring process, it was only detected in two periods at a low concentration as 0.006 ppb. This observed concentration is well below MAC-EQS$_w$ = 4 ppb (Figure 3.51).

Cypermethrin is a priority pollutant. It does not show homogeneous distribution in water. It can be highly adsorbed onto the sediment. MAC-EQS$_w$ value is very low as 0.00006 ppb. In the validation studies conducted within the scope of the thesis, LOD was obtained as 0.035 ppb which is considerably higher than MAC-EQS$_w$. However, the method did not allow the lower LOD values. Therefore, the concentrations detected in the basin (0.17 ppb-0.7 ppb) were higher than the MAC-EQS$_w$ values (Figure 3.52).

Siprodinil is a specific pollutant commonly observed in December 2015-June 2016 period. The maximum concentration was 6.19 ppb in BMR20 in December 2015. However, this concentration is significantly lower than the MAC-EQS$_w$ value of 21 ppb (Figure 3.53).

Tebuconazole is a specific pollutant observed only in stations BMR03, BMR10 and BMR52 during October and December 2015. The maximum concentration is 0.0106 ppb and it is below the MAC-EQS$_w$ value (121 ppb) (Figure 3.54).

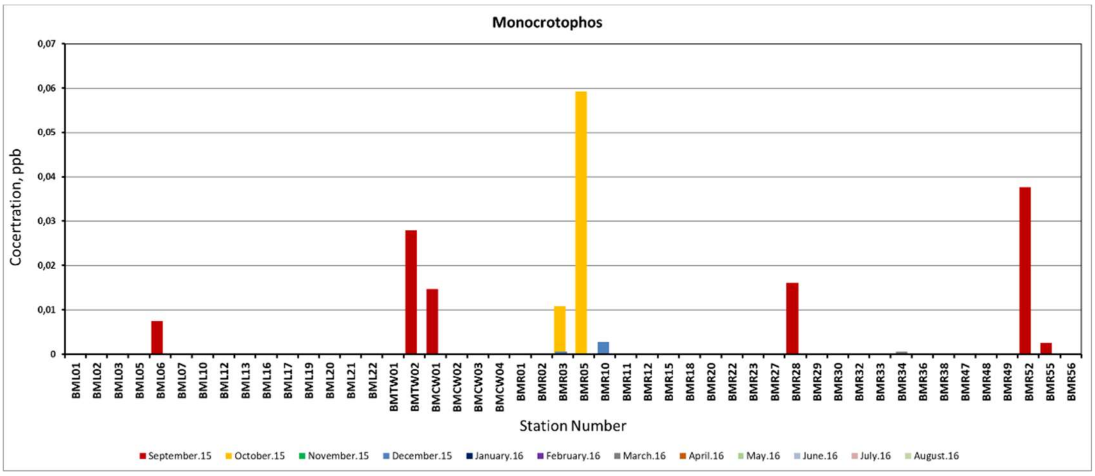

Figure 3.43 The observed Monocrotophos concentrations at the station of BMRB for the monitored period

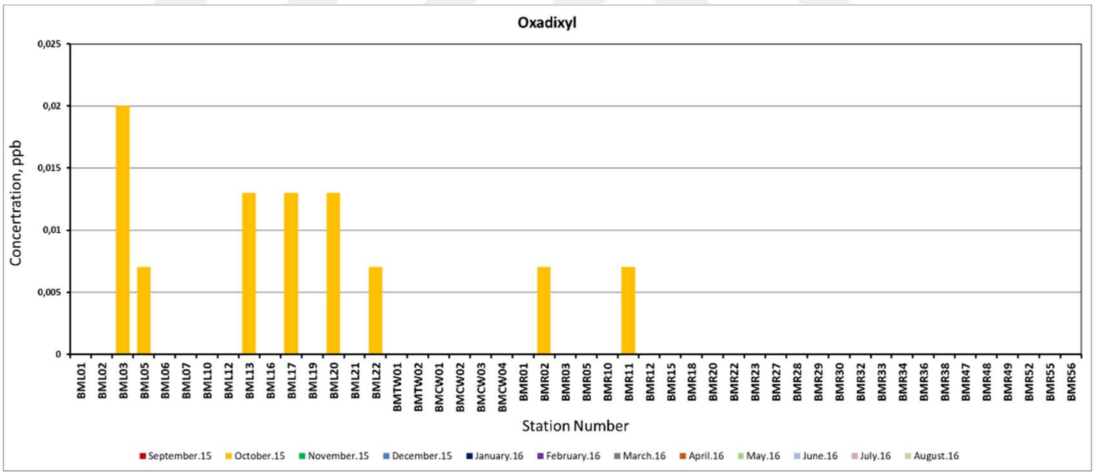

Figure 3.44 The observed Oxadixyl concentrations at the station of BMRB for the monitored period

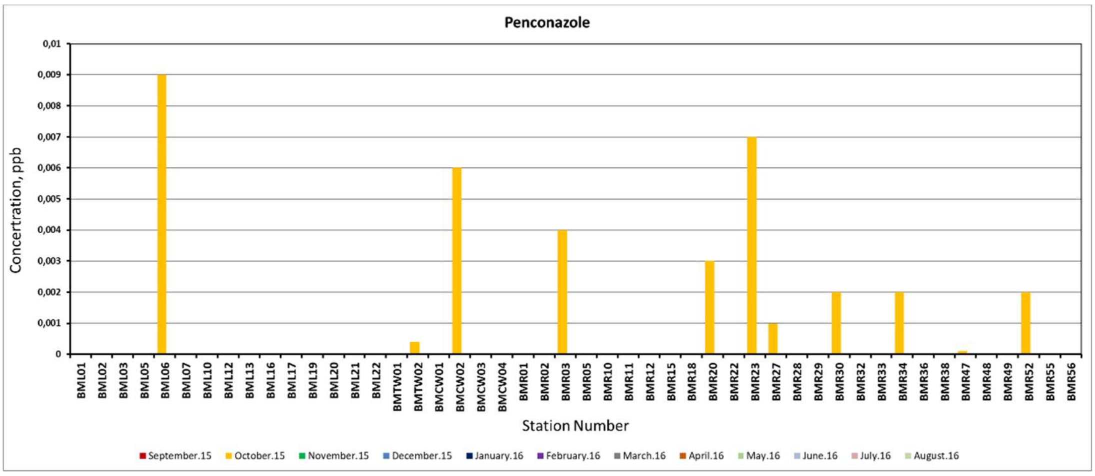

Figure 3.45 The observed Penconazole concentrations at the station of BMRB for the monitored period

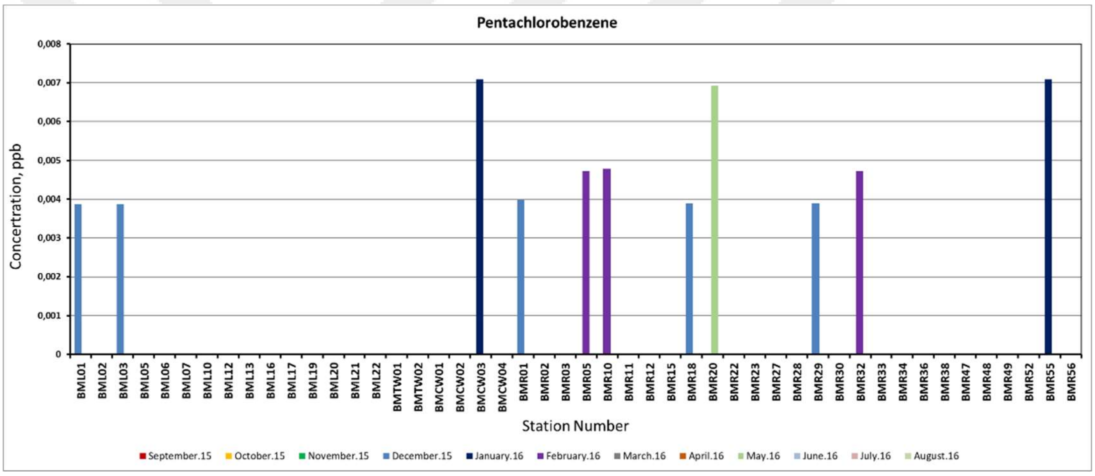

Figure 3.46 The observed Pentachlorobenzene concentrations at the station of BMRB for the monitored period

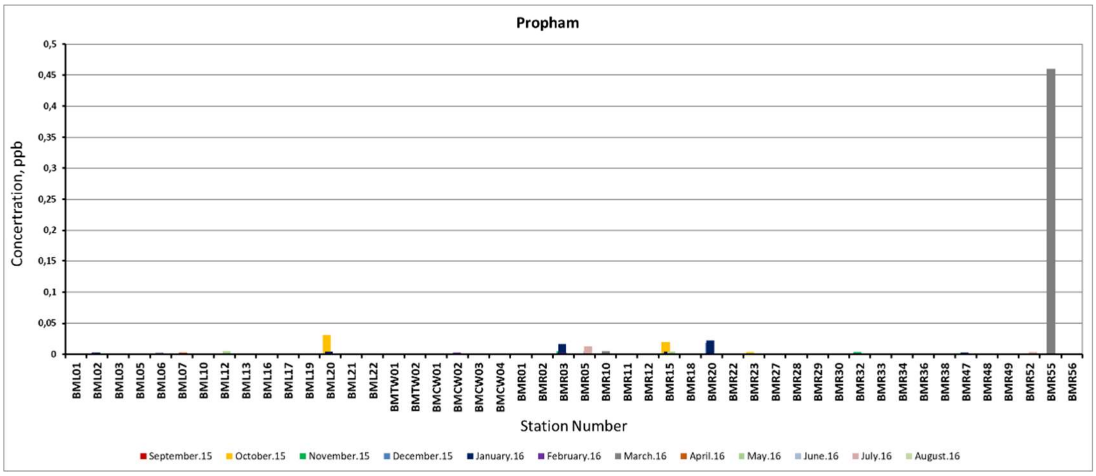

Figure 3.47 The observed Propham concentrations at the station of BMRB for the monitored period

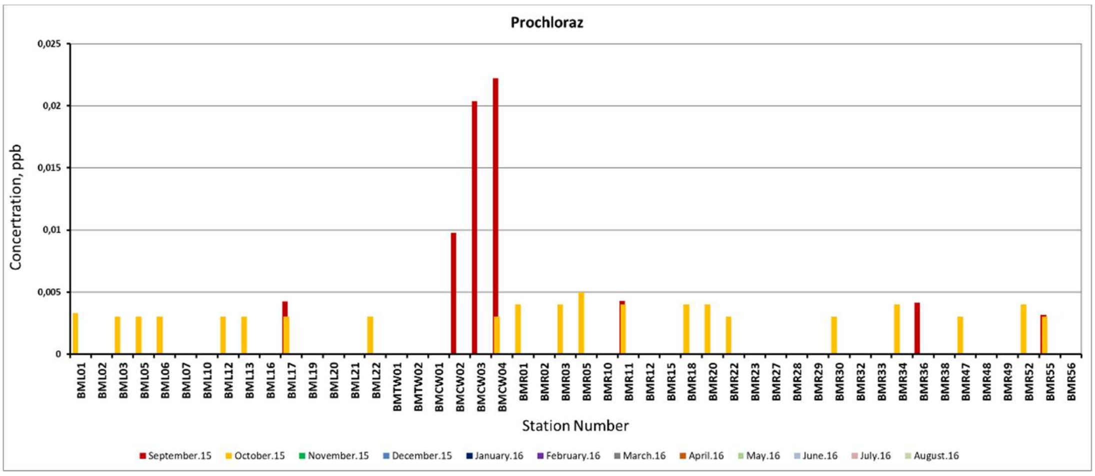

Figure 3.48 The observed Prochloraz concentrations at the station of BMRB for the monitored period

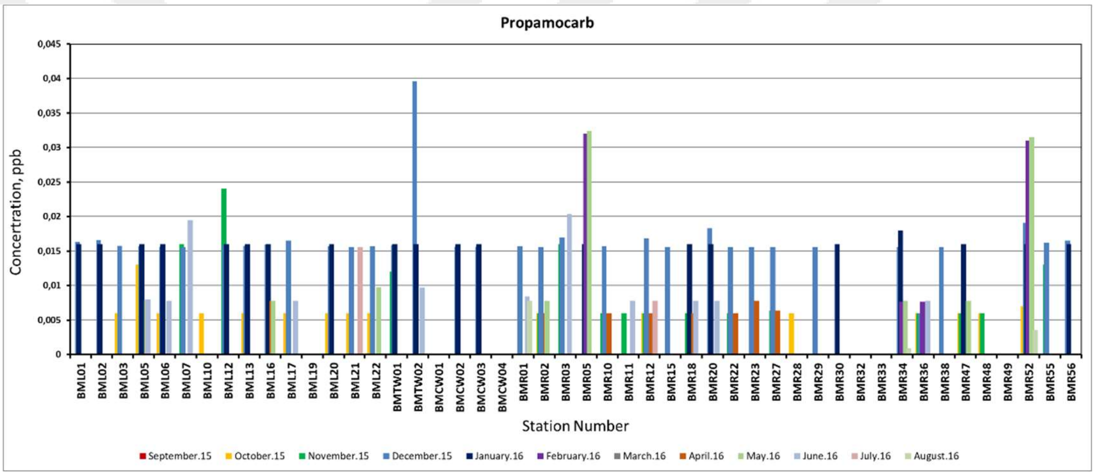

Figure 3.49 The observed Propamocarb concentrations at the station of BMRB for the monitored period

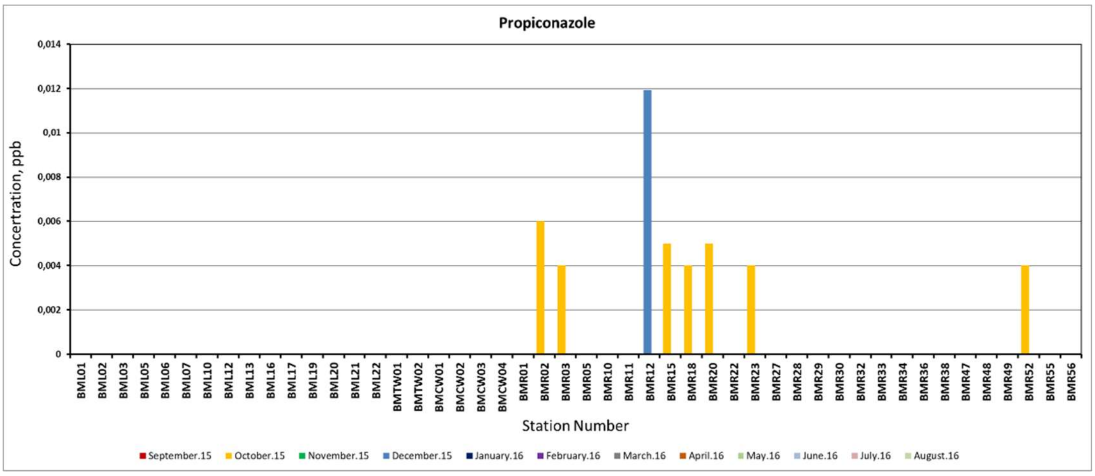

Figure 3.50 The observed Propiconazole concentrations at the station of BMRB for the monitored period

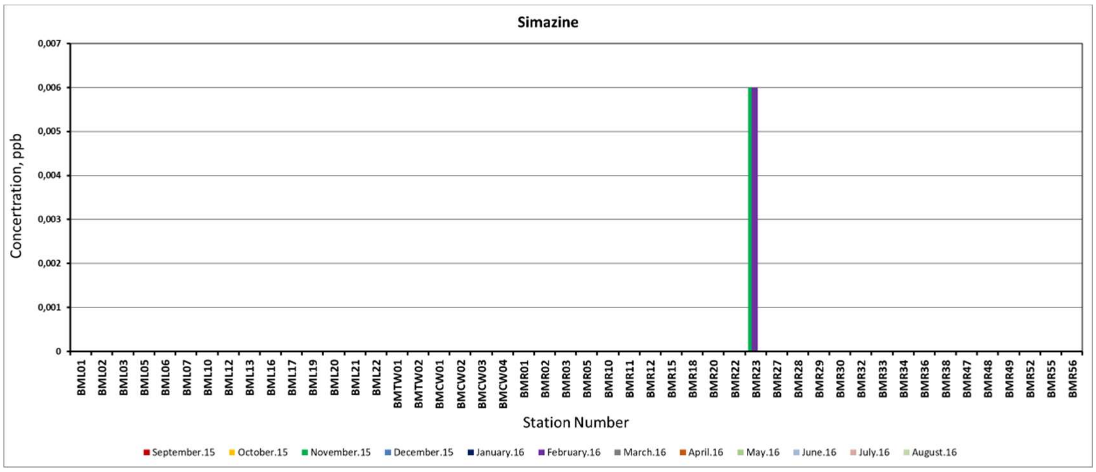

Figure 3.51 The observed Simazine concentrations at the station of BMRB for the monitored period

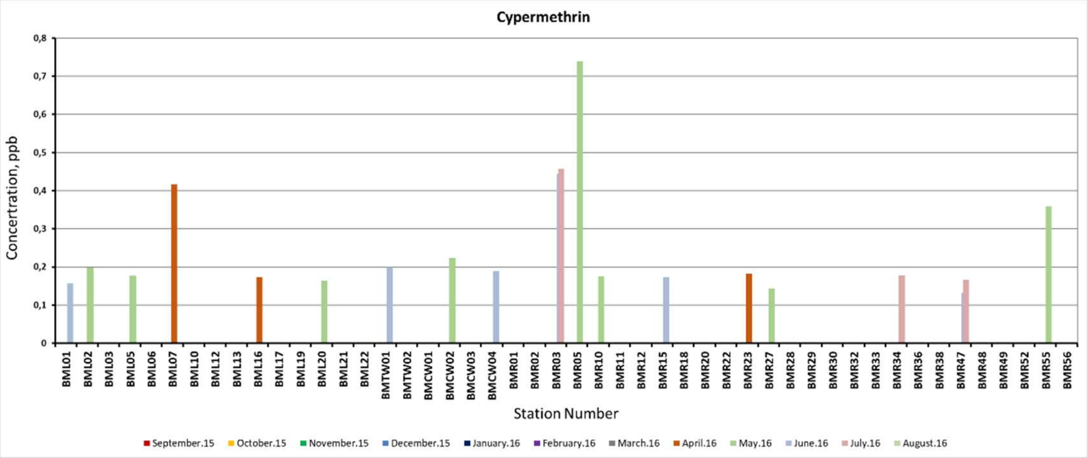

Figure 3.52 The observed Cypermethrin concentrations at the station of BMRB for the monitored period

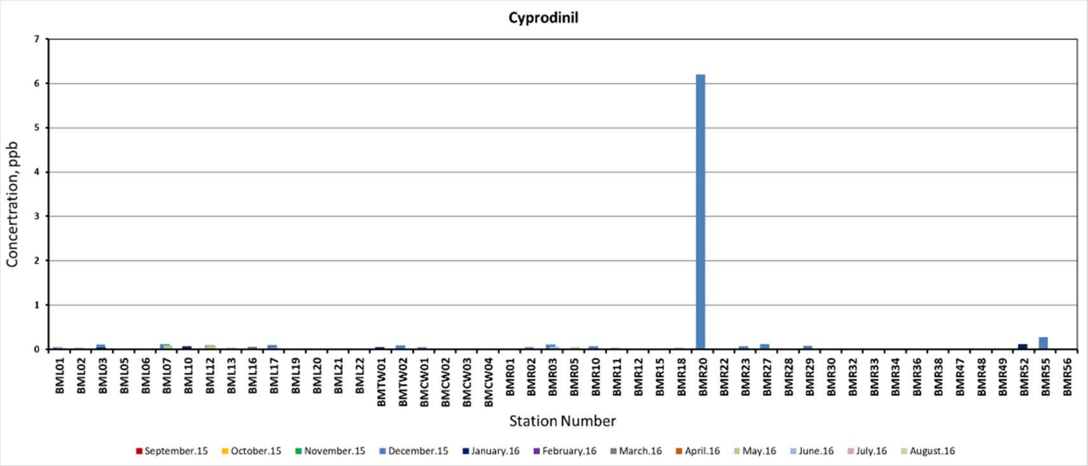

Figure 3.53 The observed Cyprodinil concentrations at the station of BMRB for the monitored period

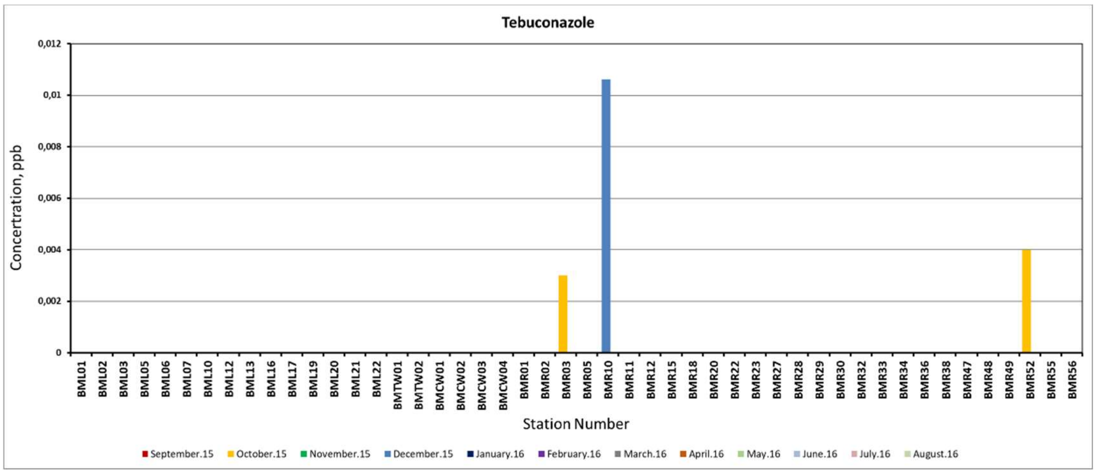

Figure 3.54 The observed Tebuconazole concentrations at the station of BMRB for the monitored period

The concentration of terbuthylazine varied between 0.013 ppb and 0.06 ppb. The maximum concentration of 0.06 ppb was obtained in BMCW02, the coastal station. Determined concentrations; MAC-EQS$_w$ values are below (Figure 3.55).

Terbutryn is on the list of priority pollutants. It was observed in the BMRB only in BML16 in June 2016 and with a maximum concentration of 0.007 ppb and in BML01 with 0.0035 ppb. These values are less than MAC-EQS$_w$ = 0.034 ppb (Figure 3.56).

Thiabendazole was detected in a limited number of stations in December 2015 and January 2016 and the maximum concentration was 6.5 ppb in BMR12 (Figure 3.58).

Thiamethoxam was detected only in September 2015 at BMR03 and BMR52 stations at 0.0025 ppb concentration. The detected values for both stations are below the MAC-EQS$_w$ values (Figure 3.59).

Trifluralin is the priority pollutant observed in stations BML05, BMTW02, BMR20 and BMR32 during January and April 2016 periods. The maximum concentration was 0.0065 ppb (Figure 3.61).

α-HCH (α-BHC), β-HCH (β-BHC), δ-HCH (δ-BHC), Δ-HCH (Δ-BHC) are hexachlorocyclohexane organochlorine insecticides. They are in the group of priority pollutants. They are present in the air and in the surface waters near the hazardous waste areas, in the form of steam or small particles in the air. They decompose into substances with less toxicity by algae, fungi and bacteria in soil, sediment and water. It accumulates in fish. α-HCH (Figure 3.62), β-HCH (Figure 3.63), δ-HCH (Figure 3.64) are isomers detected during the monitoring period in the BMRB. They have been identified extensively at lake stations. Some of the river stations at which α-HCH and β-HCH were detected are BML13, BMTW02, BMR03, BMR05 and BMR23. δ-HCH was observed mostly in lake waters.

In summary, the pesticides exceeding the AA-EQS$_w$ value are Aldrin (Figure 3.65), Cypermethrin (Figure 3.66), and Thiabendazole (Figure 3.67). Pesticides with concentrations exceeding MAC-EQS$_w$ are Diflubenozuron, Fenpropatrin, Chlorfenvinphos and Cypermethrin.

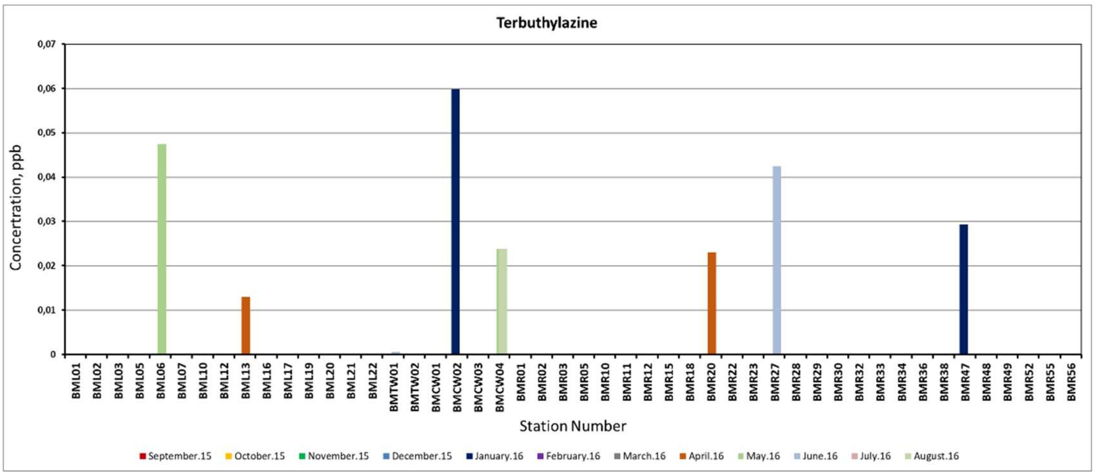

Figure 3.55 The observed Terbuthylazine concentrations at the station of BMRB for the monitored period

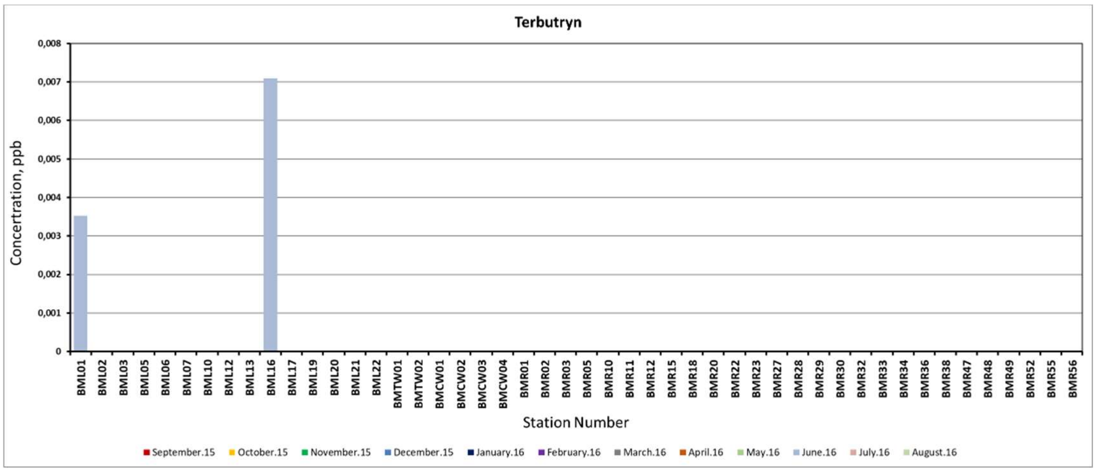

Figure 3.56 The observed Terbutryn concentrations at the station of BMRB for the monitored period

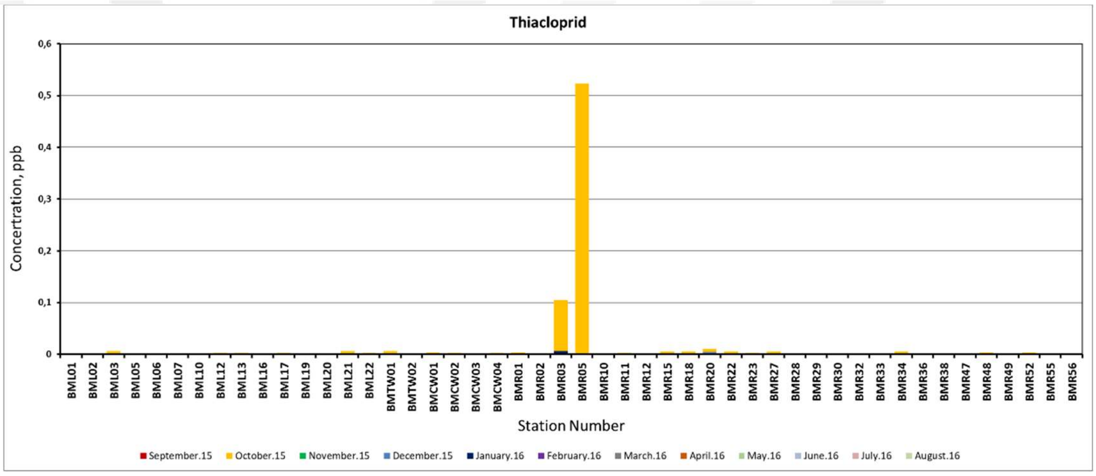

Figure 3.57 The observed Thiacloprid concentrations at the station of BMRB for the monitored period

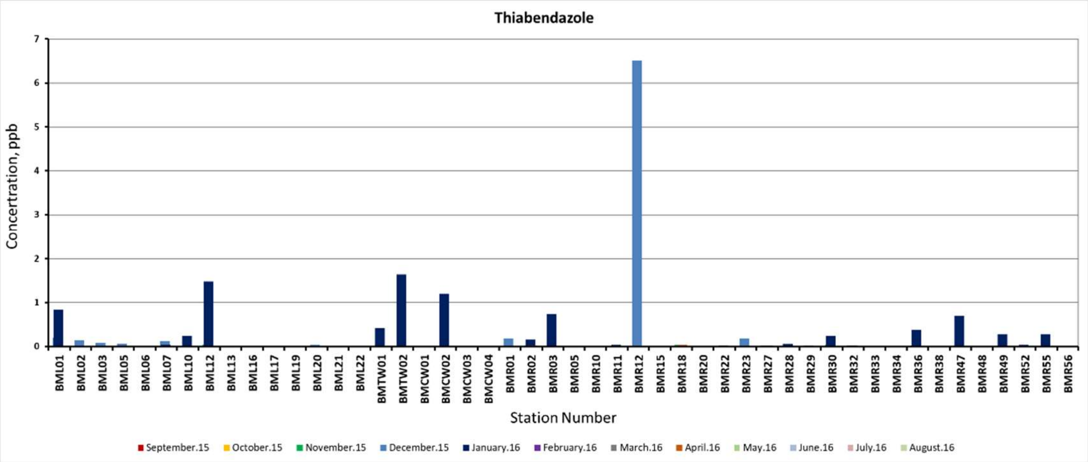

Figure 3.58 The observed Thiabendazole concentrations at the station of BMRB for the monitored period

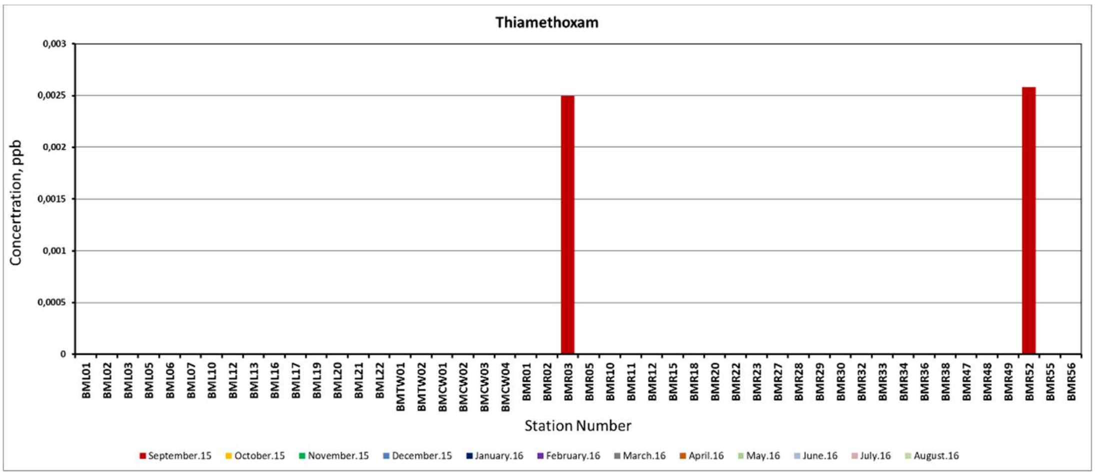

Figure 3.59 The observed Thiamethoxam concentrations at the station of BMRB for the monitored period

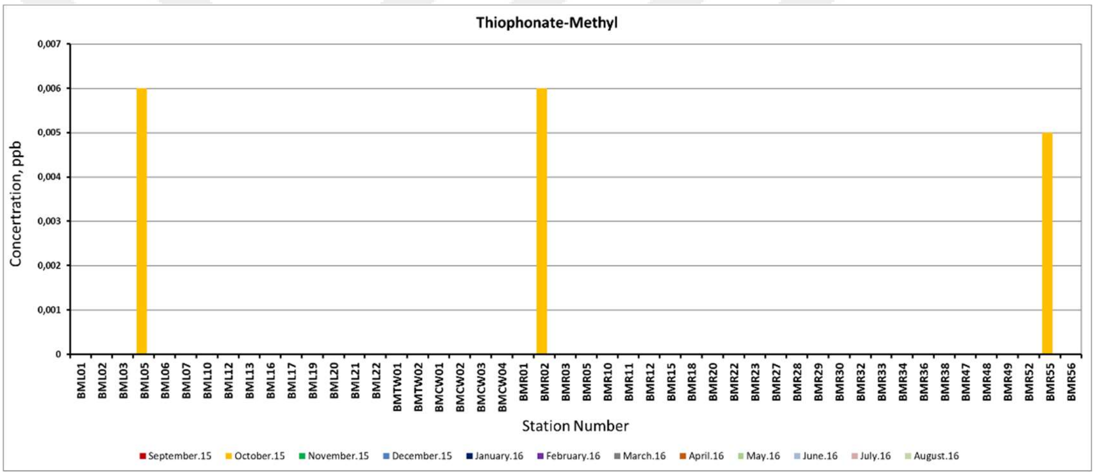

Figure 3.60 The observed Thiophonate-Methyl concentrations at the station of BMRB for the monitored period

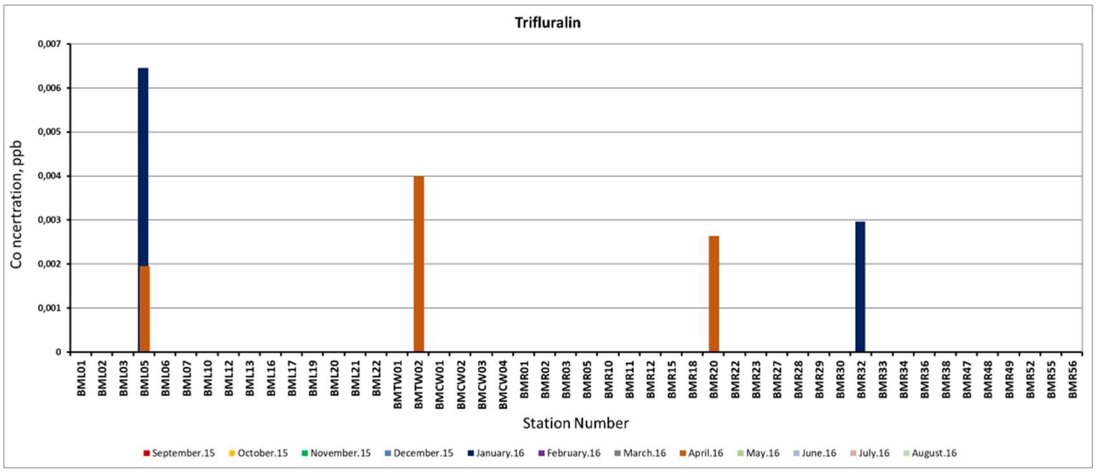

Figure 3.61 The observed Trifluralin concentrations at the station of BMRB for the monitored period

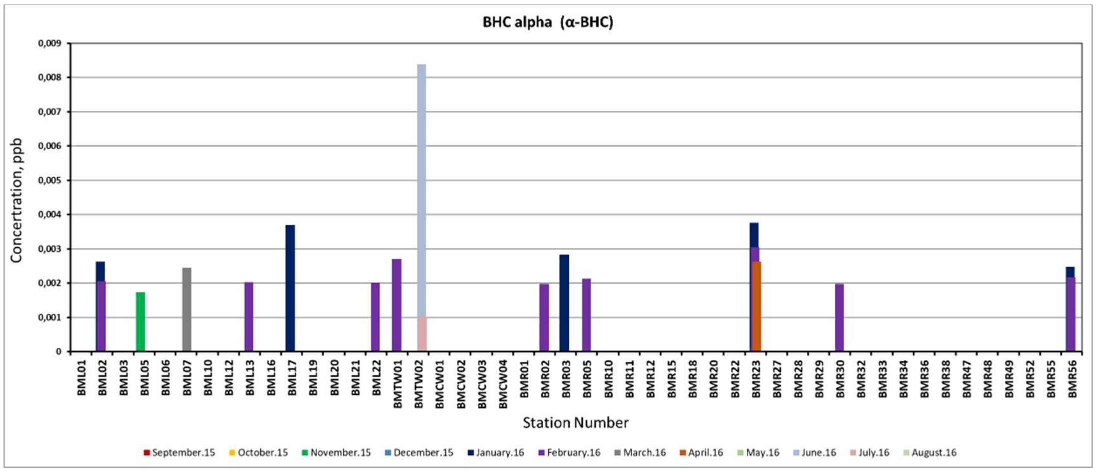

Figure 3.62 The observed α-BHC concentrations at the station of BMRB for the monitored period

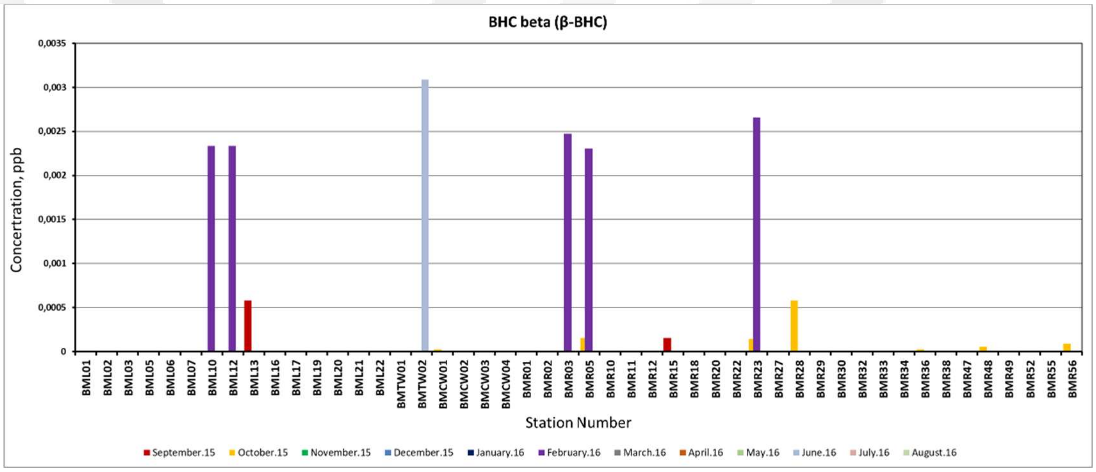

Figure 3.63 The observed β-BHC concentrations at the station of BMRB for the monitored period

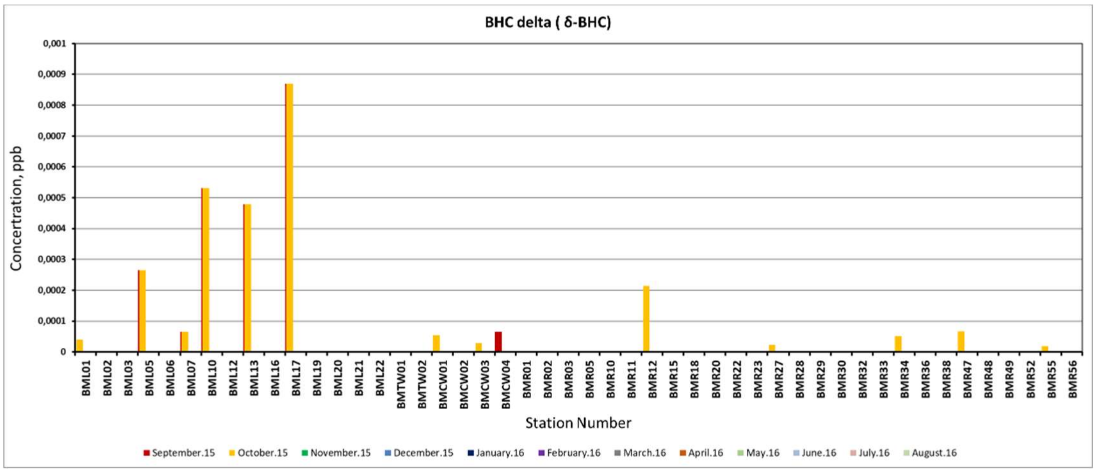

Figure 3.64 The observed δ-BHC concentrations at the station of BMRB for the monitored period

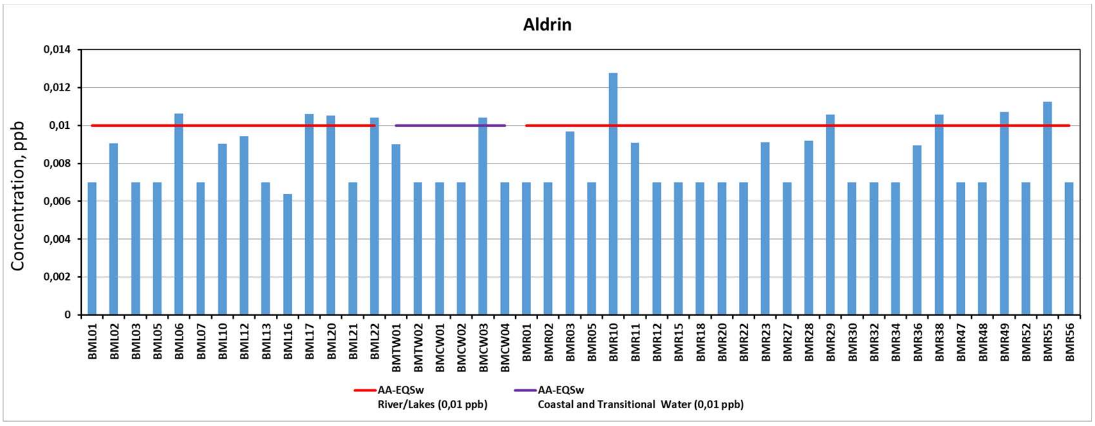

Figure 3.65 The annual average concentrations of Aldrin at the stations of BMRB

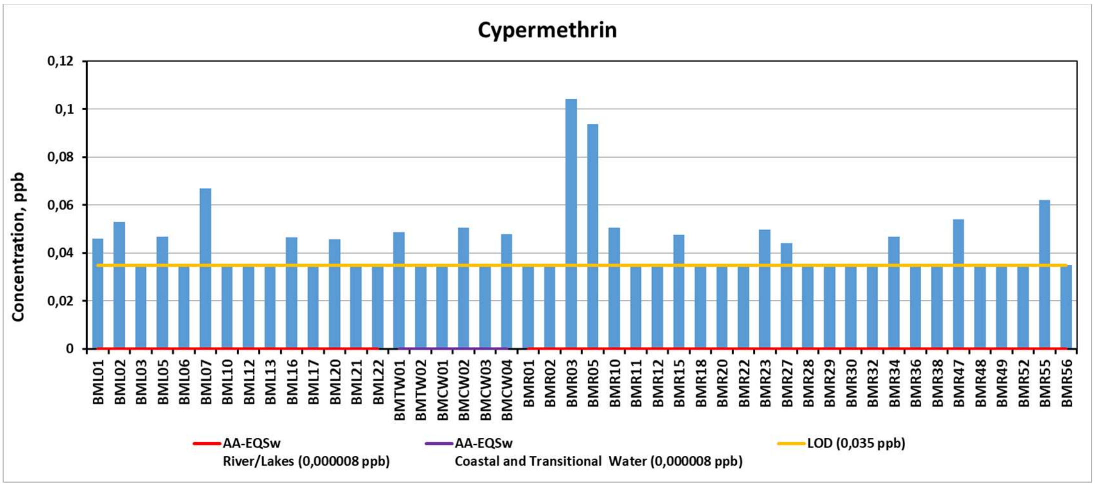

Figure 3.66 The annual average concentrations of Cypermethrin at the stations of BMRB

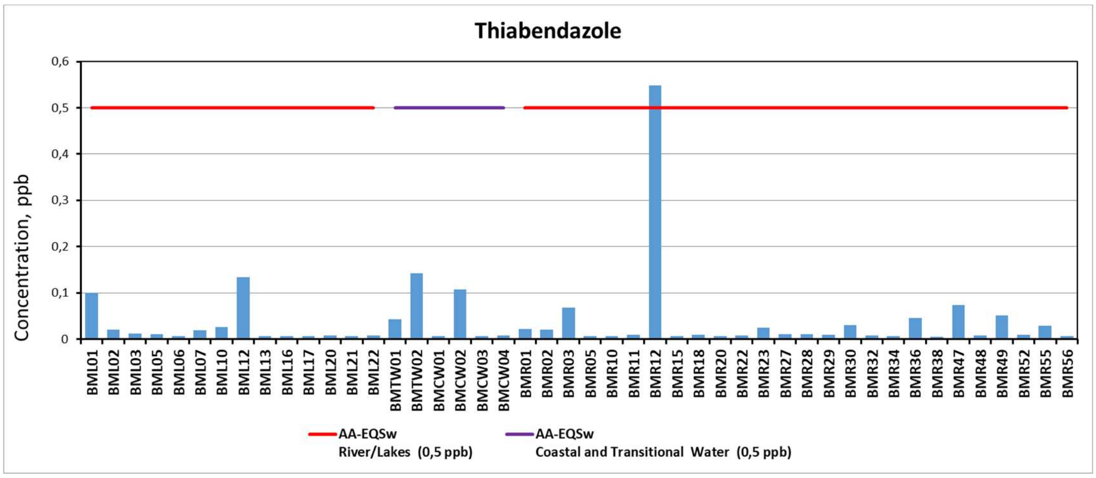

Figure 3.67 The annual average concentrations of Thiabendazole at the stations of BMRB

3.1.2 Polycyclic Aromatic Hydrocarbons Pollution in Büyük Menderes River

The polycyclic aromatic hydrocarbons (PAH) detected in BMRB during 12 month monitoring studies were 1-methylnaphthalene, 2-chloronaphthalene, Anthracene, Acenaphthylene, Acenaphthene, Benz (a) anthracene, Benzo(a) pyrene, Benzo-ghi-perylene, benzo (b) fluoranthene, Benzo (k) fluoranthene, Dibenz (a, h) anthracene, Phenanthrene, Fluoranthene, Fluorene, Indeno (1,2,3) pyrene, Chrysene, Naphthalene, Perylene and Pyrene. The detected concentrations of PAH were presented in Figures between Figure 3.68 and Figure 3.86. The results were given as the PAH concentrations above LOD of the corresponding PAH, and the concentrations of PAH below its LOD value. However, if a clear chromatogram of any PAH obtained in GC MSMS analysis even though the concentration was less than LOD value, the result was presented. Since the concentrate of any PAH could make a sense in terms of pollution profile of the Basin. The PAHs which are not detected at all were not mentioned in this section.

1-methylnaphthalene is a PAH listed as a specific pollutant. It is a two-ring PAH with the highest water solubility. The solubility increases by using alcohol, ether and benzene. 1-methylnaphthalene sources are coal production, detergent production, wetting chemicals in textile industry, vitamin K production and utilization as wood protection chemicals. Organic substances in the environment (especially fossil fuels and tobacco) are often found as compounds of polycyclic aromatic hydrocarbons as a result of incomplete combustion or pyrolysis. Its half-life in surface water is 54 hours. MAC-EQS$_w$ values for 1-methylnaphthalene in rivers, lakes, coastal and transitional waters is 29 ppb. During the monitoring period, 1-methylnaphthalene was observed in September 2015, April 2016 and July 2016. Maximum concentration was obtained in September 2015 with 2.08 ppb in station BMR11. The concentrations determined in BMRB do not exceed the MAC-EQS$_w$ value (Figure 3.68).

Anthracene is on the list of priority pollutants. It has three rings and low water solubility. The MAC-EQS$_w$ value is 0.4 ppb for surface waters. It has very little volatile property, but generally it has deposition properties in sediment. Its solubility can be increased by using methanol, acetone, hexane, ethylene and toluene. Anthracene sources are paint and pigment production, its utilization as wood preservative. It is generally found in the environment as a compound of polycyclic aromatic hydrocarbons as a result of incomplete combustion or pyrolysis of organic substances. It has a high toxic effect on aquatic organisms and it may cause long-term effects on aquatic organisms (Anthracene, 2019). The detected concentrations of anthracene in the basin is given in Figure 3.69. It was widespread PAH and observed almost every monitoring station of the basin in September 2015. Its maximum concentration observed was 0.028 ppb at BML03. It was not commonly observed at all stations in October 2015, December 2015 and even in May 2016. The concentration of anthracene was below the determined MAC-EQS$_w$ value.

Acenaphthylene is characterized by low to very low volatility. When it is dissolved, it volatilizes moderately but adsorbs very strongly on organic matter. It slowly dissolves when it is in soil. It can easily reach the water table or migrate into a waterway when it is dissolved. It will be diluted in the water body before partially volatilizing. Fragments of acenaphthylene can also be moved towards a waterway, where they will disperse on the surface of the water and then slowly dissolve. Even though the source of acenaphthylene is removed from the environment, the adsorbed fraction remains in the environment and it takes a very long time to have its complete disappear. It could cause contamination in either the gaseous or dissolved state Acenaphthylene may be obtained by fractionation of coal tar, or by the catalytic dehydrogenation of acenaphthylene. It could be found mixed with other PAHs in commercial products like coal tar, coal tar pitch, creosote, bitumen and asphalt (Acenaphthylene, 2019).

Acenaphthylene is listed as a specific pollutant in Turkish surface water regulations regarding the Water Framework Directive. Its MAC-EQS$_w$ value was determined as of 66 ppb. It was commonly observed PAH in the basin during monitoring period between years 2015- 2016. The maximum concentration detected in the basin was 0.13 ppb at BML03 station in September 2015. Although this is the highest concentration, it is below the MAC-EQS$_w$ value (Figure 3.70).

Acenaphthene is a component of crude oil and a combustion product. Emissions from oil refineries, coal processing, and diesel engines are the main acenaphthene sources. It is used as chemical intermediate. It could be also released into the environment through wastewater discharges and waste incineration. It could be released form pharmaceuticals, paints and plastics industries. It is used as insecticide and fungicide production. It can be readily biodegraded in the water. The evaporation half-life of acenaphthene evaporation is 11 days for rivers and 39 days for lakes (Acenaphthene, 2019). Acenaphthene was detected in December 2015, February 2016, and April 2016 in lakes, rivers, transitional and coastal water stations (Figure 3.71). The maximum concentration observed was 0.11 ppb in BMR52. This value is far below the MAC-EQS$_w$= 66 ppb.

Benzyl-a-anthracene was not either in national specific pollutant list of Turkey nor in WFD. The analytical method for this PAH was available in the laboratory infrastructure of Dokuz Eylül University Measurement Laboratory. Therefore, there is no available MAC-EQS$_w$ value for this PAH. Concentrations below 0.01 ppb were observed for a significant part of the monitoring period. However, in March 2016, 0.27 ppb concentration was obtained at BMR27 station. If the MAC-EQS$_w$ values of other PAHs are evaluated as reference value, it is seen that the concentrations of Benz-a-anthracene in the basin do not exceed this limit value (Figure 3.72).

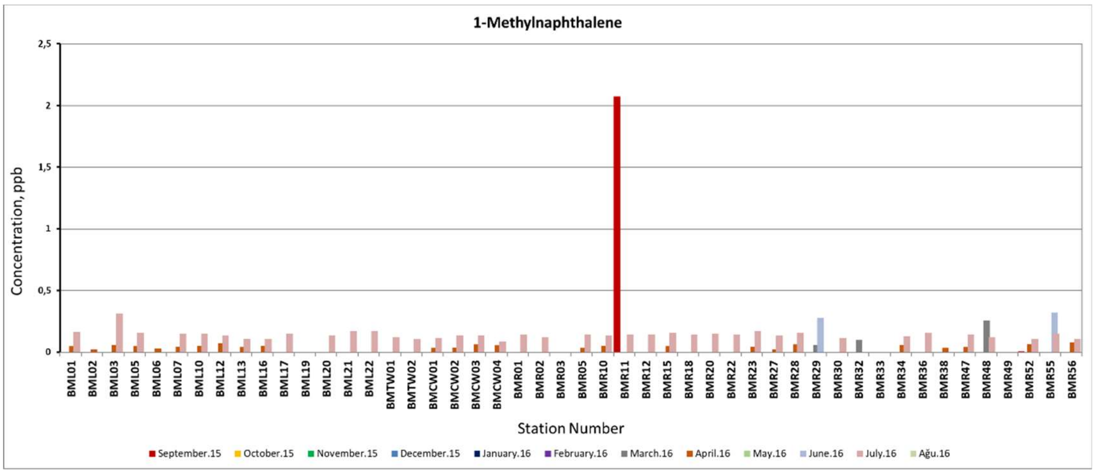

Figure 3.68 Monthly variation of 1-Methylnaphthalene concentration at stations of BMRB

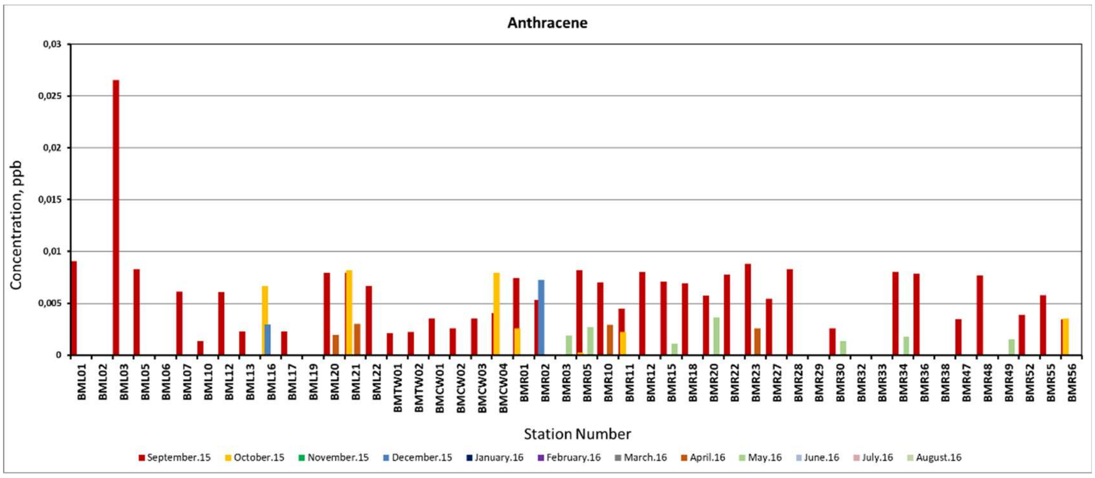

Figure 3.69 Monthly variation of Anthracene concentration at stations of BMRB

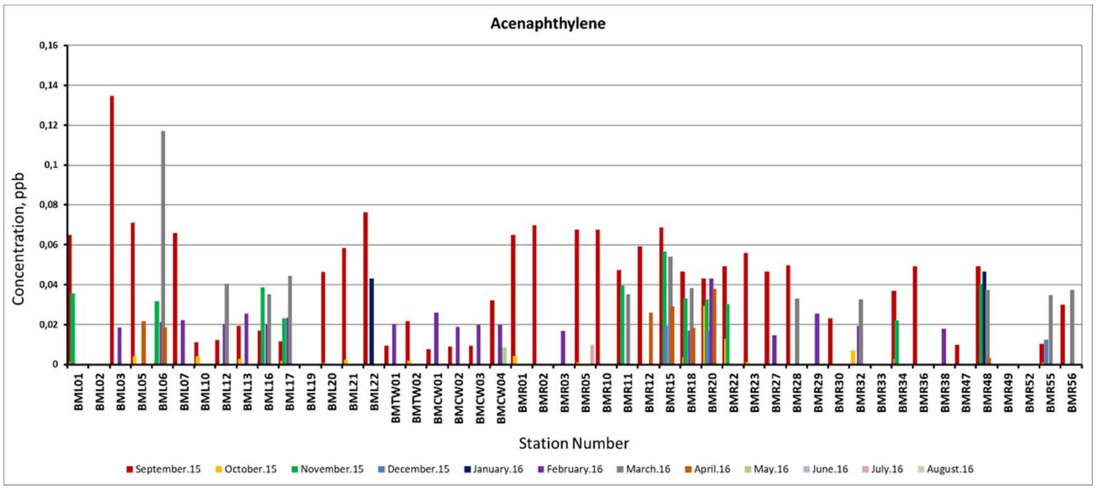

Figure 3.70 Monthly variation of Acenaphthylene concentration at stations of BMRB

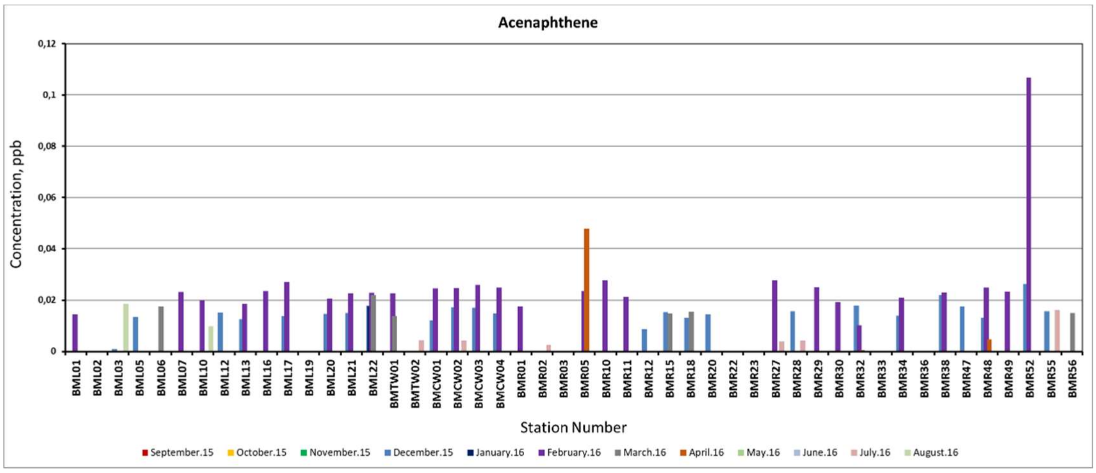

Figure 3.71 Monthly variation of Acenaphthene concentration at stations of BMRB

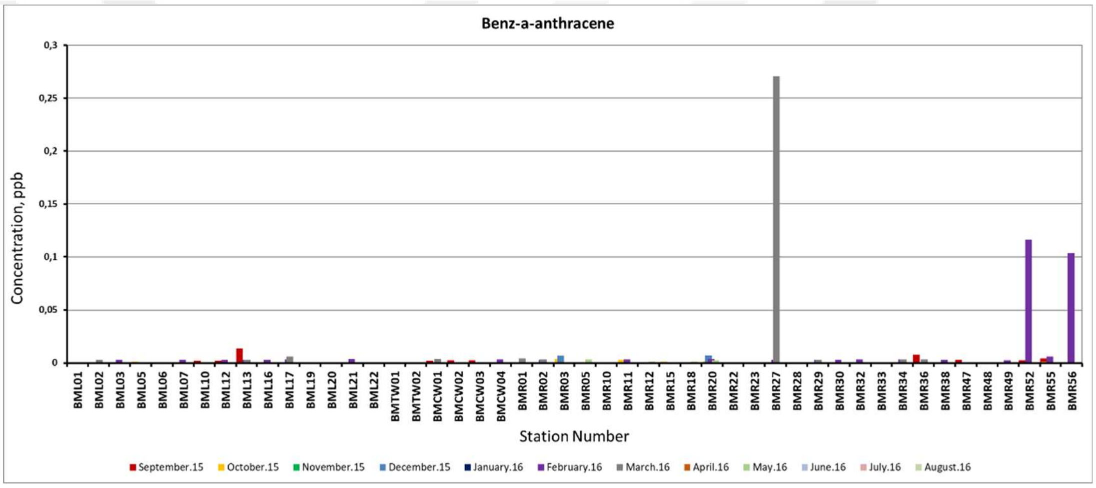

Figure 3.72 Monthly variation of Benz-a-anthracene concentration at stations of BMRB

Benzo-ghi-perylene (BgP) is one of the PAHs with 6 rings. It is the least water-soluble PAH. It has very little volatile property, since then, it has the ability to accumulate in sediment. The solubility is increased by using benzene, acetone, dichloromethane, toluene. Benzo (g-h-i) perylene sources are plastic, petrochemical and metal industries. It is generally found in the environment as a compound of polycyclic aromatic hydrocarbons as a result of incomplete combustion or pyrolysis of organic substances. Benzo (g-h-i) perylene is a PAH with a high toxic effect on aquatic organisms. Toxic property is likely carcinogenic (Benzo-ghi-perylene, 2019).It is one of the priority pollutants in WFD. Its MAC-EQS$_W$ value is 0.0082 ppb for rivers / lakes and 0.00082 ppb for coastal and transitional waters. The LOD value obtained in the DEU laboratory for this PAH is 0.02 ppb which is higher than the

MAC-EQS$_W$. Therefore, the presence of this PAH in the basin must be evaluated by considering this fact. Benzo-ghi-perylene (BgP) was most commonly detected in September 2015 period with the concentrations between 0.0015 ppb and 0.035 ppb. Although LOD value is 0.02 ppb for this PAH, a clear chromatogram was obtained in GC/MS-MS and the concentrations were presented accordingly. It can be seen form the Figure 3.73 that the concentrations are generally less than 0.003 in October 2015, December 2015, April 2016 and July 2016.

Benzo-a-pyrene (BaP) is on the list of priority pollutants as well. It is the most carcinogenic and mutagenic PAHs known. Therefore, it is used as a marker in PAH analysis in water and food. BaP is a 5-ring PAH and the least soluble one in water among the other PAHs. It is extremely stable and it has a higher boiling point than n-alkanes with the same carbon number. It is lipophilic and apolar. It is found in exhaust gases of gasoline and diesel vehicles, in cigarette smoke and smoke moisture, in amino acid, fatty acid, carbohydrate pyrolysis products, in coal tar and tar pitch, asphalt, wood smoke, coal combustion emissions, in commercial solvents, polishers, mineral oils and creosote (Pubchem Benzo[A]Pyrene, 2019). Its MAC-EQS$_W$ value is 0.27 ppb for rivers and lakes, 0.027 ppb for coastal and transitional waters. The LOD value determine in DEU laboratory is 0.009 which is 1/3 of the MAC-EQS$_W$ as asked in the EU WFD guidelines. It was mostly observed in September 2015 in the basin but at the low concentrations. It was observed in transitional waters BMTW01 and BMTW02. The concentration reached a maximum level of 0.013 ppb in December 2015. But this concentration is already below the transition water MAC-EQS$_W$ value (Figure 3.74).

Benzo-b-fluoranthene is a 5-ring PAH which is listed as a priority pollutant in WFD. It has very little volatile property and it has the ability to accumulate in sediment. The solubility is increased by using benzene, alcohol, acetic acid. Benzo (b) fluoranthene are generated from plastic, petrochemical and metal industries. Incomplete combustions of fossil fuel or tobacco are the other main sources of Benzo (b) fluoranthene in the environment. Toxic property is likely carcinogenic. Its half-life in water is between 4-500 hours (Pubchem, Benzo-b-fluoranthene, 2019). It was particularly observed in September 2015 period, the concentration reached 0.013 ppb level in BML03. Although the observed concentration is less that its MAC-EQS$_w$ value (0.017ppb), it could pose a risk of contaminant in the basin (Figure 3.75).

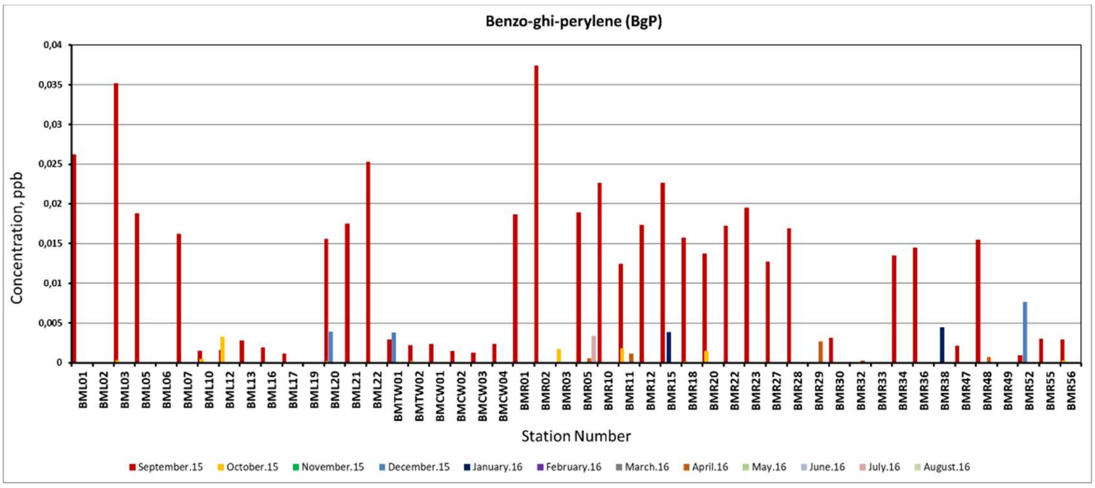

Figure 3.73 Monthly variation of Benzo-ghi-perylene (BgP) concentration at stations of BMRB

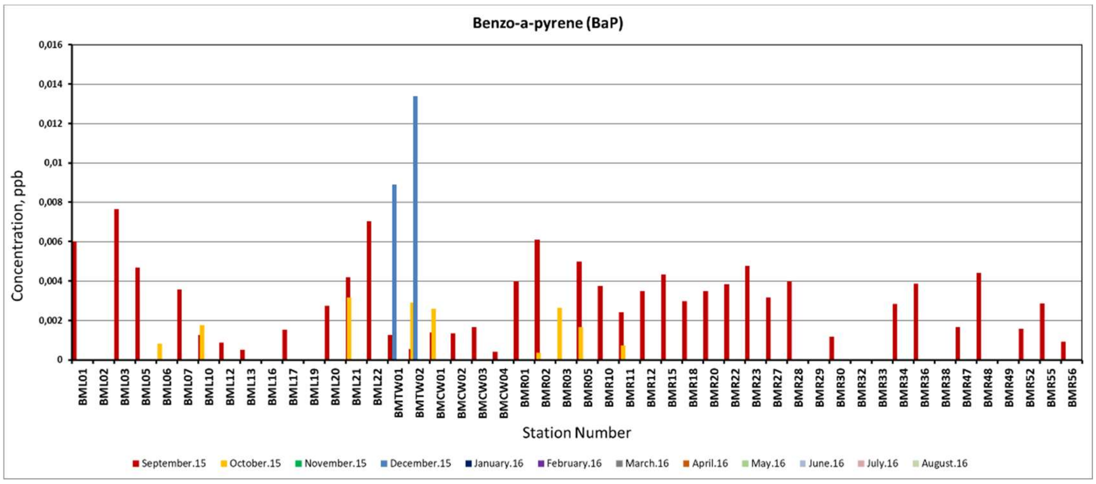

Figure 3.74 Monthly variation of Benzo-a-pyrene (Bap) concentration at stations of BMRB

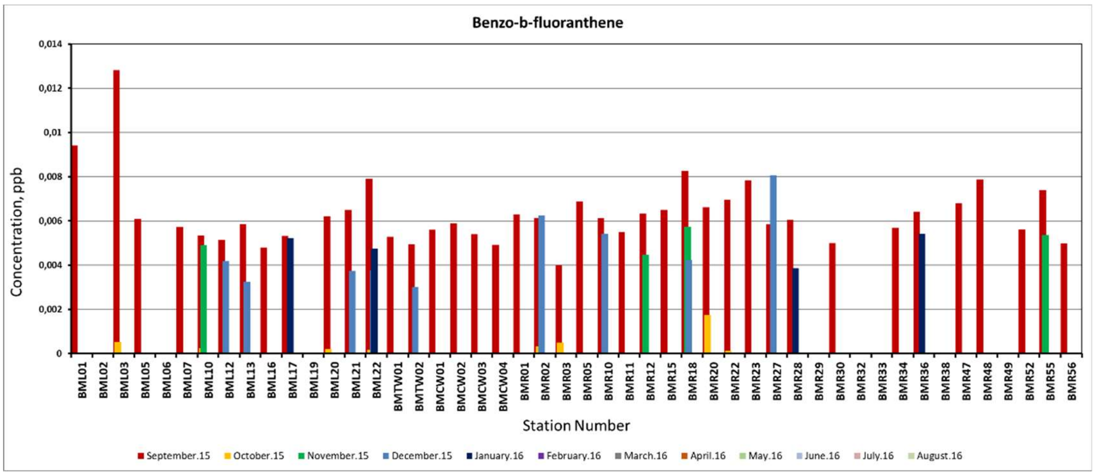

Figure 3.75 Monthly variation of Benzo-b-fluoranthene concentration at stations of BMRB

Benzo(k)fluoranthene is primarily found in gasoline exhaust, cigarette smoke, coal tar, coal and oil combustion emissions, lubricating oils, used motor oils and crude oils. It is used only for research purposes. Benzo(k)fluoranthene is reasonably anticipated to be a “human carcinogen” (PubChem Benzo(k)fluoranthene, 2019). Benzo-k-fluoranthene's MAC-EQS_w value is 0.017 ppb for rivers / lakes, coastal and transitional waters. It is in the list of priority pollutant given in WFD. It was most commonly observed in BMRB in September 2015, October 2015 and December 2015. The detected concentrations during 12 month monitoring period were mostly below 0.005 ppb. The concentration of this PAH reached to 0.045 ppb in BMR20 and 0.013 ppb in BMR03 in September 2015 (Figure 3.76). It was only observed once above the MAC value. Therefore, the contamination by this PAH in the basin is questionable.

Dibenz-a,h-anthracene was not in the national specific pollutants list to be monitored in water basins of Turkey. The analytical method for this PAH was available in the laboratory infrastructure of Dokuz Eylül University Measurement Laboratory. Therefore, there is no available MAC-EQS_w value for this PAH. Dibenz-a,h-anthracene was mostly detected in lakes and transitional waters in December 2015 and January 2016 periods. BMR01, BMR34 and BMR56 were the river stations where Dibenz-a,h-anthracene was observed. Its concentration in BMR20 reached to the maximum level of 0.007 ppb in December 2015 and January 2016. It was also detected in BML12, BML13, BML16, BML17, BML20, BML22 in the same monitoring periods (Figure 3.77).

Phenanthrene is one of the three ring PAHs with relatively higher water solubility. It has very little volatile property and it has the ability to accumulate in sediment. The solubility is increased by using toluene, ether, Chloroform, Acetic acid and Benzene. Phenanthrene is used in the production of intermediate explosives, paints and diphenic acids in pesticide production. Its half-life in a surface water is 16-200 days (Phenanthrene, 2019). It is included in the national list of specific pollutants to be monitored in water basins. Its MAC-EQS$_w$ value has been determined as 11.2 ppb. Phenanthrene was commonly observed in BMRB during September 2015 and October 2015 with the concentrations below 0.1 ppb. The maximum concentration was around 0.25 ppb in BML03 and it is below the MAC-EQS$_w$ value (Figure 3.78).

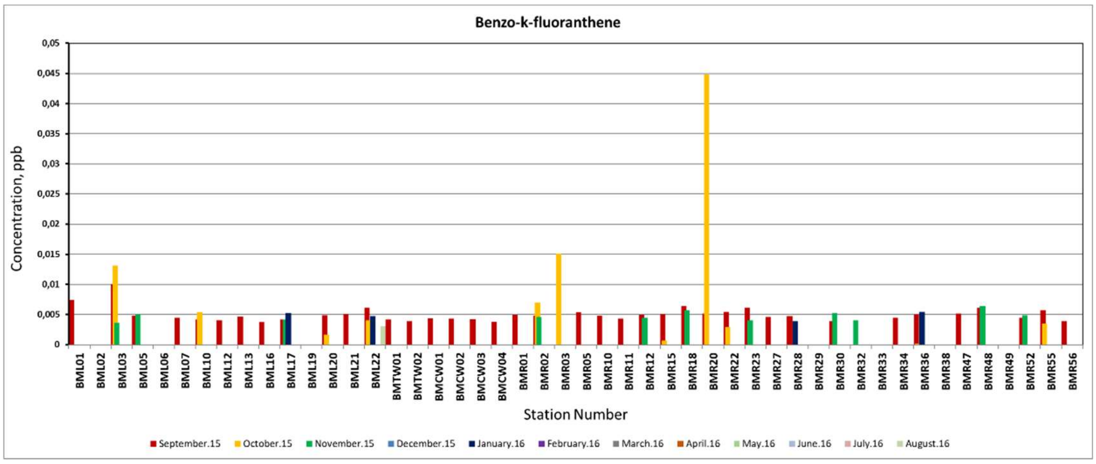

Figure 3.76 Monthly variation of Benzo-k-fluoranthene concentration at stations of BMRB

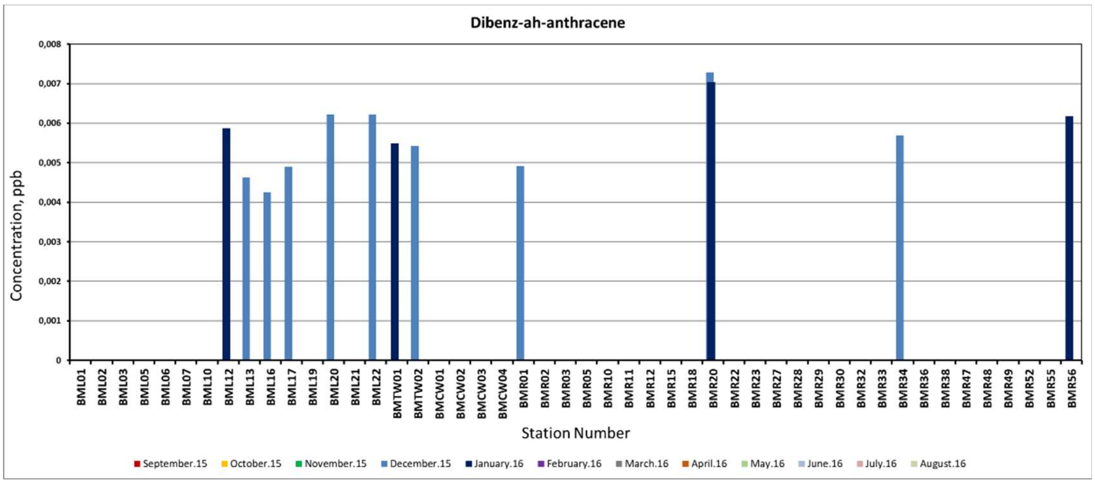

Figure 3.77 Monthly variation of Dibenz-ah-anthracene concentration at stations of BMRB

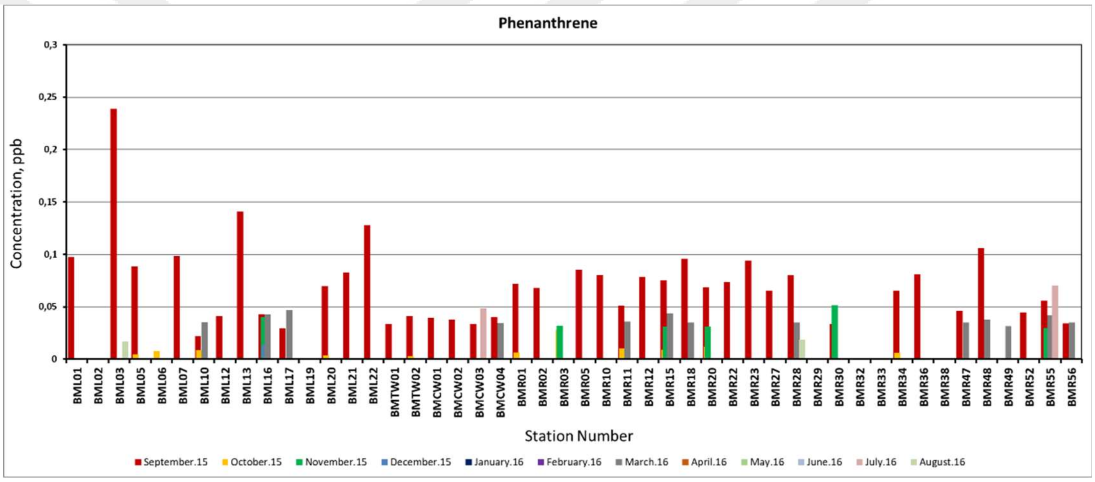

Figure 3.78 Monthly variation of Phenanthrene concentration at stations of BMRB

Fluoranthene is one of the four rings PAHs with the low solubility in water among. The solubility is increased by using hot alcohol. Fluoranthene sources are raw materials for paint production, pharmaceuticals and agricultural products. It is included in the possible cancer-causing chemical group due to its toxicity. Its water solubility is 0.26 mg / L, half-life in the air 5 hours, half-life in the soil is between 150-200 days (Fluoranthene, 2019). It is included in the list of priority pollutants of WFD and its MAC-EQS$_w$ value is 0.12 ppb. It was commonly observed in September 2015 and December 2015 periods, between January 2016 and March 2016 and in June 2016 in the BMRB. The maximum concentration was observed in BML03 with 0.17 ppb which is above MAC-EQS$_w$ value means that, it could pose contamination risk in the river basin (Figure 3.79).

Fluorene is on the list of specific pollutants of Turkey. Florene is a very low volatility solid with 3 ring structure. Its solubility in water is very low. It has very little volatile property and therefore, it can accumulate in sediment. The solubility is increased by using glacial acetic acid, methanol, in hot alcohol, acetone, benzene, carbon disulfide and toluene. Sources of Fluorene are incomplete combustion of coal, oil, gas, wood, garbage, tobacco and charred meat. It is found in coal tar and sewage sludge. It is released into the air from asphalting and diesel exhaust. It is very toxic to aquatic organisms and carcinogenic (Pubchem, Fluorene, 2019). It was commonly observed in the basin in September 2015 and November 2015 and. The detected concentrations were below 0.04 ppb. The maximum observed concentration of 0.09 ppb was even below MAC-EQS$_W$ (47 ppb) means that this PAH is not a main contaminant in the basin (Figure 3.80).

Indeno-(1,2,3-cd)-pyrene (Ind) is one of the least soluble PAHs with its 6-ring structure. It has very little volatile property and therefore, it can accumulate in sediment. The solubility is increased by using benzene, ethylene, toluene. Indeno-(1,2,3-cd)-pyrene could be generated from plastic, petrochemical and metal industry emissions. It is toxic to aquatic life and also carcinogenic. Its half-life in surface water is not known, but the half-life in sediment is between 58-730 days. MAC-EQS$_W$ value is uncertain. The highest concentration observed in the Büyük Menderes River Basin is around 0.12 ppb. Although commonly detected along the basin in September 2015, the concentrations are often less than 0.01 ppb (Figure 3.81).

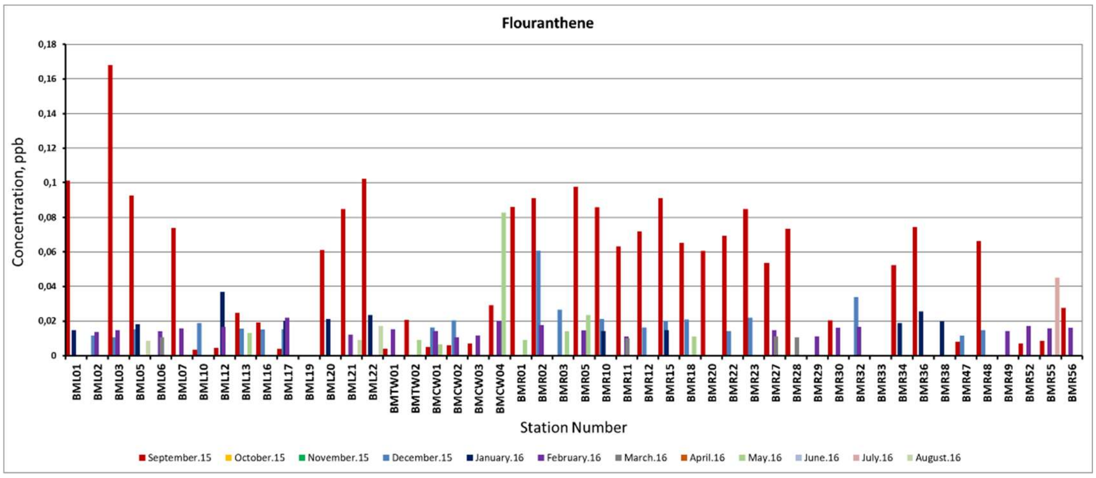

Figure 3.79 Monthly variation of Fluoranthene concentration at stations of BMRB

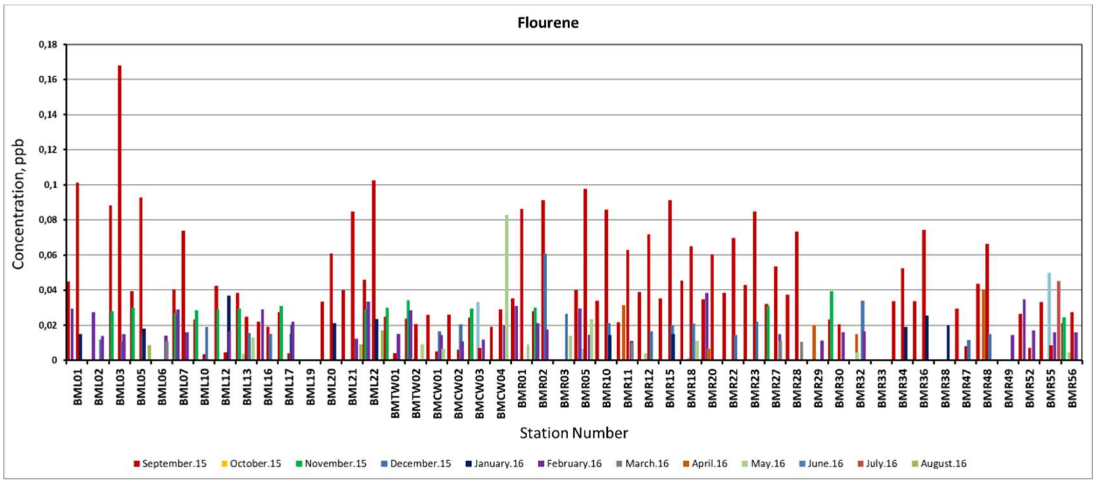

Figure 3.80 Monthly variation of Flourene concentration at stations of BMRB

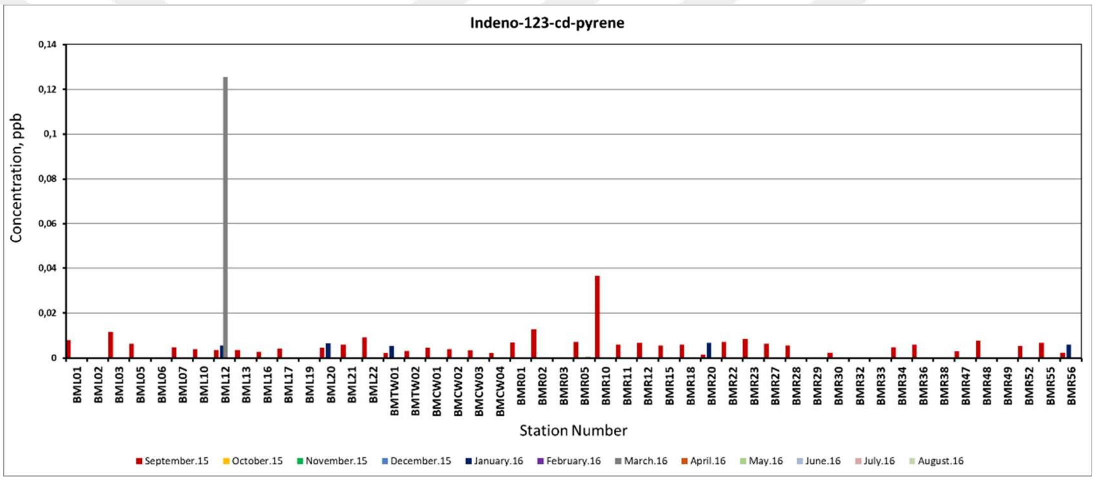

Figure 3.81 Monthly variation of Indeno-123-cd-pyrene concentration at stations of BMRB

Chrysene is another PAH in specific pollutant list of Turkey. Slightly soluble in alcohol, ether, carbon bisulfide, and glacial acetic acid. Moderately soluble in boiling benzene. Insoluble in water. Chrysene is more likely to be found mixed with other PAHs in commercial products like coal tar, coal tar pitch, creosote, bitumen and asphalt. Coal tar is used as a fuel in the steel industry, distilled to give coal tar pitch and creosote, and it has been used in the clinical treatment of skin disorders such as eczema and dermatitis. Chrysene has long lasting effects for aquatic life and it is very toxic (Pubchem, Chrysene, 2019). MAC-EQS$_w$ for Chrysene is 19 ppb. It was generally detected at concentrations below 0.05 ppb in all the stations. The highest concentration of 0.37 ppb was observed in March 2016 at BMR27 station (Figure 3.82).

Naphthalene is in the list of priority pollutants of WFD. It has low solubility in water but can be increased by using benzene, alcohol, ether and acetone. Wastewater from leachate, plastic, detergent, paint, pharmaceutical, food, petrochemical and metal industries are the main naphthalene sources in the environment. It has a very toxic effect on aquatic organisms. Its half-life in water is 4-8 hours. Its observed concentrations, reported by EPA, is in the range of 0.74 ppb and 73 ppb. The MAC-EQS_w value given in WFD is 130 ppb. Naphthalene concentration did not exceed this value in BMRB during the monitoring period of years between 2015-2016. It was more commonly detected in September 2015-December 2015 at the concentrations below the MAC-EQS_w (Figure 3.83).

Perylene is another PAH included in the list of specific pollutants. It has low solubility in water but the solubility can be increased. It could be freely soluble in carbon disulfide, chloroform; moderately soluble in benzene; slightly soluble in ether, alcohol, acetone; very sparingly soluble in petroleum ether and finally, very soluble in acetone, chloroform. It will not volatilize into air from soil and water surfaces. Perylene has long lasting effects on aquatic life and it is toxic (Pubchem, Perylene, 2019).The MAC-EQS_w value given in WFD is 0.6 ppb. It was detected only in November 2015 and February 2016 with the concentrations as 0.0045 ppb and 0.00158 ppb at stations BMR55 and BMR38, respectively (Figure 3.84). It is a PAH which does not pose a contamination risk in the basin

Pyrene is in the list of specific pollutants of Turkey. It has low solubility in water but it can be increased by using ethanol, ethyl ether, benzene, toluene. It will be slightly soluble in carbon tetrachloride. Pyrene in solid state has got very low volatility. It has the ability to accumulate in sediment. Pyrene has long lasting effects for aquatic life and it is very toxic (Pubchem, Pyrene, 2019). The MAC-EQS_w value given in WFD is 0.4 ppb. It was commonly detected in almost all stations of river basin for the sampling periods of September 2015 and December 2015. The maximum concentration of 0.36 ppb was determined in BML02. It is a PAH which carries a risk of being close to 0.4 ppb (Figure 3.85).

The only PAH that exceeds AA-EQS$_w$ (0.0063 ppb) is Florenthene. The annual average concentrations at each station were given in Figure3.86. The annual average concentration of Floranthene reach up to 0.02 ppm at a lake station (BML03). The other type of evaluation could be done based on the detected concentrations of PAHs that exceeds MAC-EQS$_w$. These PAHs in BMRB are acenaphthene, benzo (k) fluoranthene, benzo-perylene, fluoranthene. In other word, certain preventive actions should be taken for these PAHs to prevent the pollution in BMRB and to reach the good ecological water status in the basin.

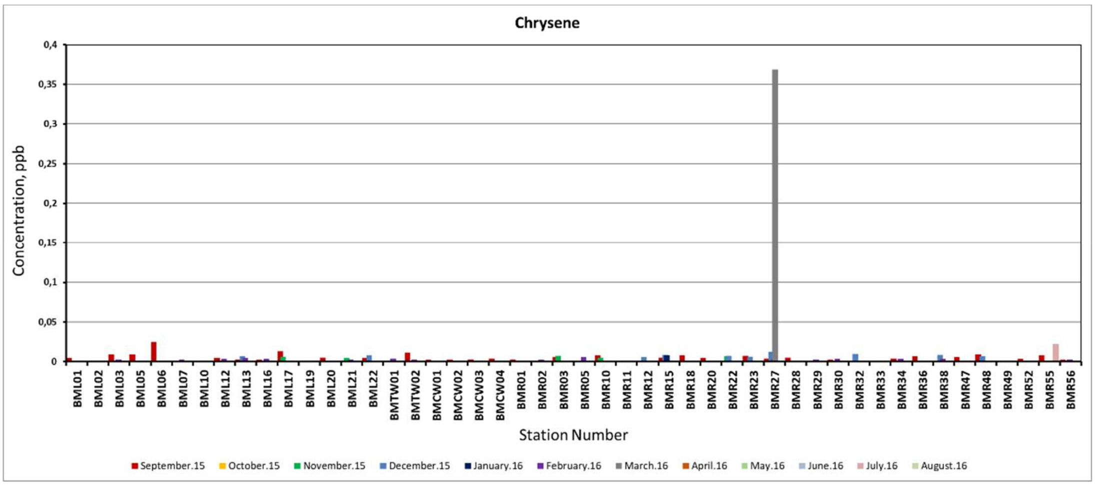

Figure 3.82 Monthly variation of Chrysene concentration at stations of BMRB

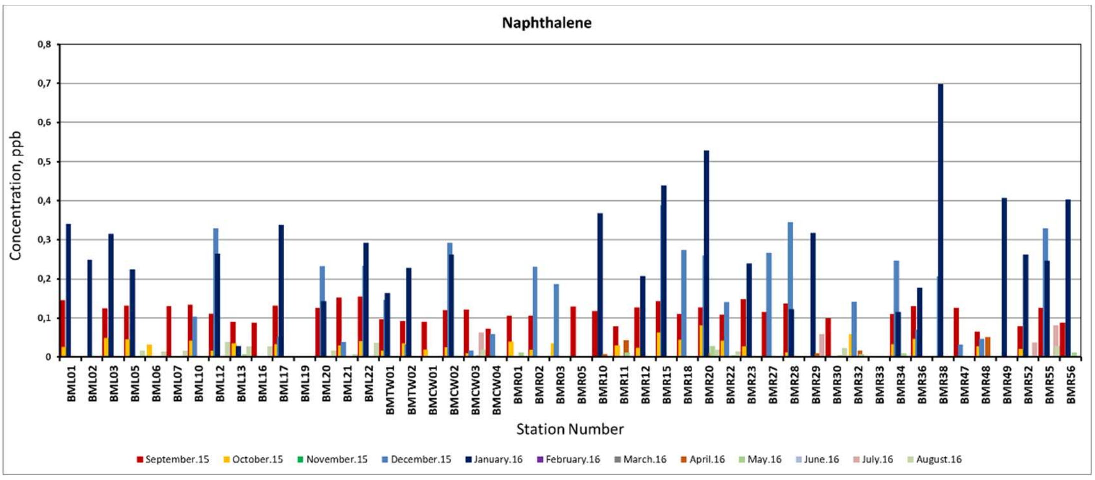

Figure 3.83 Monthly variation of Naphthalene concentration at stations of BMRB

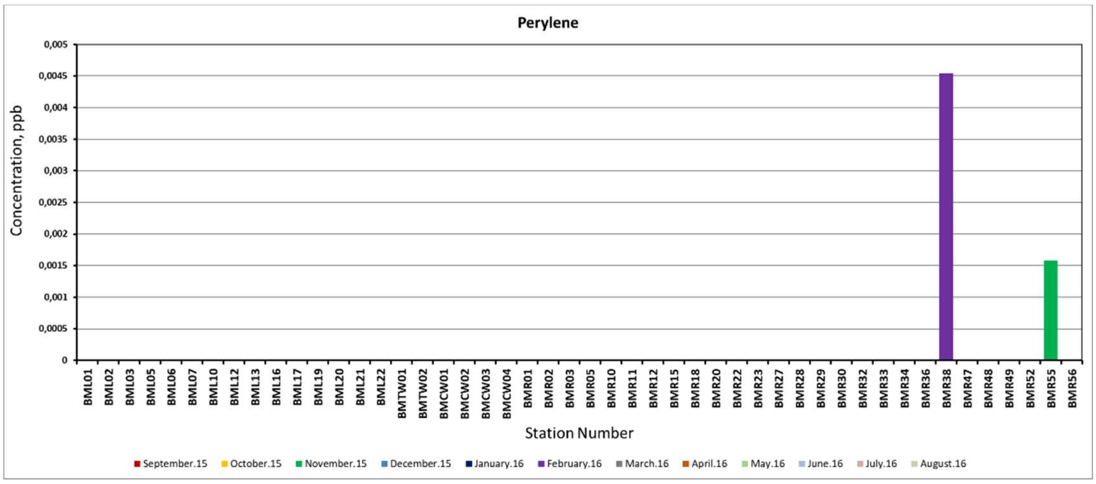

Figure 3.84 Monthly variation of Perylene concentration at stations of BMRB

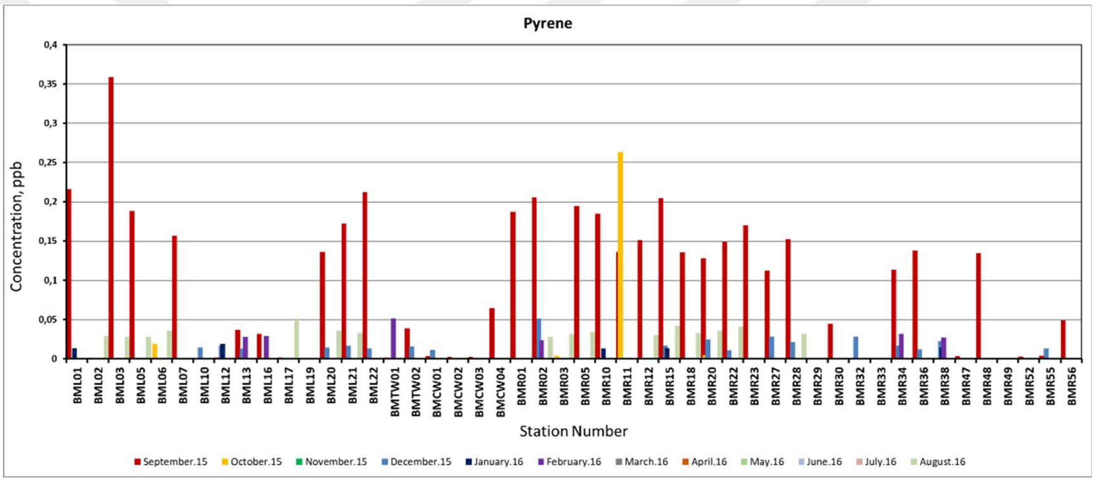

Figure 3.85 Monthly variation of Pyrene concentration at stations of BMRB

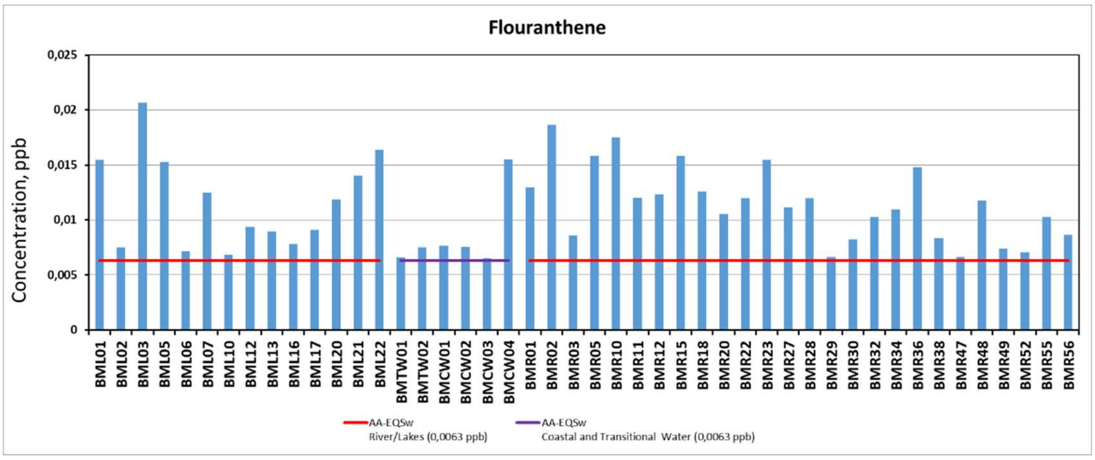

Figure 3.86 The annual average concentrations of Fluoranthene at the stations of BMRB

3.1.3 The Other Organic Pollutants in Büyük Menderes River

Phthalates, Alkylphenols, Chloroalkanes, PCBs and PFOS were evaluated in this group. As it was stated before, the concentration of some pollutants were below the LOD of the corresponding pollutants. However, they resulted in a very clear, symmetric chromatogram peaks in either GC MSMS or LC MSMS, then the reported concentrations by the equipment were given in the thesis to indicate that there was a possibility of contamination in the basin. The results of 12 months monitoring in the reviver basin were given in Figures between Figure 3.87 and Figure 3.106.

C10-C13 chloroalkanes are also called short-chain chlorinated paraffins (SCCPs). It is in the oily liquid phase and generally odorless. It is used in metal industry, sealants, as a fire retardant in textile and tires, leather industry and paints. It is persistent in nature and not readily biodegradable. It has toxic effects on aquatic life and accumulates when it is at high concentration. The half-life in the air is between 0.85-7.2 days. It is adsorbed to sediment and soil but there is not enough data about its persistence in these environments. The MAC-EQS$_w$ value of the chloroalkanes is 1.4 ppb. The concentrations below 0.05 ppb were generally observed in the basin. However, in February 2016, 5 ppb concentration of chloroalkane was detected in BMG20 and it was above the MAC-EQS$_w$ value (Figure 3.87). The AA-EQS$_w$ value of SCCP is 0.4 ppb and it was exceeded in BMG20 (Figure 3.88).

Perfluorooctane sulfonic acid (PFOS) is one of the priority pollutants listed in WFD. PFOS is an 8-carbon compound. They do not dissociate in nature due to their carbon-fluorine bonds. PFOA is mainly used as an emulsifier in the production of fluoropolymer and polytetrafluoroethylene (PTFE) in industry and through that, it provides resistance against water and stain in products such as textiles, leather, carpets and prevents the passage of oil in food packages. The compound has been also reported to be included in the structure of non-stick kitchen utensils with products such as fire extinguishing foams, pesticide formulations, paints, adhesives, polishes and household cleaning products, pharmaceutical preparations, cosmetics and denture cleaners. It has a carcinogenic effect on humans. The boiling point is 192

° C and its water solubility is 4340 mg /L. The half-life is estimated to be 3.8 years (Ünlü Endirlik & Gürbay, 2018). PFOS was detected around 0.0035 ppb only in BMN10, BMN11 and BMN12 for the monitoring periods from November 2015 to March 2016. The MAC-EQS_w value is 36 ppb for rivers and lakes, and 7.2 ppb for coastal and transitional waters. The allowed annual average concentrations in WFD were 0.00065 ppb for rivers and lakes, 0.00013 ppb for coastal and transition water. The determined PFOS concentrations were considerably lower than these limit values (Figure 3.89). On the other hand, the annual average concentration of SCCP at BMN10 station was 0.0032 ppb which is slightly above its LOD value (0.003 ppb) (Figure 3.90). This result could be evaluated as a potential risk of PFOS pollution in the river basin. However, PFOS was detected only once in the station at a concentration of 0.004 ppb means that there could be a really low possibility of PFOS contamination in the basin.

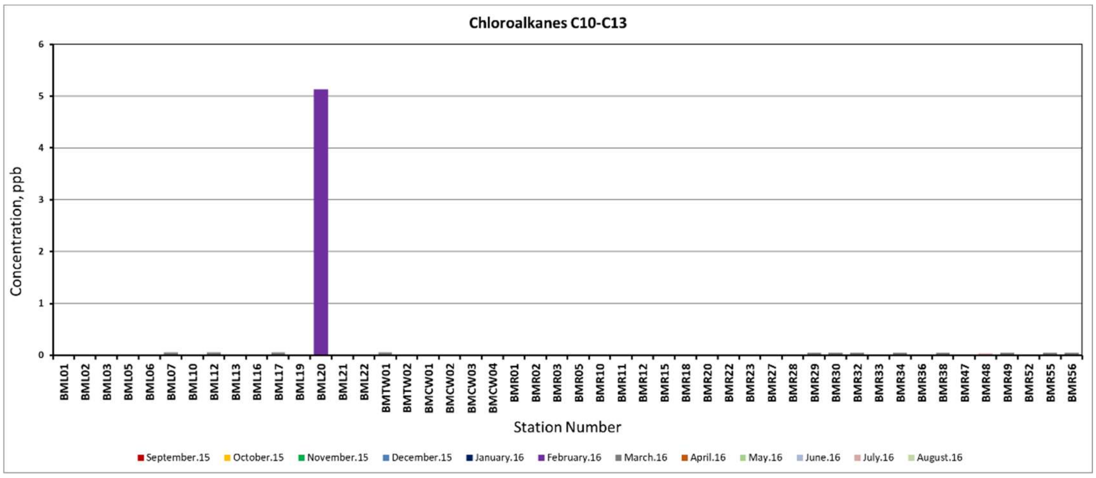

Figure 3.87 The observed Chloroalkanes C10-C13 concentrations at the station of BMRB for the monitored period

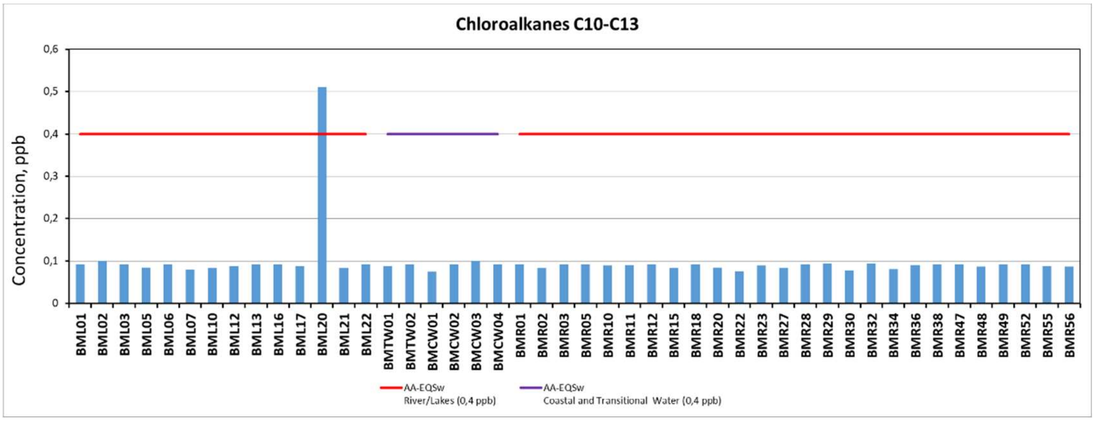

Figure 3.88 The annual average concentrations of Chloroalkanes (C10-C13) at the stations of BMRB

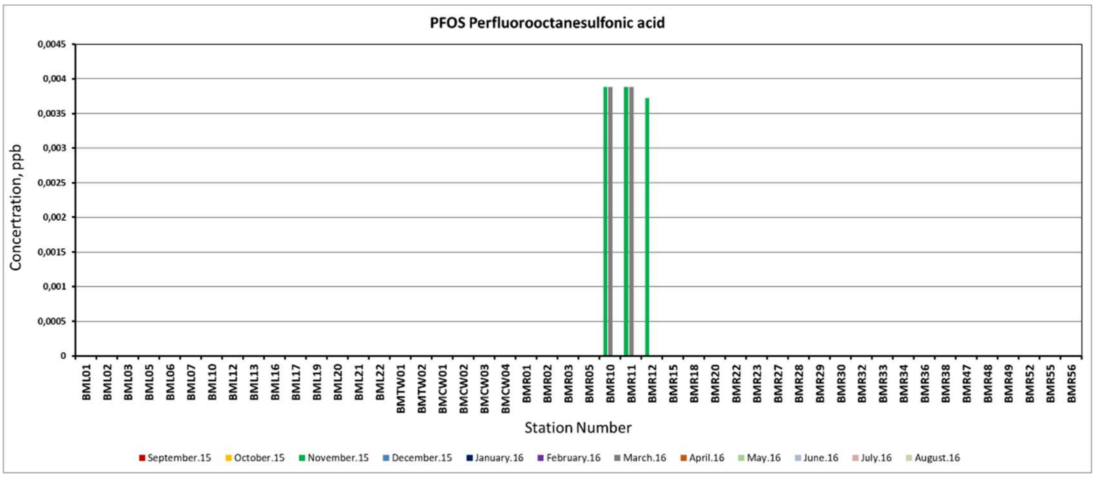

Figure 3.89 The observed PFOS (Perfluorooctanesulfonic acid) concentrations at the station of BMRB for the monitored period

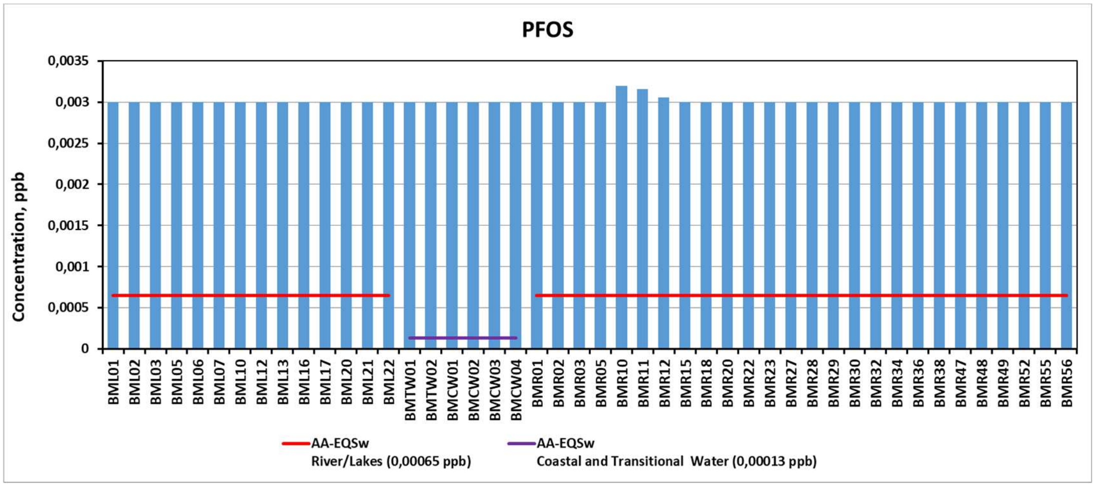

Figure 3.90 The annual average concentrations of PFOS at the stations of BMRB

PCBs can be produced directly, as well as by-products of organic chlorine compounds such as PVC production or they could be generated as a result of waste incineration. It is widely used as insulating fluids in transformers and condensers (or capacitors) in heat transfer and hydraulic systems and it could be used as an ink solvent in carbonless copy paper. It is also used in lubricating and cutting oils, paints, adhesives, insulating materials. It can be replaced with up to 10 chlorine atoms. Theoretically, there are 209 different PCB compounds. The available commercial chemical compounds or PCB molecules are about 130. Their half-life in water is at the level of years. The PCBs monitored in the concept of the thesis were PCB101 (Figure 3.91), PCB118 (Figure 3.92), PCB138 (Figure 3.93), PCB153 (Figure 3.94), PCB28 (Figure 3.95), PCB31 (Figure 3.96) and PCB52 (Figure 3.97). These were listed in the national specific pollutants of Turkey to be monitored in the natural water bodies. There is no MAC-EQS$_w$ value for PCB118. MAC-EQS$_w$ value for the other monitored PCBs, except for PCB101, is 0.02 ppb for all water bodies. The limit value for PCB101 is 0.25 ppb in rivers and lakes while it is 0.02 ppb in coastal and transitional waters. PCB contamination was predominant in BMN29 and BMN55 especially in April 2016. The concentrations exceeding the MAC-EQS$_w$ value were observed during the monitoring period. However, the annual average concentrations of the PCPs were generally lower than the limit AA-EQS$_w$. Two examples of the annual average concentrations were presented in the thesis. These are PCB138 and PCB153 as given in Figure 3.98 and Figure 3.99 respectively. PCB 153 exceeded the limit annual average concentration at BMR29 at which most of the PCBs were detected at higher concentrations in April 2016.

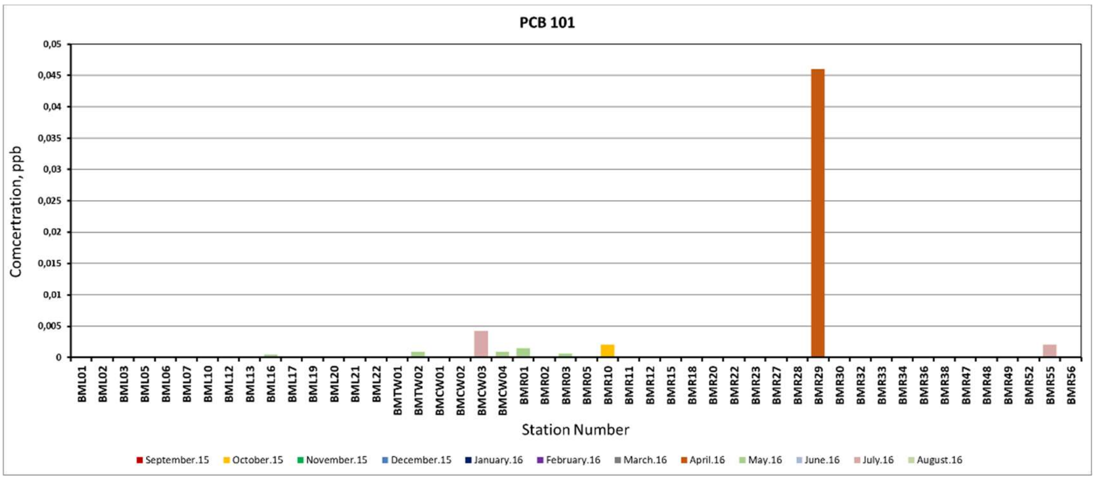

Figure 3.91 The observed PCB 101 concentrations at the station of BMRB for the monitored period

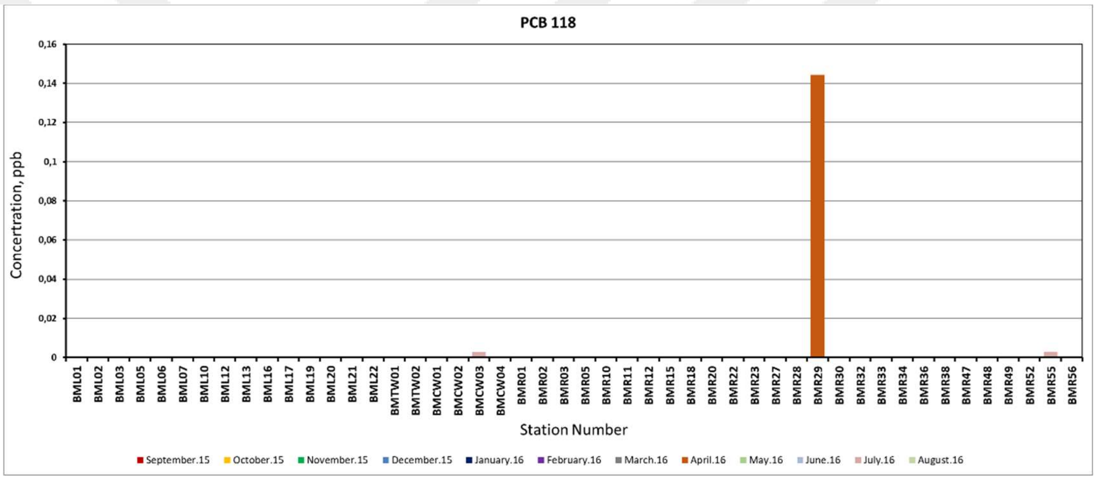

Figure 3.92 The observed PCB 118 concentrations at the station of BMRB for the monitored period

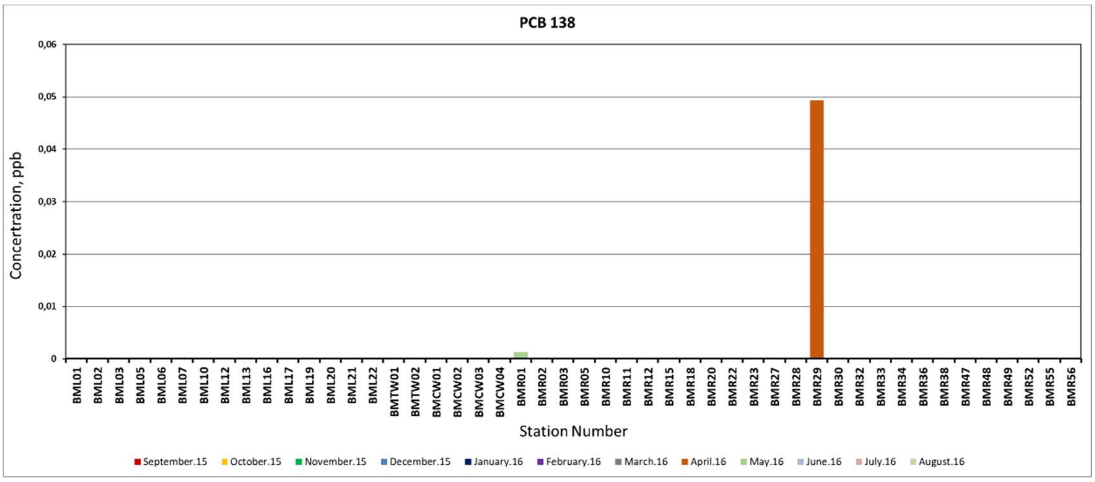

Figure 3.93 The observed PCB 138 concentrations at the station of BMRB for the monitored period

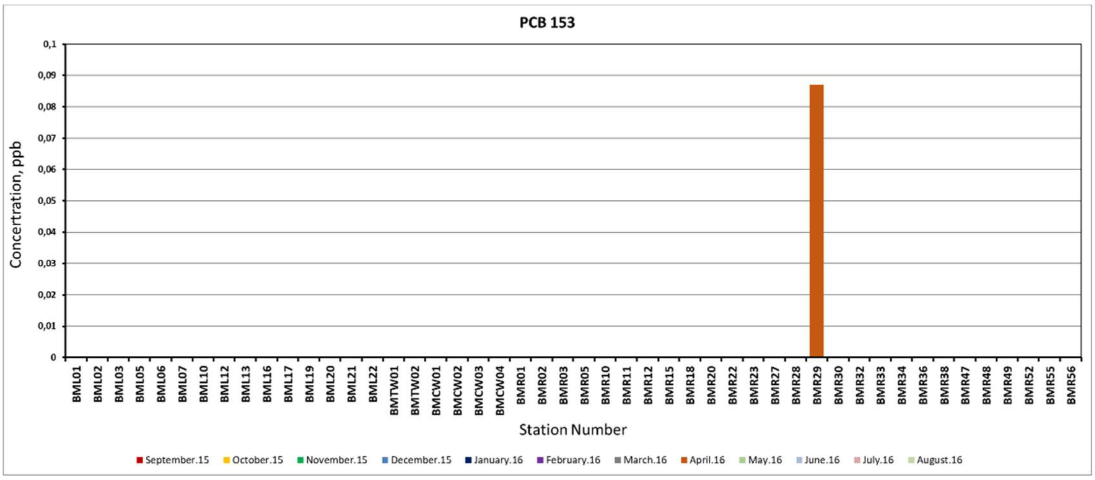

Figure 3.94 The observed PCB 153 concentrations at the station of BMRB for the monitored period

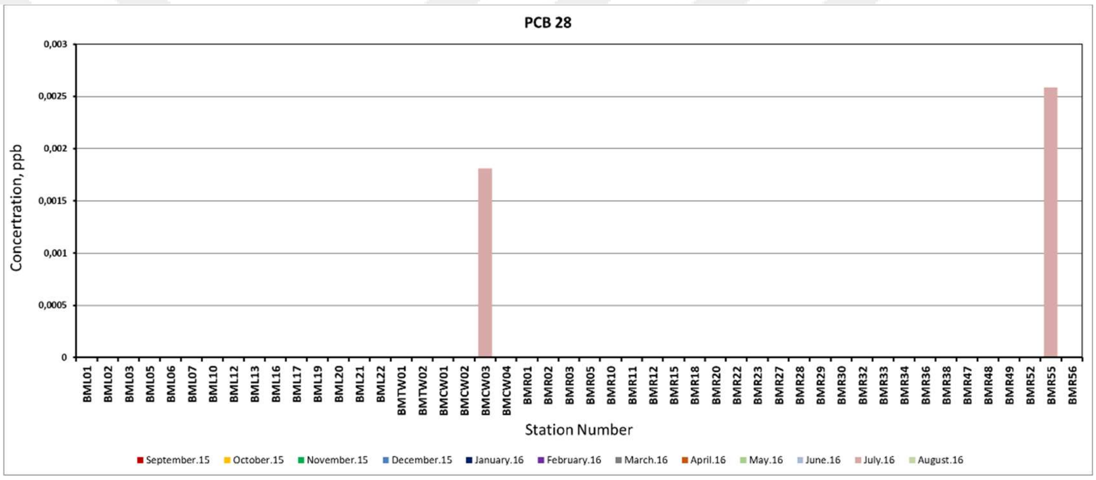

Figure 3.95 The observed PCB 28 concentrations at the station of BMRB for the monitored period

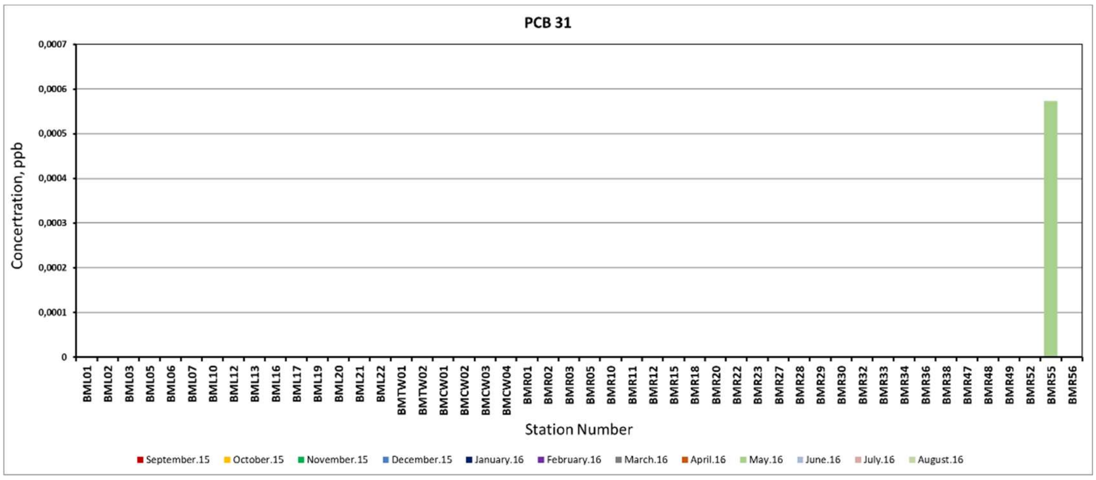

Figure 3.96 The observed PCB 31 concentrations at the station of BMRB for the monitored period

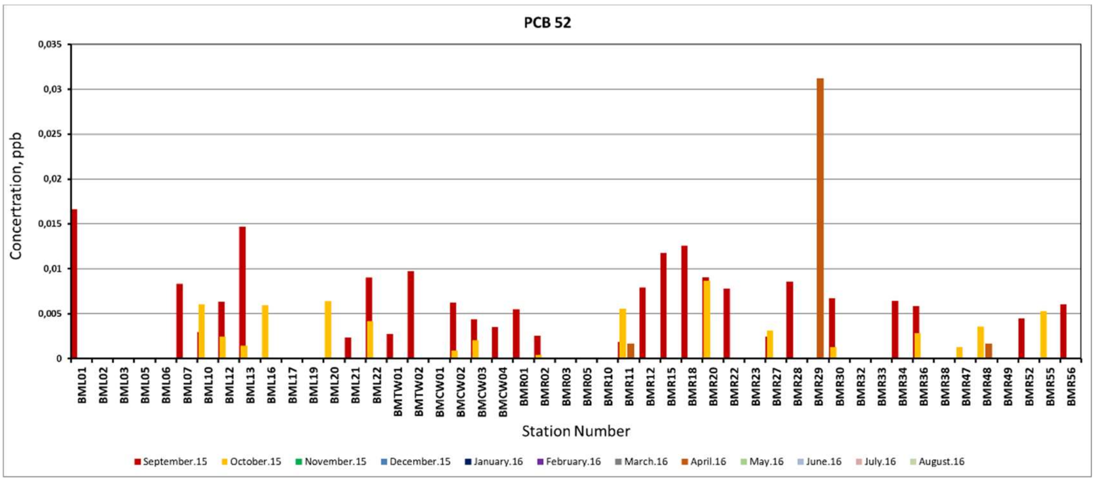

Figure 3.97 The observed PCB 52 concentrations at the station of BMRB for the monitored period

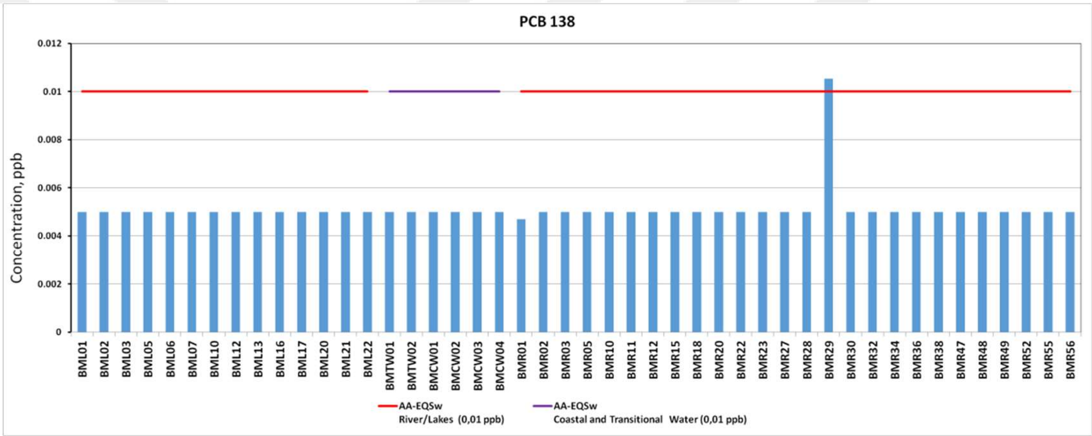

Figure 3.98 The annual average concentrations of PCB 138 at the stations of BMRB

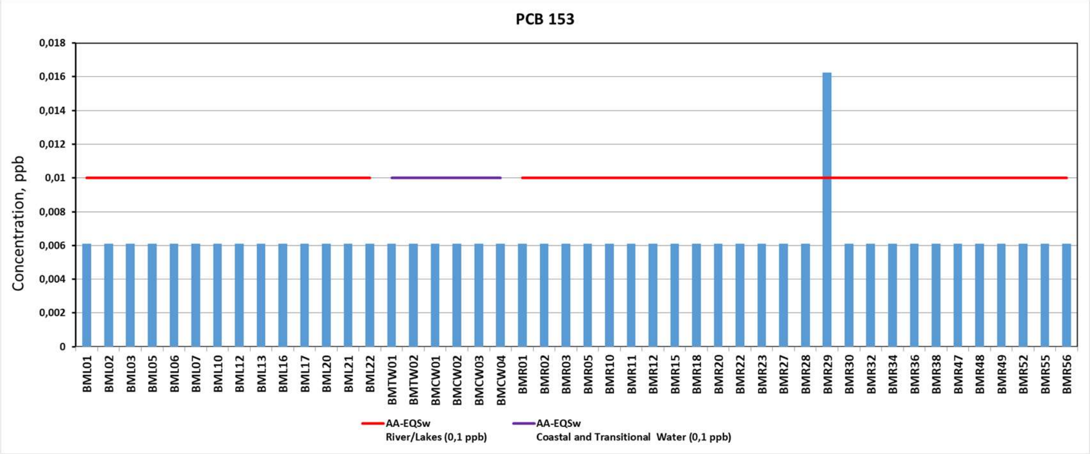

Figure 3.99 The annual average concentrations of PCB 153 at the stations of BMRB

Benzyl butyl phthalate (BBP) is a specific pollutant. BBP is used in products such as food conveyor belts, carpet tiles, artificial leather, tarpaulins and in automotive coatings. Its biggest use is the production of vinyl tiles. It is used in some vinyl gloves, in some adhesives and caulking products. Mainly used in plastic production. The boiling point is 370 ° C. Water solubility is almost none. It has got serious damages to human health, such as low fertility, sperm damage and the risk of miscarriage in pregnancy. Toxic to aquatic environment. Its half-life lasts for years (Pubchem Benzylbutylphthalate (BBP), 2019). The MAC-EQS_w value for rivers and lakes is 44 ppb and 27 ppb for coastal and transitional waters. BBP was observed in BMN02 in November 2015 and March 2016 with the concentrations above LOD. But the concentrations were as low as 0.1 ppb and below the MAC-EQS_w value (Figure 3.100).

Di(2-ethylhexyl) phthalate (DEHP) is an in the priority pollutant group. DEHP is a manufactured chemical that is commonly added to plastics to make them flexible. DEHP is a colorless liquid with almost no odor. It is present in plastic products such as wall coverings, tablecloths, floor tiles, furniture upholstery, shower curtains, garden hoses, swimming pool liners, rainwear, baby pants, dolls, some toys, shoes, automobile upholstery and tops, packaging film and sheets. It is also used in sheathing for wire and cable, medical tubing, and blood storage bags. The boiling point is 384 ° C. Its solubility is 2.70×10^{-1} mg / L in water. It is soluble in blood and fluids containing lipoproteins, highly soluble in oils and it has a carcinogenic effect. It causes developmental disorders (Pubchem Di(2-ethylhexyl)phthalate (DEHP) , 2019). It was detected especially in the March 2016, June 2016 and July 2016 periods at almost all stations of the basin. The concentration at BMN27 in September 2015 was around 0.6 ppb levels. The MAC-EQS_w value has not been declared for this pollutant by the Ministry during the study period (Figure 3.101).

Dibutyl phthalate (DBP) is a specific pollutant. DBP is used to make plastics more flexible and it is also used in carpet backings, paints, glue, insect repellents, hair spray, nail polish, and rocket fuel. It is not a naturally occurring chemical. It is soluble in various organic solvents such as in alcohol, ether and benzene. The boiling point is 340 ° C. Water solubility is 0.0112 mg / mL. It is slightly soluble in water and does not evaporate easily. DBP is also used as an ectoparasiticide. It is an environmental contaminant that poses a risk to humans and has carcinogenic (Pubchem Dibutylphthalate, 2019). Dibutyl phthalate (DBP) was observed extensively in January 2016 and August 2016. The highest concentration was 8 ppb detected at BMG12 in August 2016. The MAC-EQS$_w$ is 96 ppb and all the observed concentrations were far below this allowed maximum concentration (Figure 3.102).

Bisphenol A (BPA), Nonylphenol (NP) and Octyl phenol (OP) are the contaminants from the alkyl phenol group. Bisphenol A is in the specific pollutant group. Bisphenol A (BPA) is a chemical component in hard plastics and is found in thermal papers (e.g. receipts), food and beverage packaging (cans, plastic bottles). It causes gynecological diseases and an increase in some hormones in men. Food packaging and plastic containers can be considered as the main sources. It is a carcinogen and an environmental pollutant. Boiling point at 1.7 kPa: 250-252 ° C. Insoluble in water but very soluble in ethanol, ether, benzene, alkali. It can't volatilize into air from soil and water surfaces. It is expected to move moderately to slowly through soil (Pubchem Bisphenol A, 2019). Its MAC-EQS$_w$ value is 252 ppb for rivers and lakes and 65 ppb for coastal and transitional waters (Figure 3.103). It was mainly observed in the basin in September 2015 with a maximum concentration of 0.25 ppb.

Nonylphenol (NP) is one of the priority pollutants listed in WFD. It is an environmental pollutant caused by the degradation of nonionic surfactants in sewage. It is used as surface-active agent in cleaning, in cosmetic products and as spermicide in birth control drugs. It poses risk to fertility and harmful to the unborn child. Insoluble in water but soluble in benzene, carbon tetrachloride and heptane. The boiling point is 317 ° C. This material is carcinogenic, irritant and harmful to the environment. Very toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment (Pubchem Nonylphenol, 2019). Although the highest concentration was obtained at BMN05, it is as low as 0.7 ppb and below MAC-EQS$_w$ value of 2 ppb (Figure 3.104).

Octylphenol (OP) is used in detergent and in industrial cleaning products as dispersant, stabilizer and antifoaming agents. It is also used in textile, polymer and surface treatment processes. It is a corrosive substance. The boiling point is 280 ° C. Insoluble in water but soluble in acetone. It is suspected of damaging fertility or the unborn child. It causes severe skin burns and eye damage. Very toxic to aquatic life with long-lasting effects (Pubchem Octyl phenol, 2019). Octylphenol (OP) was detected in BMN01, BMN05, BMN20 and BMN47 only in September 2015. The concentrations were above its LOD value but lower than MAC-EQS$_w$. The highest concentration was measured as 0.5 ppb in BMN34 and it is again lower than MAC-EQS$_w$ (Figure 3.105).

The concentrations of tinned compounds determined for all sampling periods at all stations. Tin is mostly used in cans and in jars. It is consumed in a wide range of fields such as paint, perfume, soap, polyurethane production, toothpaste production in the aircraft and ship industry, electrical and electronic industries, coating of steel plates, printing, kitchen equipment and glass industry. It may cause respiratory, digestive tract, eye and skin irritation. It can damage the central nervous system. The boiling point of thinned compounds is 2507 °C. Slightly soluble in hot water (Material Safety Data Sheet Tin Metal, 2000). The observed tin compounds concentrations were given in Figure 3.106. As it can be seen from the figure, the concentration of these compounds did not exceed the MAC-EQS$_w$ and AA-EQS$_w$ values in any stations. Similarly, cyanide, phenol and total hydrocarbons are included in the list of specific pollutants. However, the concentrations of these pollutants were below the LOD.

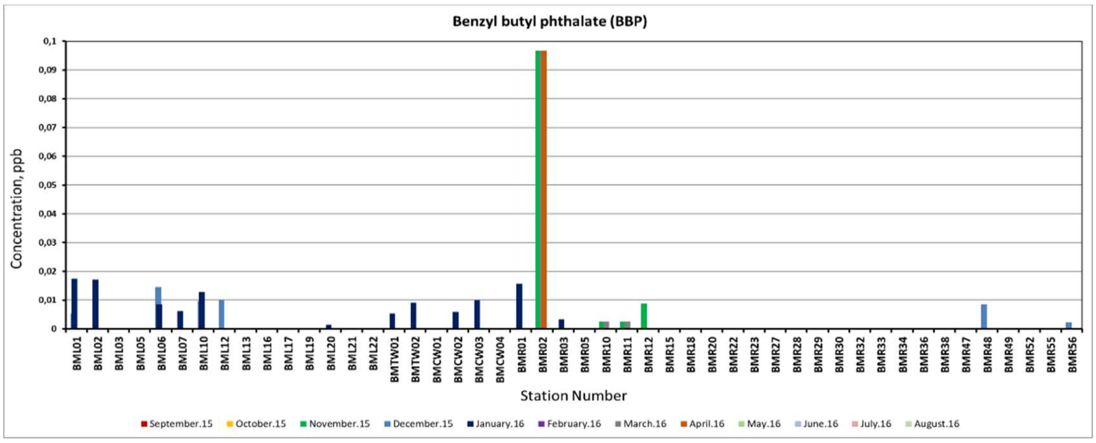

Figure 3.100 The observed Benzyl butyl phthalate concentrations at the station of BMRB for the monitored period

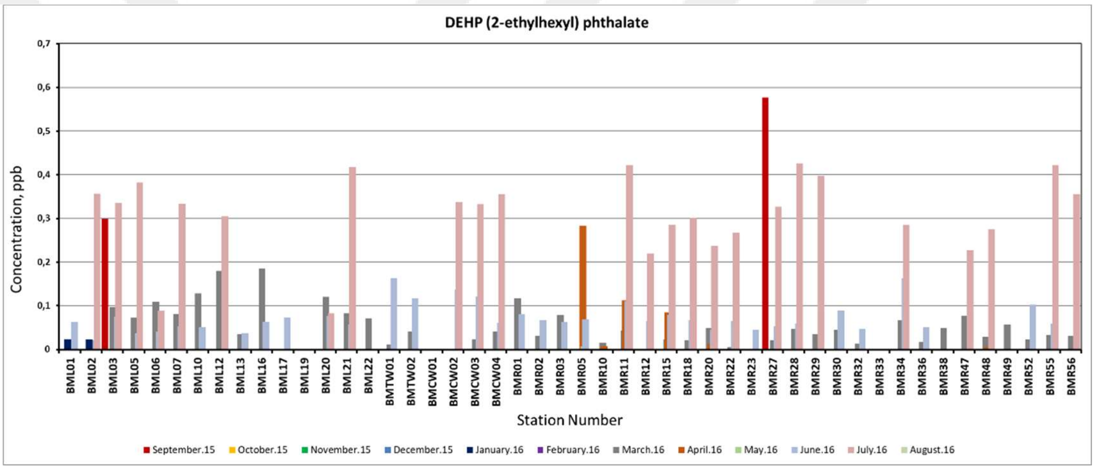

Figure 3.101 The observed DEHP (2-ethylhexyl) phthalate concentrations at the station of BMRB for the monitored period

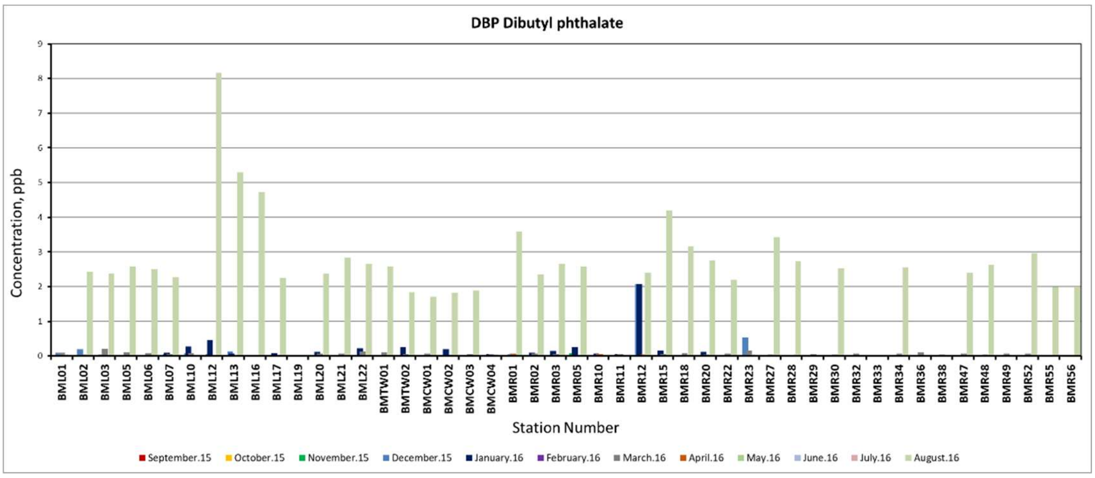

Figure 3.102 The observed DBP Dibutyl phthalate concentrations at the station of BMRB for the monitored period

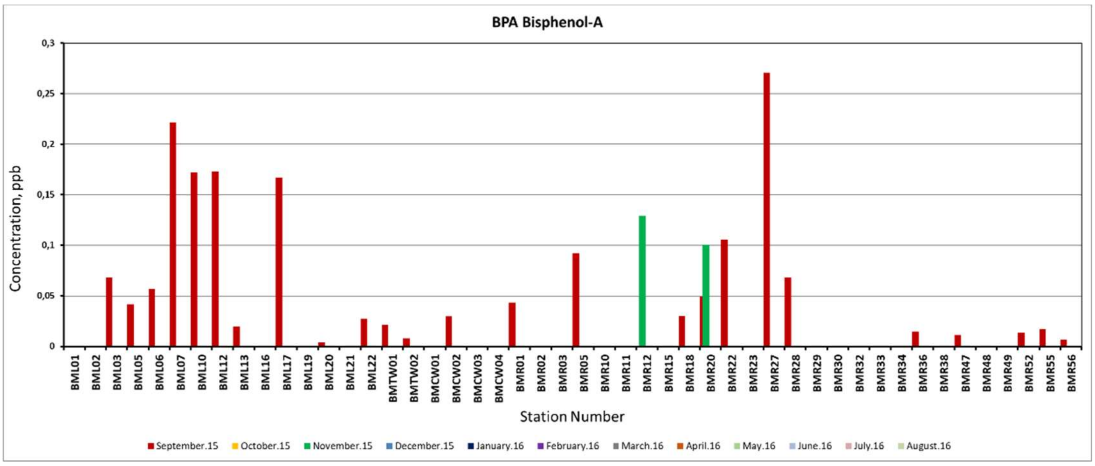

Figure 3.103 The observed BPA Bisphenol-A concentrations at the station of BMRB for the monitored period

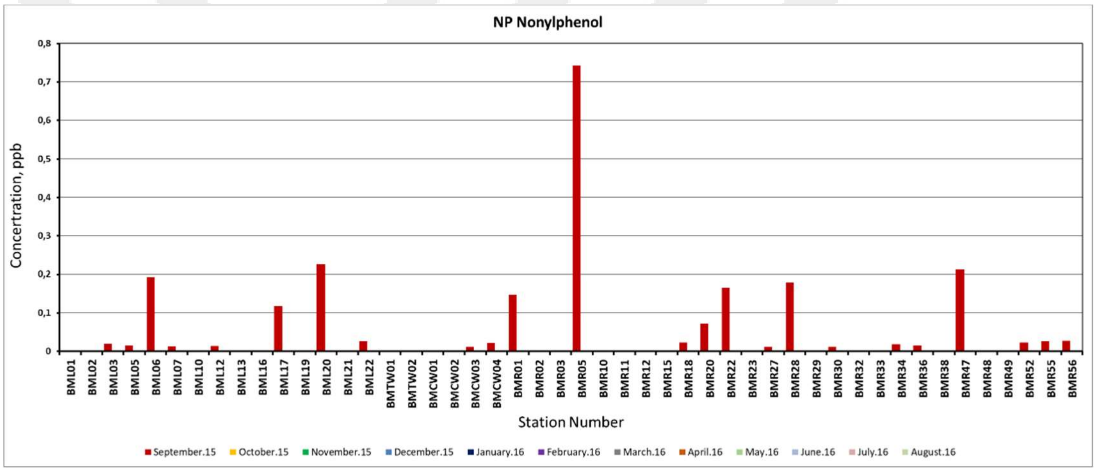

Figure 3.104 The observed NP Nonylphenol concentrations at the station of BMRB for the monitored period

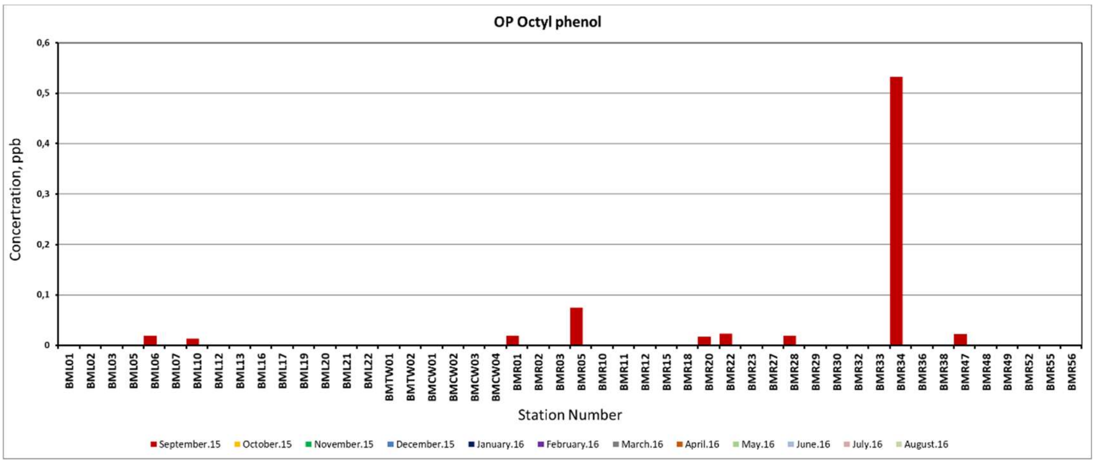

Figure 3.105 The observed OP Octyl phenol concentrations at the station of BMRB for the monitored period

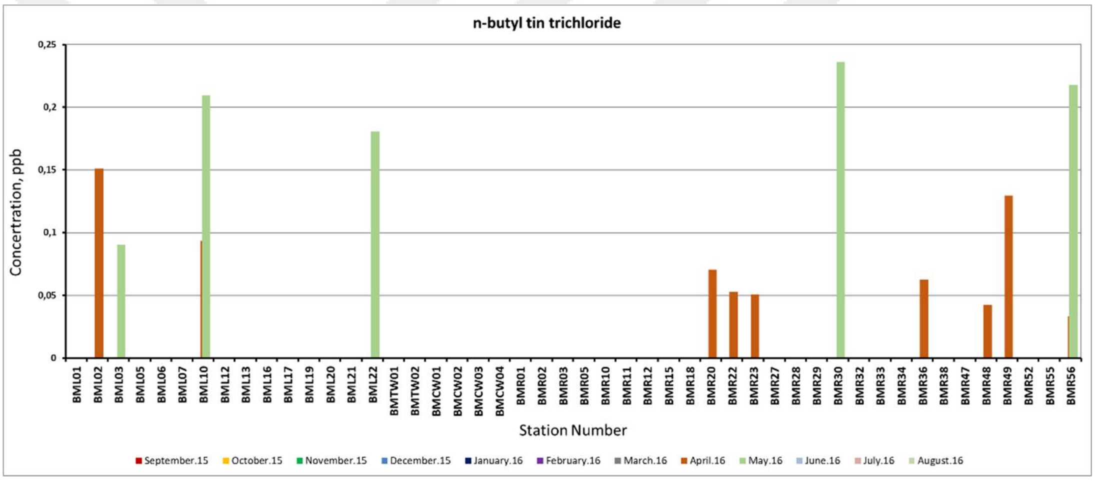

Figure 3.106 The observed n-butyl tin trichloride concentrations at the station of BMRB for the monitored period

3.1.4 Metal Pollution in Büyük Menderes River

Metal analysis results include September 2015 and August 2016 periods. Metal pollution was evaluated according to the LOD, MAC-EQS$_W$ values and the stations with the highest concentration. The concentration of metals observed in the BMRB during the monitoring period was given in figures between 3.107 and 3.142.

Aluminum (Al) is one of the major constituents of most soils**.** However, it is not required for plant growth. MAC-EQS$_W$ for rivers and lakes is 27 ppb. The aluminum concentrations at all lake and river stations were higher than its MAC-EQS$_W$ value.

The same situation was observed for the coastal and transitional waters at which MAC-EQS$_w$ is 22 ppb. The stations where annual average aluminum concentrations exceeded AA-EQS$_w$ value were given in Figure 3.108. The highest aluminum concentration detected in all periods was 7072 ppb which was observed at BMCW04 station in January 2016 (Figure 3.107). The major reason for the high aluminum concentration is due to washing out of aluminum from the soil with rainfall or irrigation. In other words, the background concentration is probably, already, high due to the soil structure. Therefore, high aluminum concentration is acceptable.

The concentration of antimony (Sb) in lakes and rivers did not exceed its MAC-EQS$_w$ (103 ppb). The highest antimony concentration obtained was 63.5 ppb at BMR01 station. When coastal and transitional waters considered, it was observed that the value of MAC-EQS$_w$ (45 ppb) was not exceeded (Figure 3.109). The stations where antimony exceeds AA-EQS$_w$ value were given in Figure 3.110.

Arsenic (As) has a MAC-EQS$_w$ value of 53 ppb and a LOD value of 0.95 ppb. Arsenic concentration was mostly below the MAC-EQS$_w$ value. The concentrations higher than MAC-EQS$_w$ were observed in BML06, BML07, BML10 and BML16 stations. Arsenic was observed in coastal and transitional waters, and the MAC-EQS$_w$ value was exceeded in BMTW01 and BMCW04 stations in January. Arsenic was detected in river waters every period, especially in the Yukarı Banaz BMR01 station, where industrial and domestic discharges are exceeded in all sampling periods. It reached a maximum level (2318 ppb) in July 2016. The highest concentration was 3813 ppb and it was observed in BML10 (Figure 3.111). The stations where the AA-EQS$_w$ value for arsenic exceeds were given in Figure 3.112.

When copper (Cu) monitoring results are analyzed, it is seen that MAC-EQS$_w$ (3.1 ppb) for river water, transitional water and MAC-EQS$_w$ (5.7 ppb) concentrations in the lake and coastal water stations were exceeded. It was observed that the copper concentration in the lakes was higher than MAC-EQS$_w$ (3.1 ppb) at least once during all monitoring periods. The same results were observed in coastal and transitional waters means that MAC-EQS$_w$ (5.7 ppb) has been exceeded at least once. The copper pollution was heavy at river stations, especially at BMR05, BMR20, BMR52 and BMR55. The observed concentrations were around 30 ppb which is far above the MAC-EQS$_W$ value. In summary, it can be concluded that there is significant copper pollution in Büyük Menderes River Basin. The highest concentration obtained in all periods was 500 ppb and it was observed in BML06 (Figure 3.113). The stations where the copper exceeds the AA-EQS$_W$ value were given in Figure 3.114.

The barium (Ba) concentration did not exceed 680 ppb MAC-EQS$_W$ value at any station (Figure 3.115). It is clear that there is no barium pollution in the basin.

Beryllium (Be) concentrations observed in coastal and transitional waters, lakes and rivers were mostly lower than LOD. The MAC-EQS$_W$ value is 3.9 ppb which was exceeded in the BML06 and BML07 stations in lakes only once in May 2016. Although beryllium was observed in coastal and transitional waters in December 2015 and January 2016, the MAC-EQS$_W$ value was not exceeded. Similarly, beryllium was observed in rivers time to time during monitoring period but MAC-EQS$_W$ value was only exceeded at BMR01 station in February 2016. The highest concentration obtained in all periods was 12810 ppb which was observed in BMR01 (Figure 3.116).

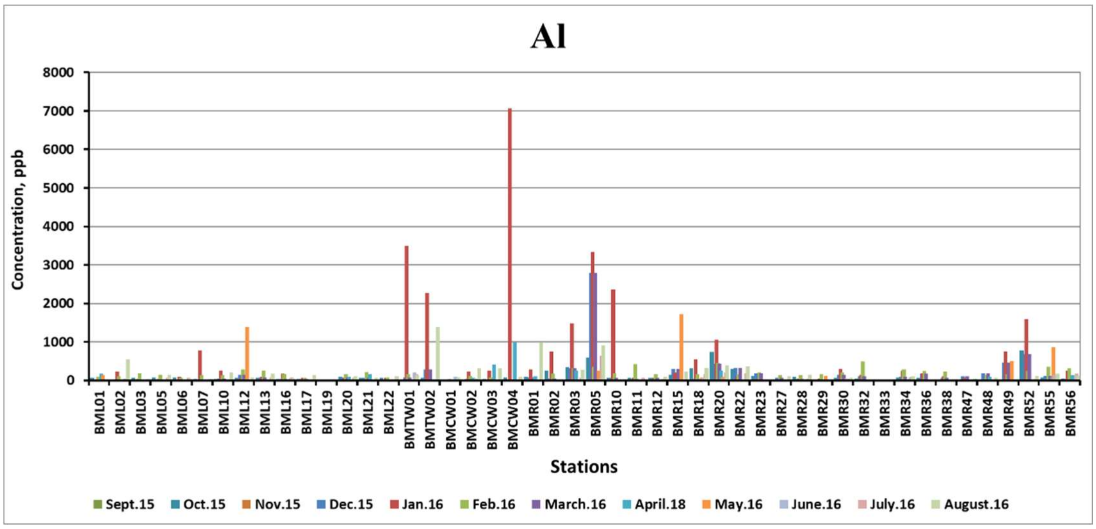

Figure 3.107 Monthly variation of Al concentration at stations of BMRB

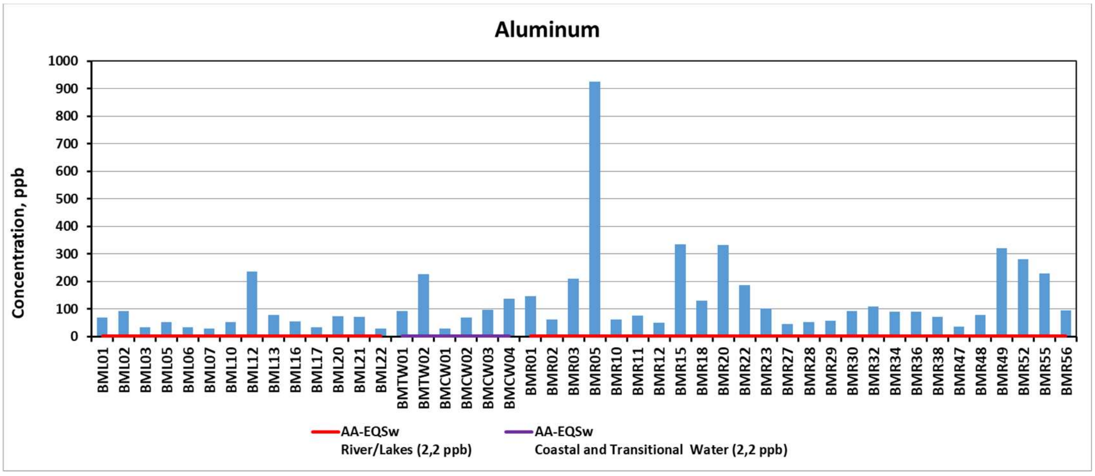

Figure 3.108 The annual average concentrations of Aluminum at the stations of BMRB

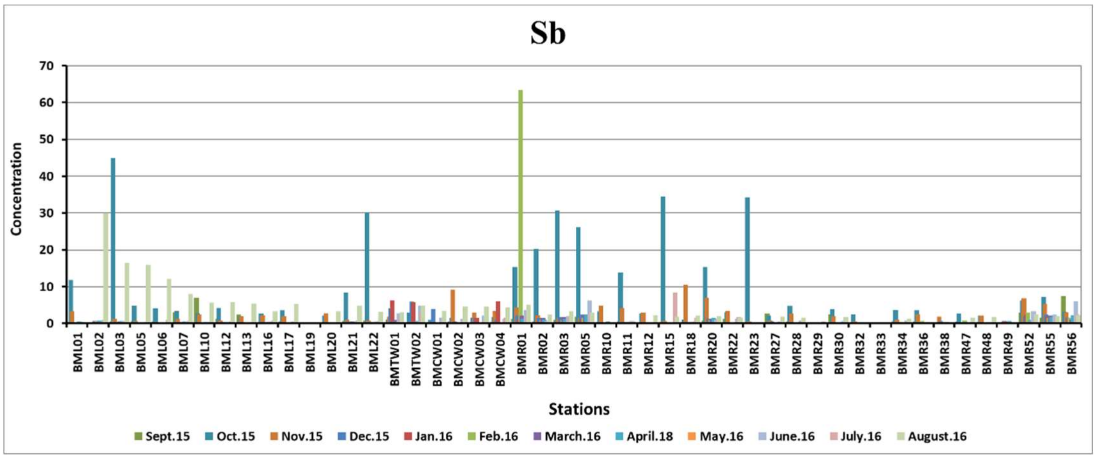

Figure 3.109 Monthly variation of Sb concentration at stations of BMRB

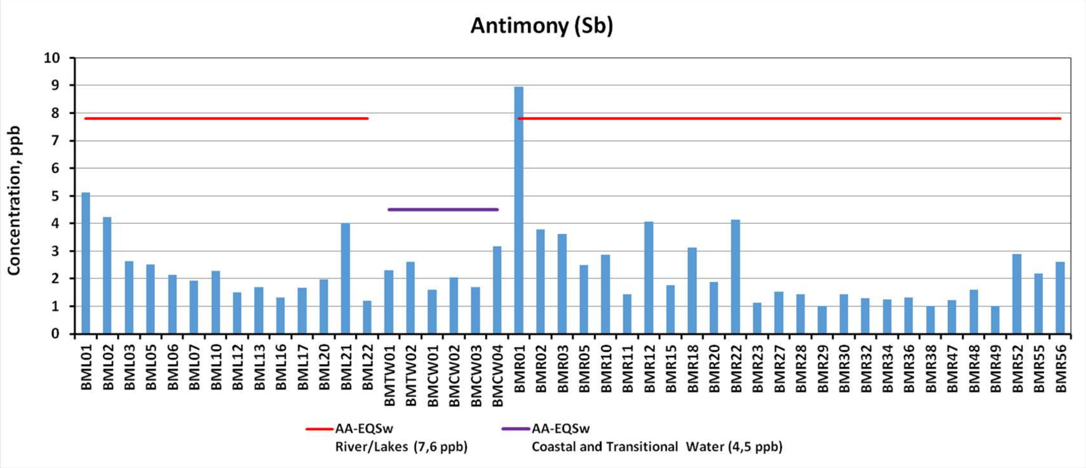

Figure 3.110 The annual average concentrations of Antimony (Sb) at the stations of BMRB

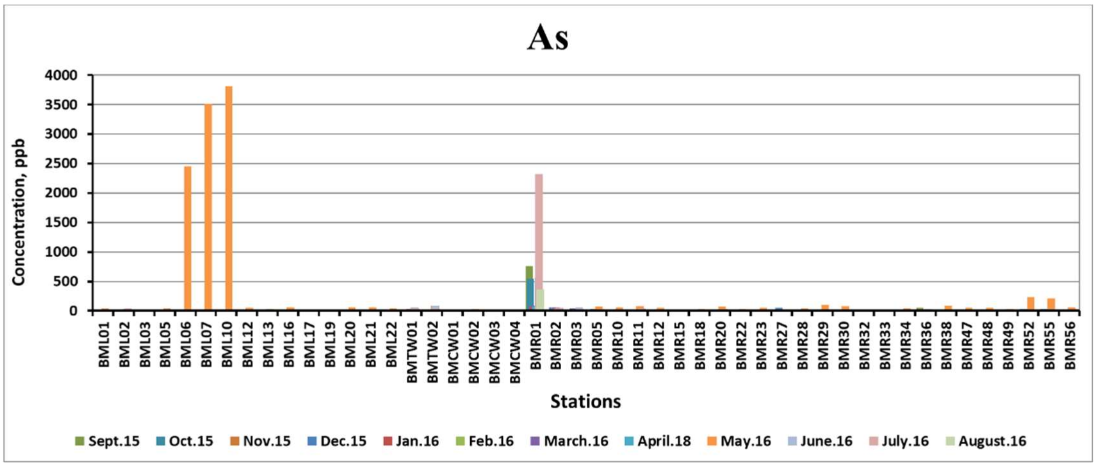

Figure 3.111 Monthly variation of As concentration at stations of BMRB

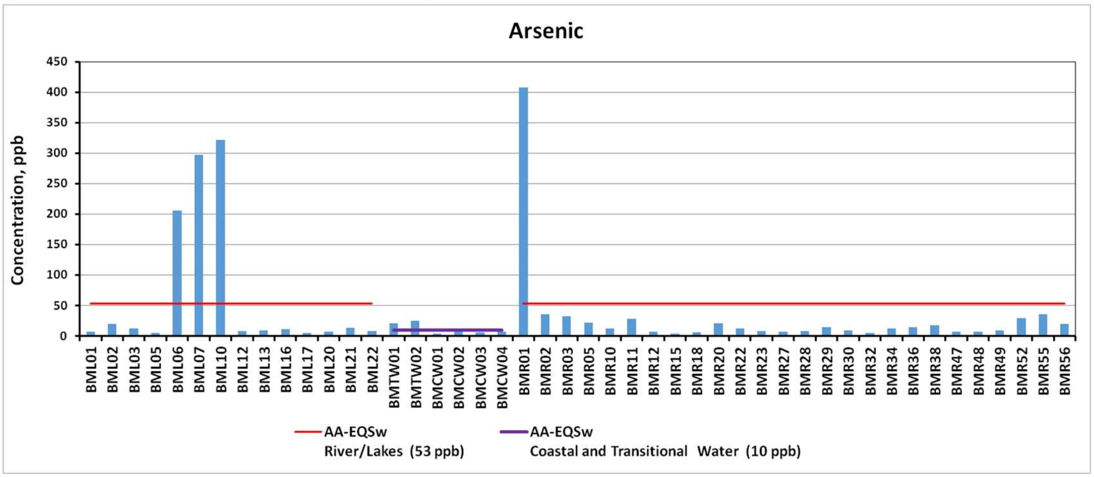

Figure 3.112 The annual average concentrations of Arsenic at the stations of BMRB

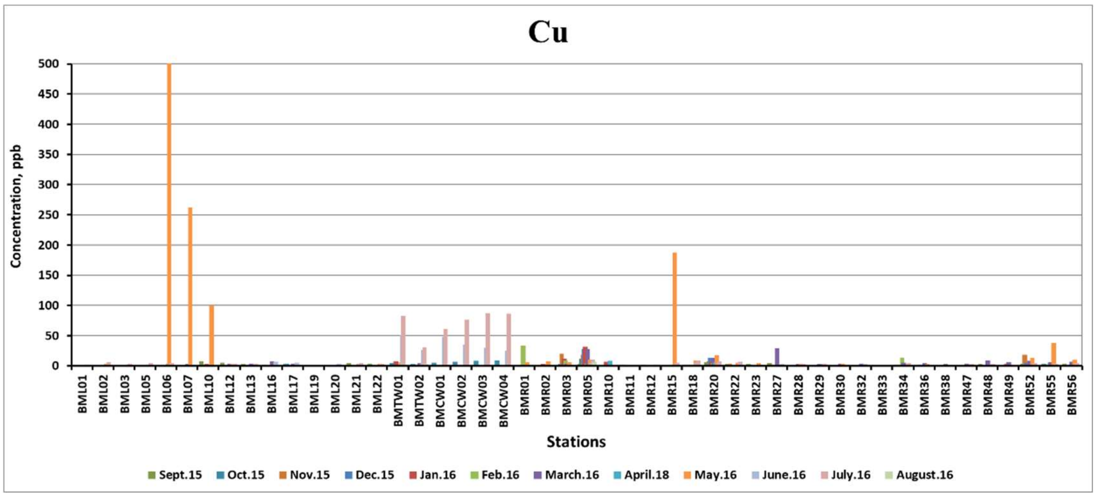

Figure 3.113 Monthly variation of Cu concentration at stations of BMRB

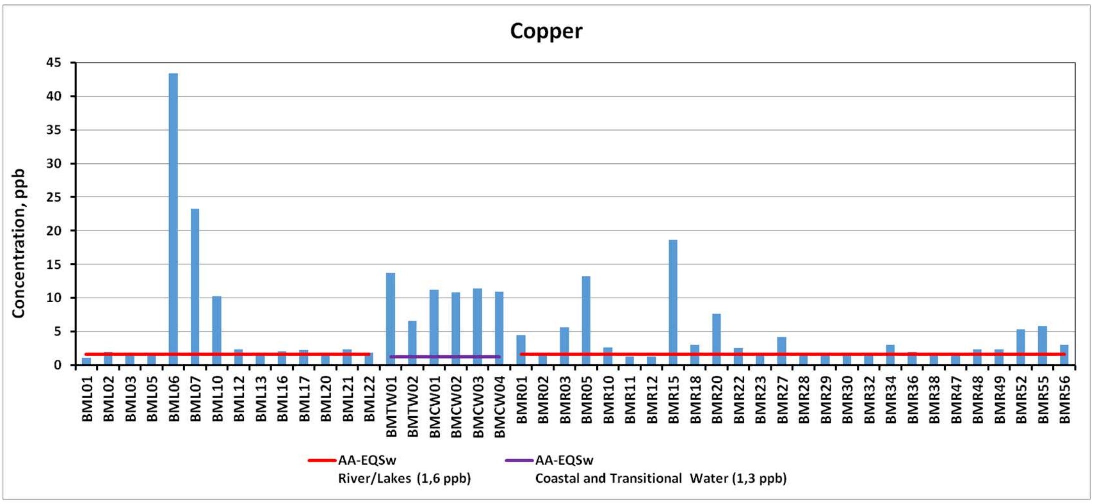

Figure 3.114 The annual average concentrations of Copper at the stations of BMRB

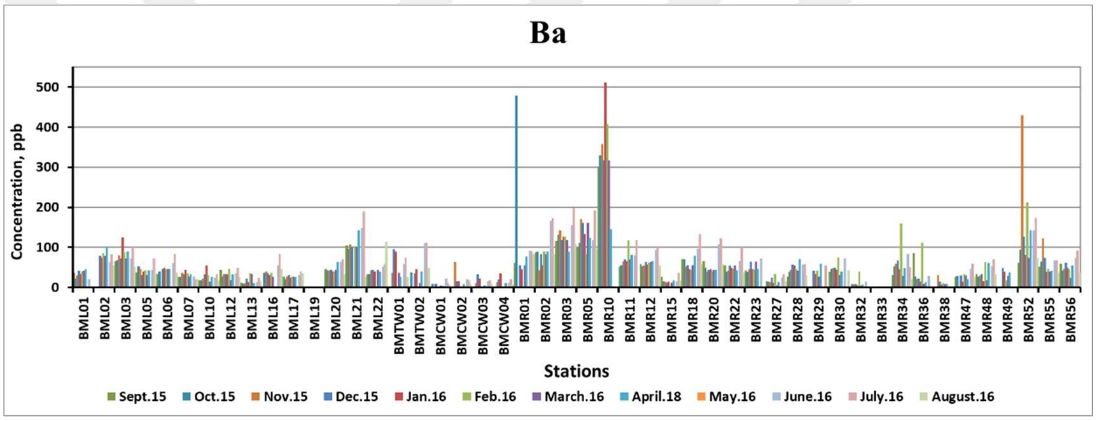

Figure 3.115 Monthly variation of Ba concentration at stations of BMRB

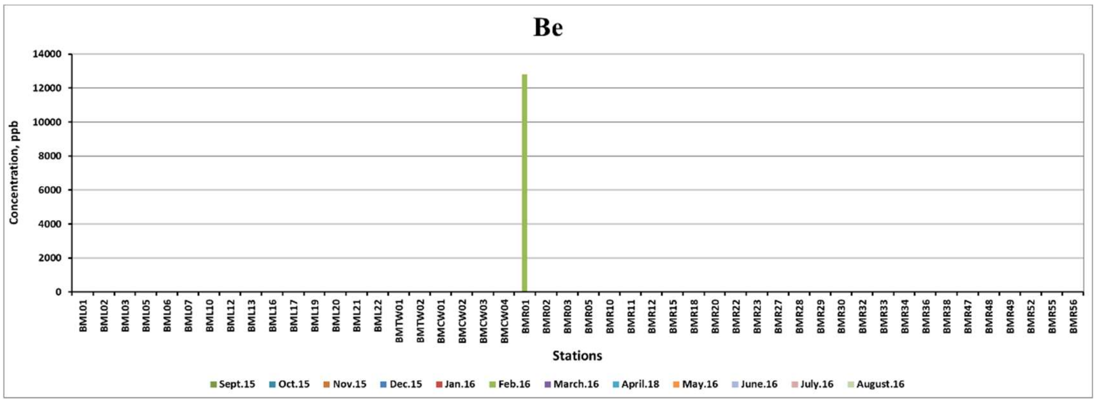

Figure 3.116 Monthly variation of Be concentration at stations of BMRB

The MAC-EQS$_W$ value for boron (B) is 1472 ppb. The boron concentration in the coastal and transitional waters of Büyük Menderes Basin was as high as 3500 ppb.

The boron concentration was higher than the MAC-EQS$_w$ value for all sampling periods. Boron has been observed in the lake waters and the value of MAC-EQS$_w$ has been exceeded, especially at BML06, BML07, BML10 and BML16 stations. In the rivers stations of BMR01 and BMR52 where there was industrial discharge, boron concentration was high and exceeded the value of MAC-EQS$_w$ (Figure 3.117). The stations where boron exceeds AA-EQS$_w$ value were given in Figure 3.118.

Mercury (Hg) concentrations were generally below MAC-EQS$_w$ (0.07 ppb). A high concentration of 170 ppb was obtained in February 2016 at the BMR01 station, which receives industrial and domestic discharges. The concentrations above the MAC-EQS$_w$ values were observed in samples taken from the lake waters BML07, BML10, BML12, BML13, BML17, BML21, BMR03 and at the river stations BMR05, BMR55 and BMR56 with industrial discharge, especially during October 2015. Mercury was observed for the transition and coastal waters during the sampling period of June 2016 and July 2016, as well, and the value of MAC-EQS$_w$ was exceeded especially at BMTW01 and BMCW04 stations. The highest concentration obtained in all periods was 170 ppb and it was observed in BMR01 (Figure 3.119)

Zinc (Zn) concentrations exceeded MAC-EQSw values of 231 ppb and above 1000 ppb were observed. For example, the concentration at BML16 station was 285 ppb in June 2016. Zinc concentrations for coastal and transitional waters exceed MAC-EQS$_w$ (76 ppb) especially in January 2016. Zinc was above the MAC-EQS$_w$ (231 ppb) in three different periods, especially, at BMR05 and BMR02 stations to where industrial discharges occur. The highest concentration obtained in all periods was 7088 ppb and it was observed in BMR15 reference station in September 2015 (Figure 3.120). The stations where zinc concentration exceeds AA-EQS$_w$ were given in Figure 3.121.

The MAC-EQS$_w$ value for iron (Fe) is 101 ppb. It was observed in all stations and the MAC-EQS$_w$ value was exceeded at least once in each station. Especially in the BMR52 station where there is industrial discharge, iron concentrations were too high. Iron concentrations observed in Büyük Menderes Basin consistently exceeded MAC-EQS$_W$ value. The highest concentration obtained in all periods was 24064 ppb at BMR52 (Figure 3.122). The stations, where iron concentration exceeded AA-EQS$_W$ value, were given in Figure 3.123. The results indicate that there is iron pollution in the basin.

The MAC-EQS$_W$ value of silver (Ag) is 1.5 ppb which was exceeded in the lakes BML01, BML02, BML06, BML07, BML10 stations in May 2016 sampling period. MAC-EQS$_W$ value was also exceeded in BMTW01 and BMTW02 transition water stations in May. The river stations as BMR01, BMR03, BMR05, BMR, 20, BMR22, BMR55 and BMR56 stations exceeded the 1.5 ppb MAC-EQS$_W$ value. The highest silver concentration observed was 407 ppb in BML07 station (Figure 3.124). The stations where silver concentration exceeded AA-EQS$_W$value were given in Figure 3.125.

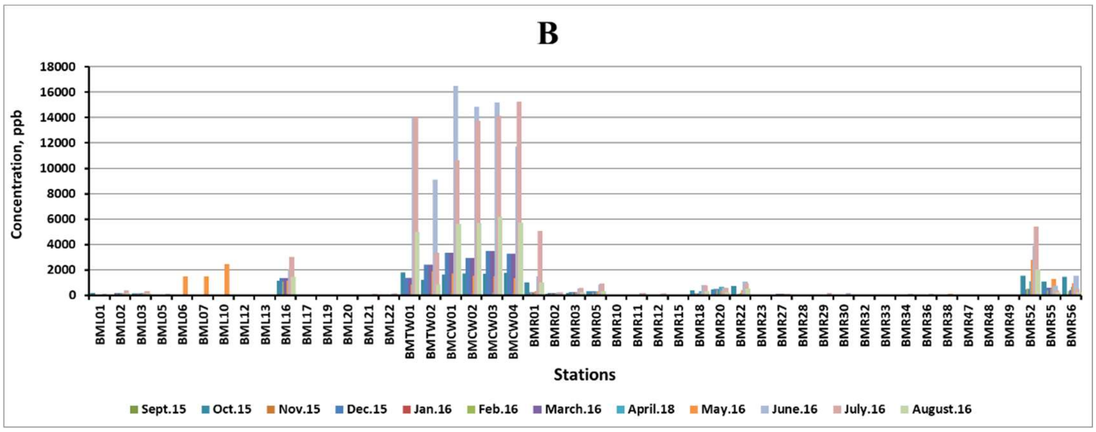

Figure 3.117 Monthly variation of B concentration at stations of BMRB

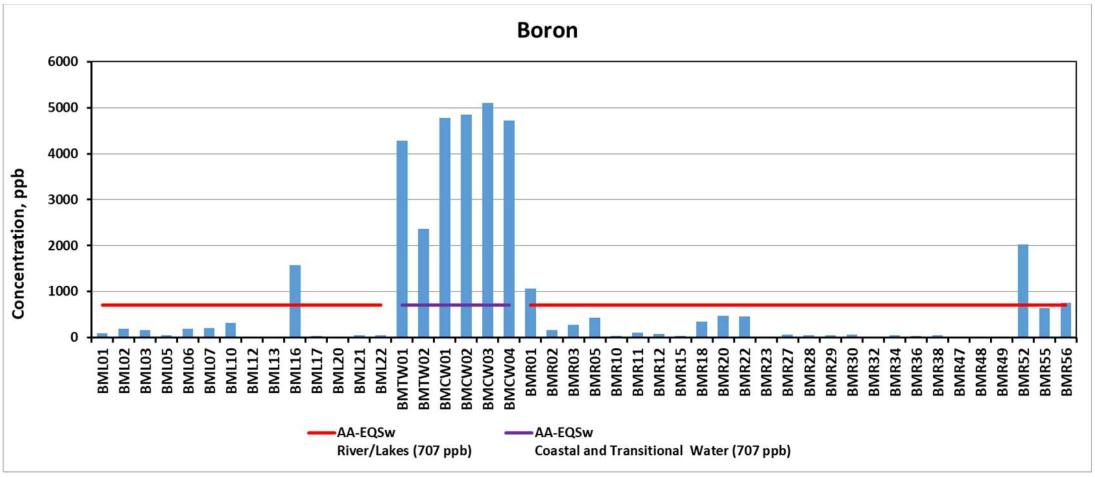

Figure 3.118 The annual average concentrations of Boron at the stations of BMRB

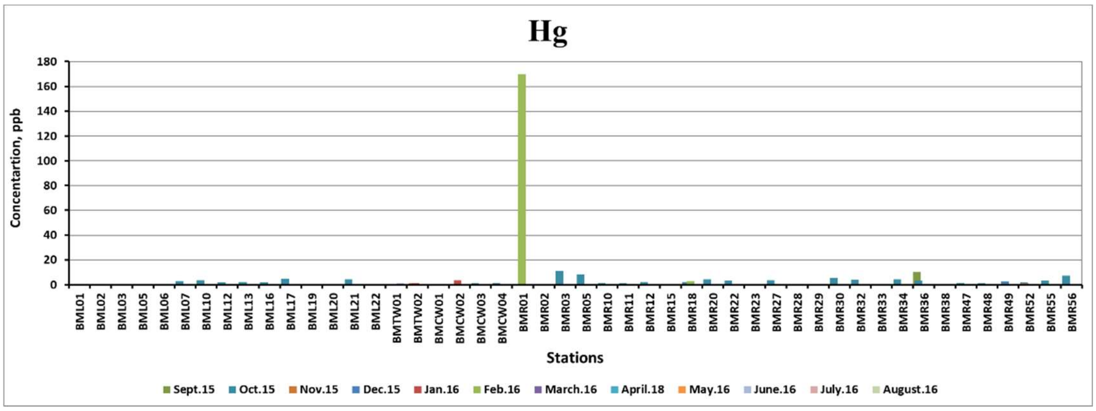

Figure 3.119 Monthly variation of Hg concentration at stations of BMRB

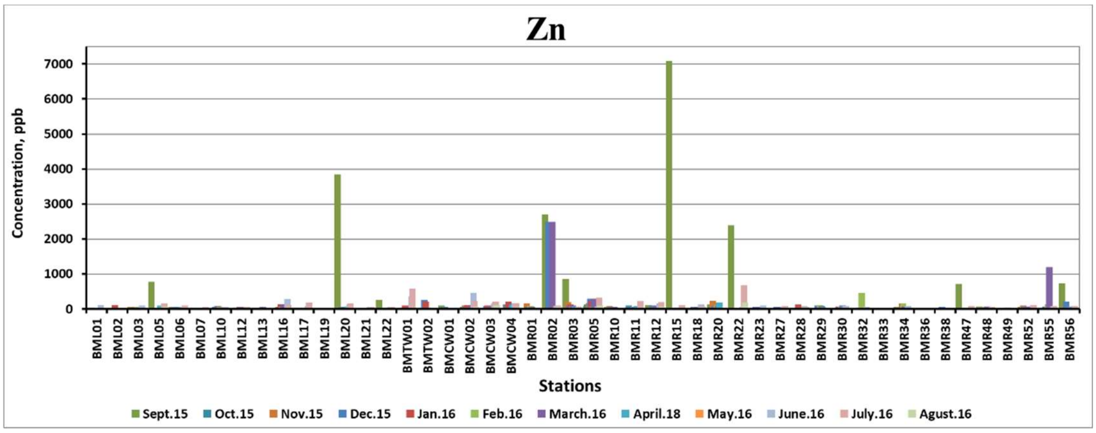

Figure 3.120 Monthly variation of Zn concentration at stations of BMRB

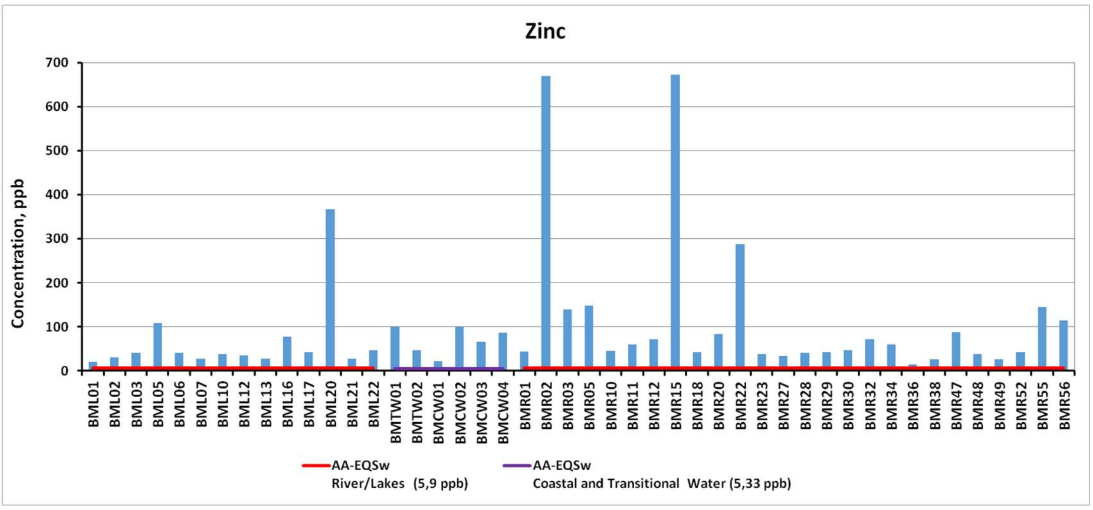

Figure 3.121 The annual average concentrations of Zinc at the stations of BMRB

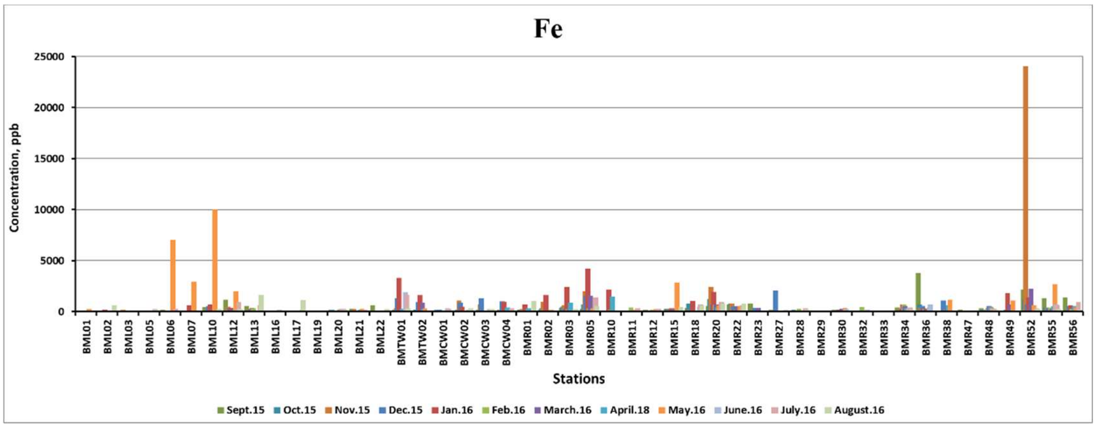

Figure 3.122 Monthly variation of Fe concentration at stations of BMRB

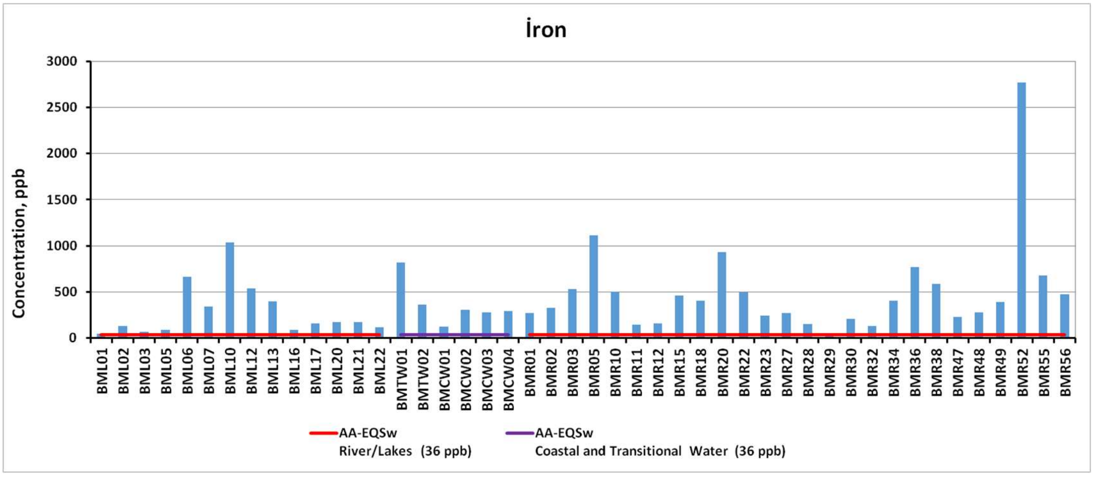

Figure 3.123 The annual average concentrations of Iron at the stations of BMRB

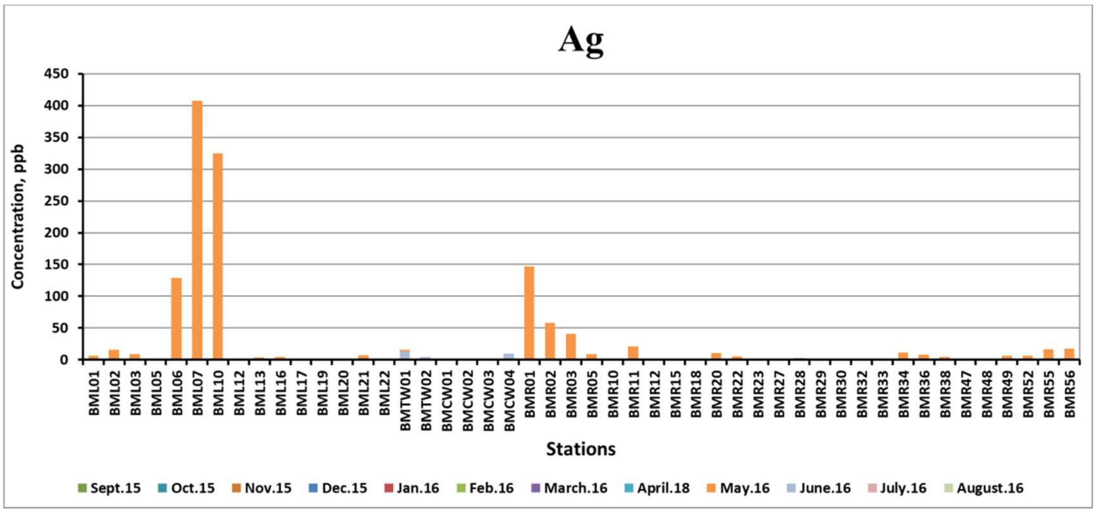

Figure 3.124 Monthly variation of Ag concentration at stations of BMRB

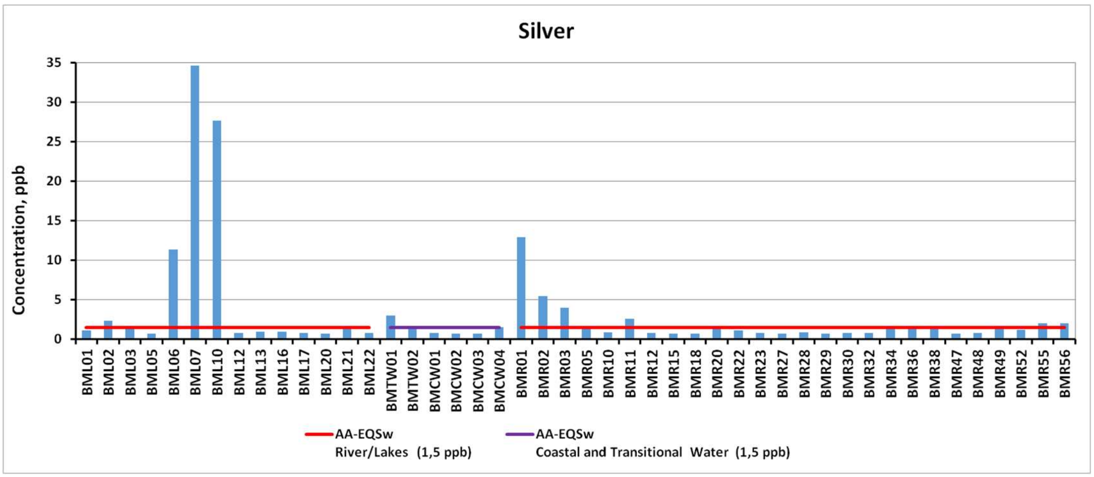

Figure 3.125 The annual average concentrations of Silver at the stations of BMRB

Cadmium (Cd) was observed in some periods in the basin. The concentrations in BML01, BML06, BML07 and BML10 were higher than MAC-EQS$_w$ (0.45 ppb) in May 2016. The concentrations in coastal and transitional waters were mostly below the LOD value. However, the concentrations above MAC-EQS$_w$ (0.45 ppb) were observed only at BMTW01, BMTW02, BMCW03 and BMCW04 stations in January 2016. While cadmium was observed time to time in stations BMR34 and BMR55, the concentration exceeded the values of MAC-EQS$_w$ (0.45 ppb) in February. The highest concentration obtained in all periods was 24 ppb and it was observed in BML06 (Figure 3.126). The stations where cadmium concentration exceeded the AA-EQS$_w$ value were given in Figure 3.127.

The MAC-EQS$_w$ value for tin (Sn) is 13 ppb and the concentrations determined in rivers and lakes were below this limit value. Although it is obtained around 11 ppb in BMCW04, it is below the MAC-EQS$_w$ value. On the other hand, BMR48 is a reference station and the observed thin concentration was 4 ppb. It is not above the MAC-EQS$_w$ value but this concentration can be considered as high for a reference station. The highest concentration obtained in all periods was 11.4 ppb and it was determined in BMCW04 station in November 2015 (Figure 3.128).

Cobalt (Co) was observed in lakes, coastal and transitional waters and rivers in the basin. In the lake waters, especially in May 2016, cobalt concentrations in BML06, BML07 and BML10 stations were higher than MAC-EQS$_w$ (2.6 ppb). The coastal and transitional water stations of BMTW01, BMTW02, BMCW03 and BMCW04 showed concentrations above the MAC-EQS$_w$ value only in January 2016. In the BMR05 and BMR52 stations where there were industrial discharges, the MAC-EQS$_w$ value was exceeded several times. The highest concentration obtained in all periods was 27.8 ppb and it was observed in BMR52 (Figure 3.129). The stations where cobalt concentration exceeded AA-EQS$_w$ (0.3 ppb) value were given in Figure 3.130.

Chromium (Cr) concentration in the stations was mostly higher than MAC-EQS$_w$ (142 ppb). This limit value was exceeded three times in BMR03, which is close to Uşak Organized Industrial Zone, and five periods in BMR05 station. BML07 station exceeded the MAC-EQS$_w$ value in May 2016. Chromium was observed in coastal and transitional waters, BMTW01 and BMTW02, at concentrations higher than MAC-EQS$_w$ (88 ppb). The highest concentration obtained in all periods was 757 ppb and it was observed in BMR05 station in January 2016 (Figure 3.131). The stations where chromium concentration exceeded AA-EQS$_w$ value were given in Figure 3.132.

Lead (Pb) was observed in the lakes, but MAC-EQS$_w$ (1.4 ppb) was not exceeded. However, the river stations BMR01, BMR03, BMR05, BMR20, BMR52 and BMR55 were heavily polluted with lead due to industrial discharges. The MAC-

EQS$_w$ was exceeded at least six sampling periods at these stations. The highest concentration obtained in all periods was 75 ppb and it was observed in BML10 station in May 2016. For the coastal and transitional waters, MAC-EQS$_w$ (14 ppb) was exceeded only in January 2016 (Figure 3.133). The stations where the lead concentrations exceeded the AA-EQS$_w$ value were given in Figure 3.134.

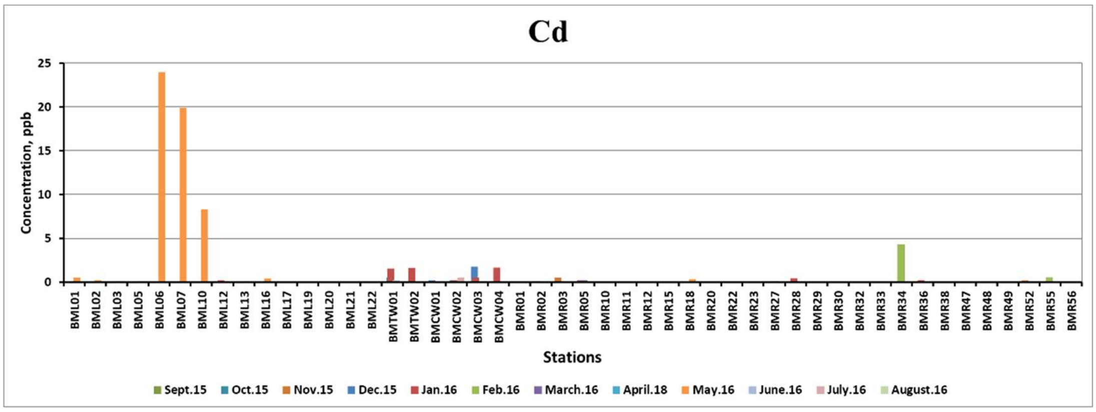

Figure 3.126 Monthly variation of Cd concentration at stations of BMRB

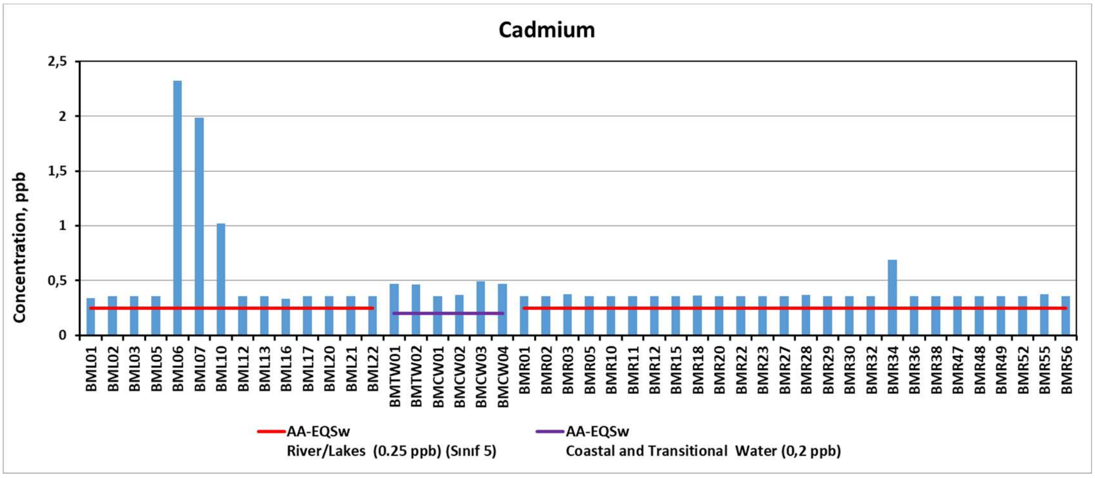

Figure 3.127 The annual average concentrations of Cadmium at the stations of BMRB

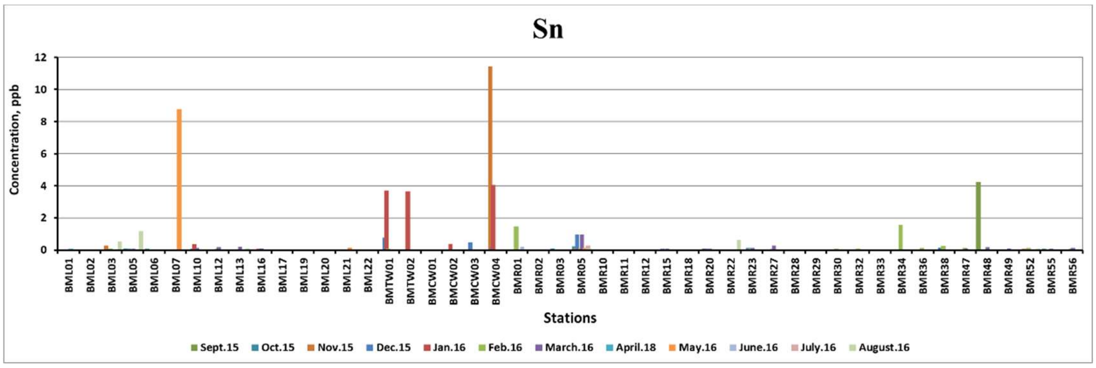

Figure 3.128 Monthly variation of Sn concentration at stations of BMRB

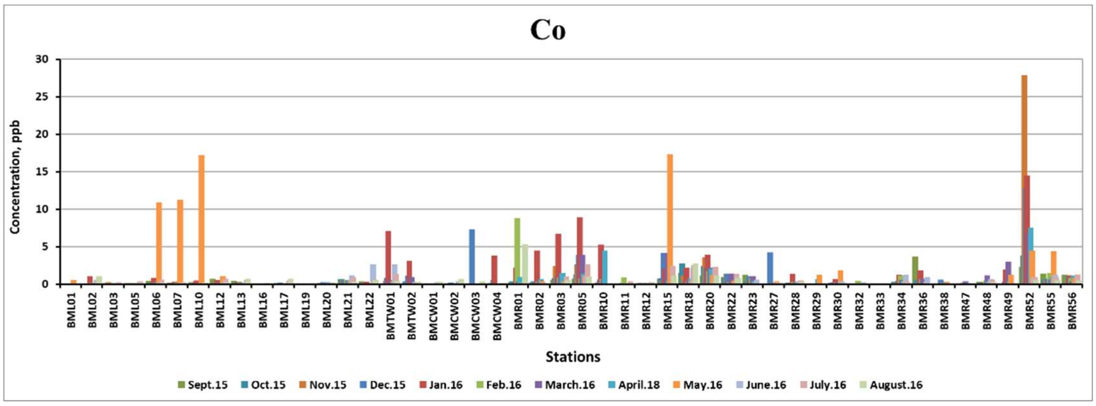

Figure 3.129 Monthly variation of Co concentration at stations of BMRB

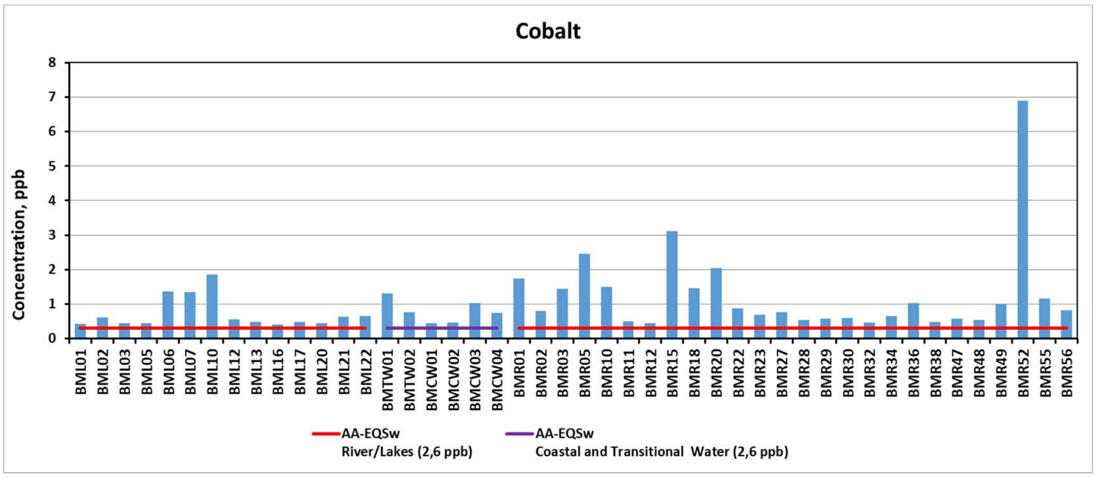

Figure 3.130 The annual average concentrations of Cobalt at the stations of BMRB

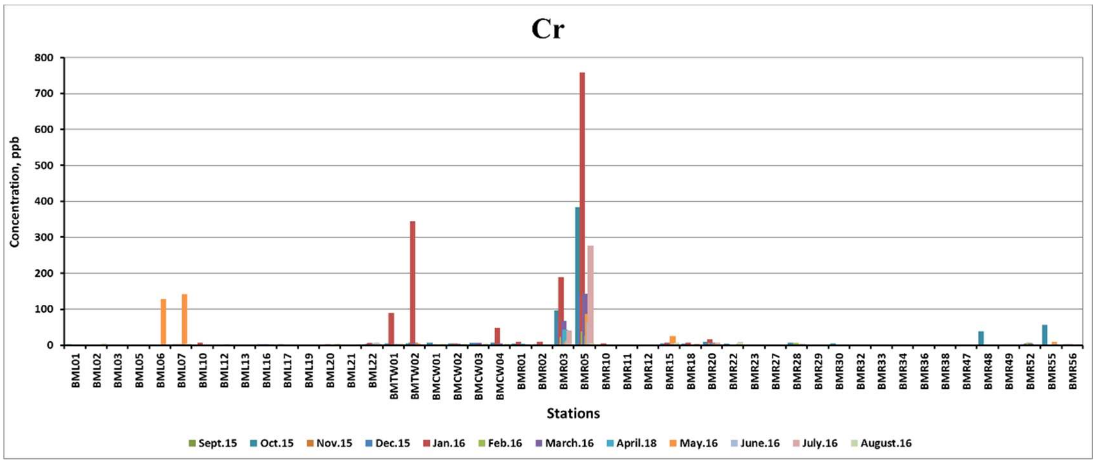

Figure 3.131 Monthly variation of Cr concentration at stations of BMRB

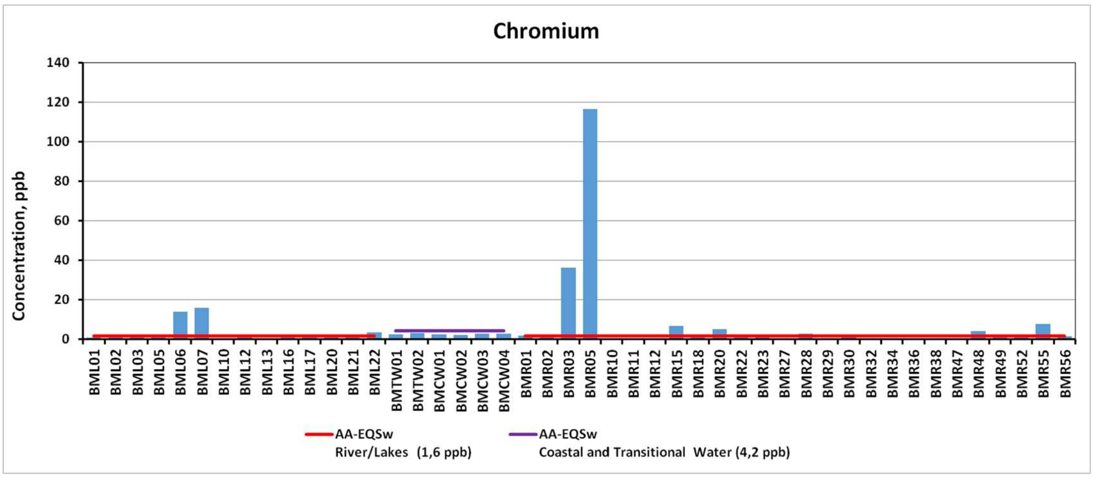

Figure 3.132 The annual average concentrations of Chromium at the stations of BMRB

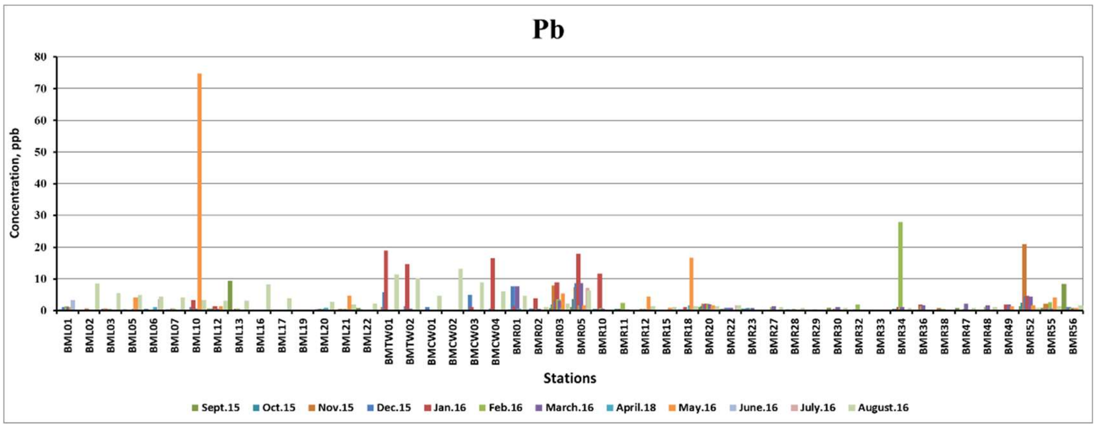

Figure 3.133 Monthly variation of Ag concentration at stations of BMRB

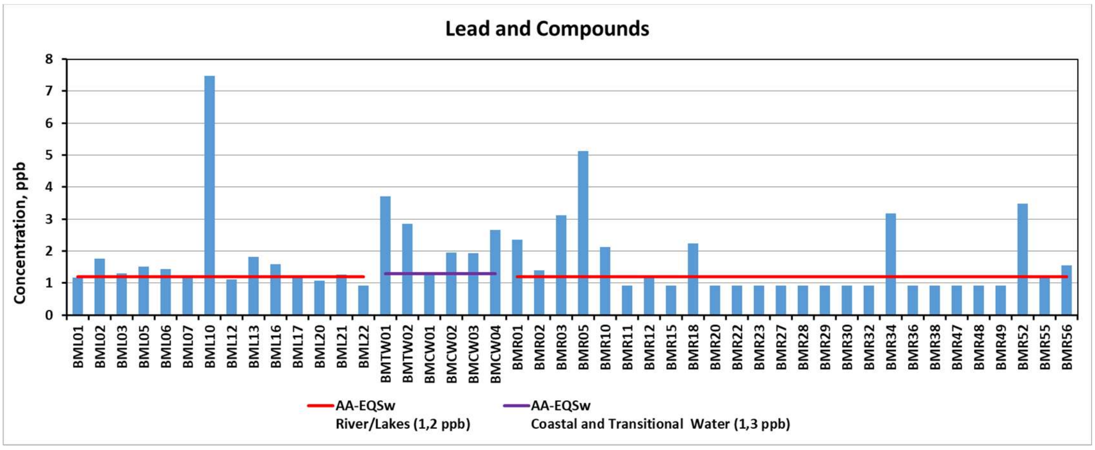

Figure 3.134 The annual average concentrations of Lead at the stations of BMRB

The MAC-EQS$_w$ value of nickel (Ni) for lakes and rivers is 34 ppb. Nickel was observed at all monitoring points at coastal and transitional waters and the MAC-EQS$_w$ value (34 ppb) was exceeded in January 2016. The high concentrations above MAC-EQS$_w$ were observed at the river water stations of BMR01, BMR02, BMR03 and BMR05. The highest concentration obtained in all periods was 113 ppb and it was observed in November 2016 at BMR52 station where industrial effluents are discharged (Figure 3.135). The stations where nickel concentration exceeded AA-EQS$_w$ value were given in Figure 3.136.

Silicon (Si) is another main constituent of the soil and it is a good mineral nutrition for plants. MAC-EQS$_w$ of silicon in river water is 1830 ppb in WFD. Silicon concentration in almost all stations were above this limit value. It was also observed in coastal and transitional waters and the concentrations higher than its corresponding MAC-EQS$_w$ (6891 ppb) were determined. Higher concentrations were observed in river waters compared to lake waters. The highest concentration obtained in all periods was 555,000 ppb (555 ppm) and it was observed in BML07 station in May 2016 (Figure 3.137). The stations where the silicon concentrations exceeded the AA-EQS$_w$ value were given in Figure 3.138. Due to its abundance in the soil, it is acceptable to have a high concentration of silicone in the surface water.

Titanium (Ti) was observed at lake, coastal and transitional waters and river sampling points during the twelve-month monitoring period. The concentrations were mostly below MAC-EQS$_w$ (42 ppb). Its concentration exceeded MAC-EQS$_w$ value by 80 ppb concentration in BML12 station only in September 2015 and 414 ppb concentration in BMR52 station in November 2015 (Figure 3.139). The stations where titanium concentration exceeded AA-EQS$_w$ value were given in Figure 3.140.

Vanadium (V) concentration in rivers did not exceed MAC-EQS$_w$ value (97 ppb). The concentration reached 198 ppb only once at the BMR01 station where there is industrial discharge. It was also observed in the lakes as BML06 and BML07 stations at concentrations higher than MAC-EQS$_w$ value. Vanadium was detected in coastal and transitional waters and the concentration was above MAC-EQS$_w$ (16 ppb) in BMTW01 station in June. The highest concentration obtained in all periods was observed in BML07 station in February 2016 period (Figure 3.141). The stations where vanadium concentration exceeded AA-EQS$_w$ value were given in Figure 3.142.

In summary, the metals that exceeded its own MAC-EQS$_w$ value were aluminum, arsenic, copper, beryllium, boron, mercury, zinc, iron, silver, cadmium, cobalt, chromium, lead, nickel, silicon, titanium and vanadium. In terms of the frequency of exceeding the MAC-EQS$_w$ value, the prominent metals in the basin are aluminum, copper, iron and silicon. In this respect, it can be said that iron, silicon, aluminum and copper pollution is a significant level in the basin. However, silicone and aluminum are the natural metals in the soil. The high concentrations of these metals in the basin should be accepted. The background concentrations can be determined and their EQA values can be revised. The metals that do not exceed the MAC-EQS$_w$ value in stations and periods are antimony, barium, tin and selenium.

The stations where metal pollution was most frequently observed are BMR01, BMR02, BMR03, BMR05, BMR20, BMR52, BMR55. Metals exceeding AA-EQS$_w$ value are aluminum, antimony, arsenic, copper, boron, zinc, iron, silver, cadmium and compounds, cobalt, chromium, lead and compounds, nickel and compounds, silicon and titanium.

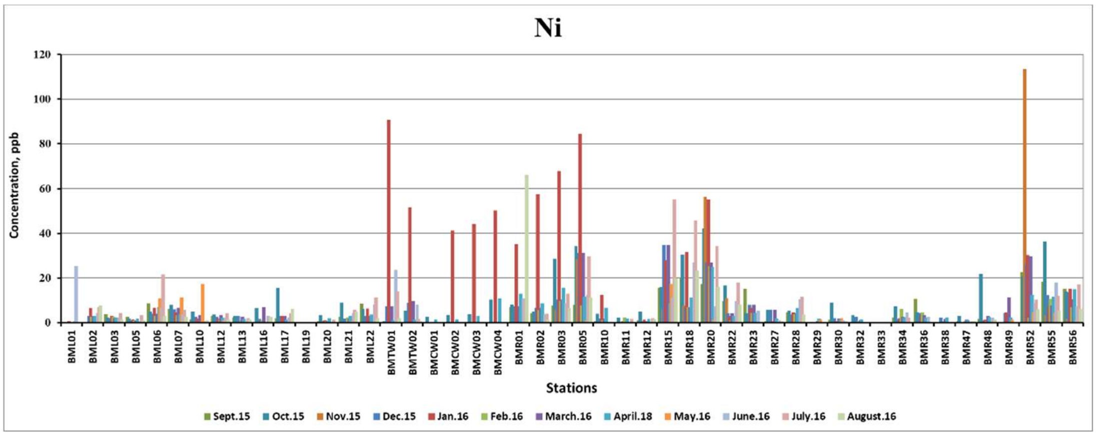

Figure 3.135 Monthly variation of Ni concentration at stations of BMRB

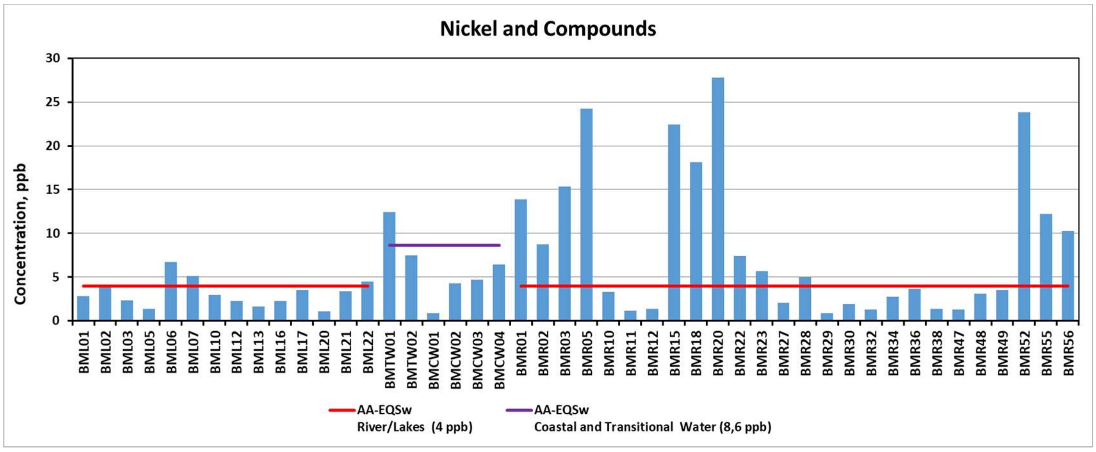

Figure 3.136 The annual average concentrations of Nickel at the stations of BMRB

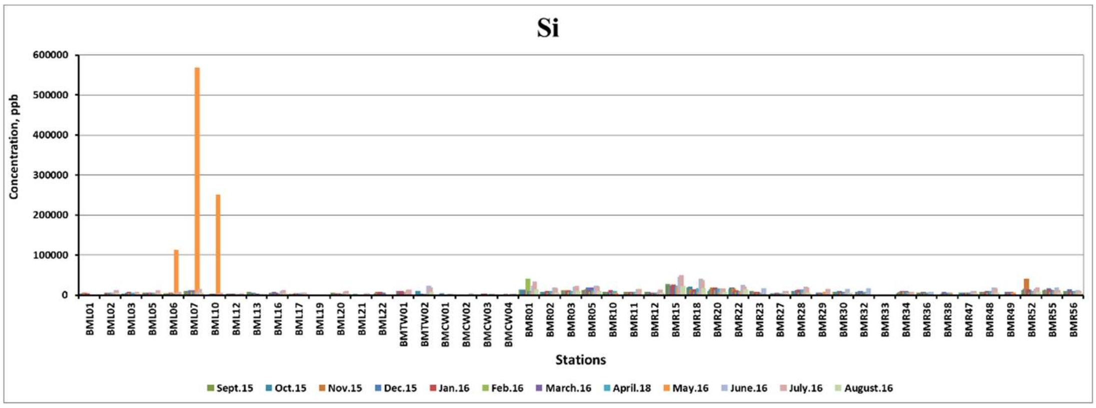

Figure 3.137 Monthly variation of Si concentration at stations of BMRB

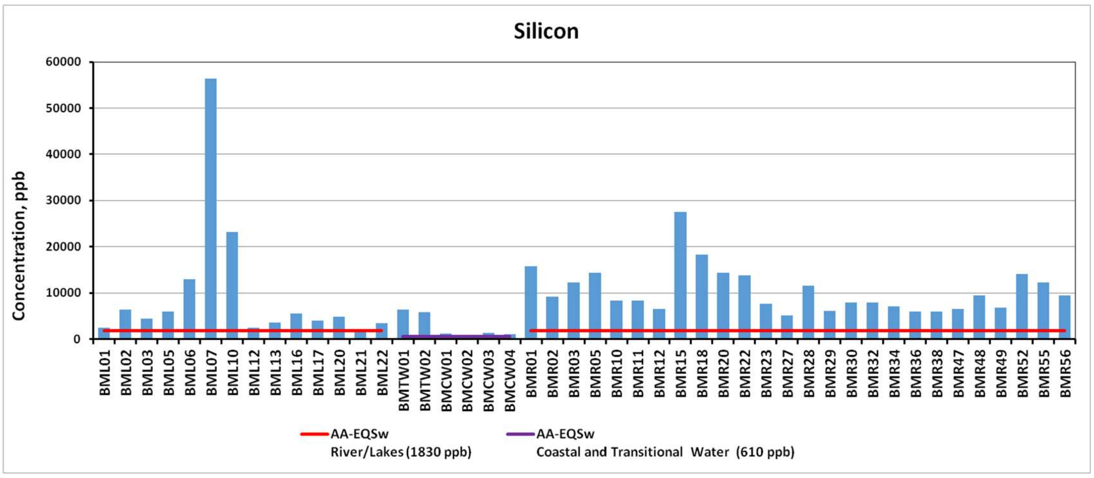

Figure 3.138 The annual average concentrations of Silicon at the stations of BMRB

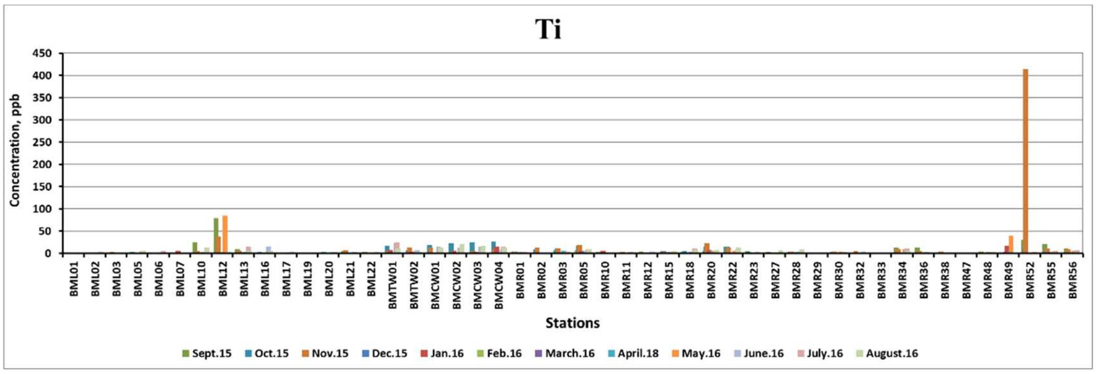

Figure 3.139 Monthly variation of Ti concentration at stations of BMRB

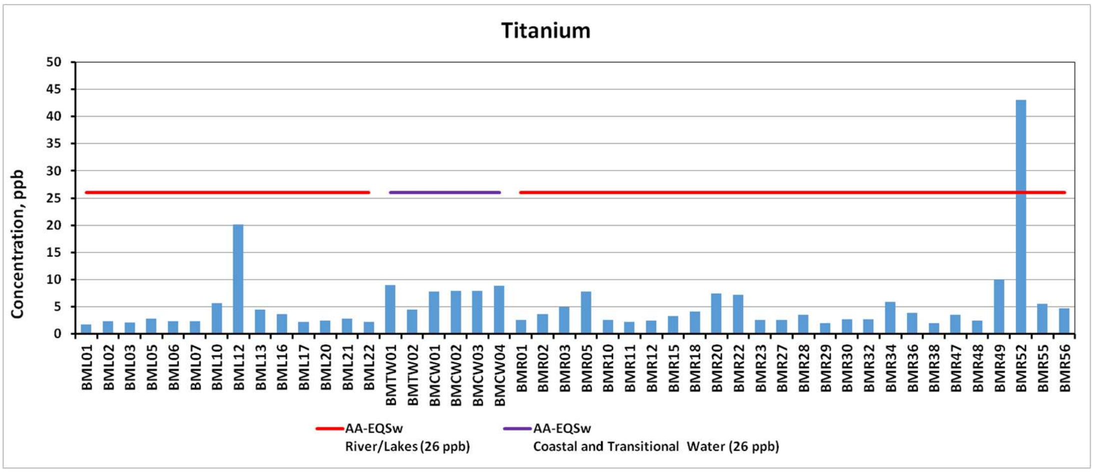

Figure 3.140 The annual average concentrations of Titanium at the stations of BMRB

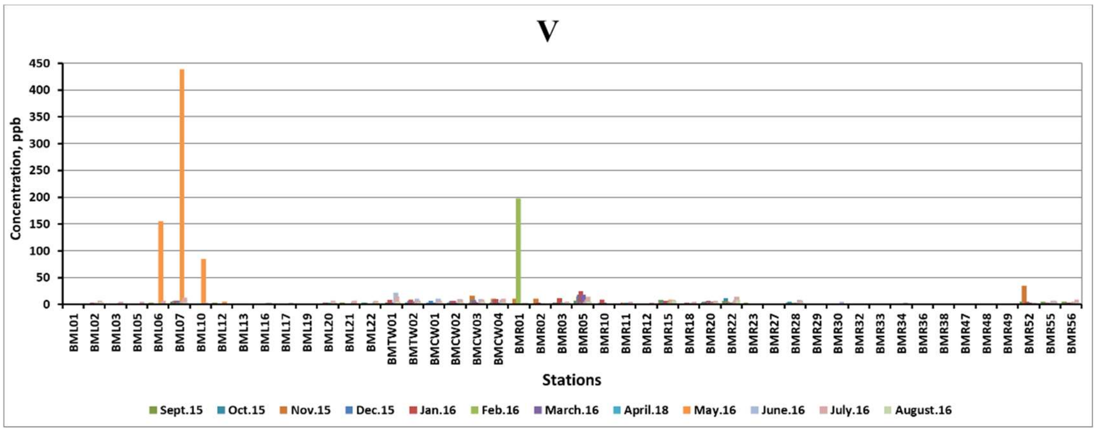

Figure 3.141 Monthly variation of V concentration at stations of BMRB

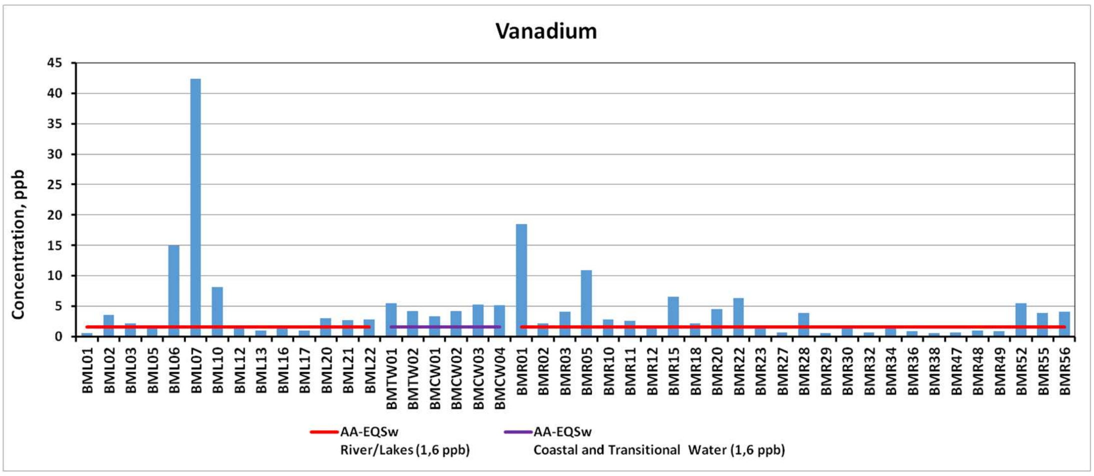

Figure 3.142 The annual average concentrations of Vanadium at the stations of BMRB

3.1.5 Sediment Quality Evaluation

Sediment samples were taken only in May 2017 for a 12-month monitoring period. The samples were collected mainly from lakes, coastal and transitional waters. Three water samples from surface, middle depth and from the deep along the water column were also collected in parallel to the sediment sampling. The same physicochemical, priority and specific pollutant analysis were performed in water samples as they were done on the regular water samples. The classification for the quality of the sediment was conducted regarding to 14 PAHs, 7 pesticides, 10 heavy metals and 3 different types of conventional pollutants like TOC, TKN and TP. The monitored parameters were given in Appendix 2 (Table A.3). The results of the water column and sediment samples in BMRB during the monitoring period were given between Figure 3.143 and Figure 3.160.

There are limited numbers of quality guidelines used to evaluate sediment quality. The one used in Canada was followed in this thesis. The methodology was developed by the Ontario Ministry of Environment and Energy Guidance on the Conservation and Management of Aquatic Sediment Quality updated in 2008. The main criteria were the Lowest Effect Level (LEL) and Severe Effect Level (SEL) of the parameters. Besides, Interim Freshwater Sediment Quality Guideline (ISQG) and Probable Effect Levels (PEL) in the Sediment Quality Guide for Aquatic Life Protection in Canada, which was updated in the year 2012 were used.

The LEL in the assessment criteria developed in Canada for the protection of aquatic life indicates the level of pollution that is tolerable by the majority of organisms in the sediment. The SEL also indicates the level of contamination expected to be harmful to the majority of organisms in the sediment. The ISQG criteria are derived using the weight of evidence of the toxicological information available if the minimum data set requirements are met. PEL is above the level of concentration expected to occur intensively negative biological effects.

The quality criteria of the Canadian Sediment Quality Directive were given in Material and Methods in Table 2.7. The evaluation of sediment quality in lakes and rivers in BMR was given in Appendix 2. The total PAH was expressed as the total concentration of 16 PAHs (Acenaphthene, Acenaphthylene, Anthracene, Benzo [k] fluoranthene, Benzo [b] fluorine, Benzo [a] anthracene, Benzo [a] pyrene, Benzo[g,h,i] perylene, Chrysene, Dibenzo [a, h] anthracene, Fluoranthene, Fluorene, Indeno [1,2,3-cd] pyrene, Naphthalene, Phenanthrene and Pyrene). The pollutants on the sediments of all samples were explained and the quality of the sediment was presented below.

BMG01 was the Işıklı Lake. PAH analysis of this station showed that the Acenaphthen, Acenaphthylene, Dibenzo (a,h) anthracene, Fluorene and

Phenanthrene are the PAHs in the sediment and the concentrations of these PAHs exceeds the Interim Sediment Quality Guidelines (ISQG) level but, fortunately, lower than PEL. Since the number PAH on the sediment is high, the total PAH concentration resulted in above the LEL. Four of the analyzed pesticide species (Aldrin, Dieldrin, Endrin and Heptachlor epoxide) could not be detected. Only 3 pesticides namely DDD, DDE and DDT were detected at very low concentrations, but, above the LEL.

The metals exceeding the ISQG level on the sediment were arsenic and chromium. Nickel concentration, unfortunately, was above the Severe Effect Level (SEL). The concentrations of other heavy metals were found to be below the pollution criteria.

Physicochemical analysis of the sediment indicated that the concentration of TKN from organic substances is much higher than the LEL and it approaches the SEL level. The total phosphorus value was close to LEL. The TOC value was found to be below the LEL.

Cindere Adıgüzel-2 reservoir lake was the BML03 station. Acenaphthene, Acenaphthylene, Fluorene and Phenanthrene exceeded ISQG but lower than PEL. The total PAH concentration was above LEL level. Six of the analyzed pesticide species could not be detected, but only, DDE was found at a very low concentration but above the LEL. Arsenic and nickel exceeded the ISQG level and concentrations of other heavy metals were found to be below the pollution criteria. TKN concentration was above LEL and total phosphorus concentration was close to LEL. The TOC value was found to be slightly above the LEL, indicating that there is organic matter accumulation on the sediment.

BML05 station was Karacasu which is a reservoir lake. The detected PAHs at this station were Acenaphthene, Acenaphthylene, Dibenzo (a,h) anthracene, Fluorene and Phenanthrene which exceeded the ISQG level. However, it was found that individual concentrations were below PEL. The total PAH concentration were above the LEL.

Aldrin, Dieldrin, Endrin and Heptachlor epoxide were not detected. Only DDD, DDE and DDT were detected at a concentration above the LEL. Arsenic slightly exceeds ISQG level. Chromium concentration was far above the ISQG. Nickel concentration was above SEL. The concentrations of other heavy metals were found to be below the pollution criteria. TKN and TOC, which are among the physicochemical parameters, are above the LEL, while the total phosphorus concentration was relatively low and below the limit values.

Tavas Yenidere reservoir lake with station number BML06 resulted in PAHs Acenaphthene, Acenaphthylene, Dibenzo (a,h) anthracene, Fluorene and Phenanthrene which exceeded ISQG levels. The total PAH concentration was again above the LEL. Four of the analyzed pesticides (Aldrin, Dieldrin, Endrin and Heptachlor epoxide) were not detected. The only pesticides found on the sediment sample at this station were DDD, DDE and DDT. Their concentrations were too low but above the LEL. Arsenic was found to be above the ISQG level, chromium was above both the SEL and PEL, and the nickel concentration was well above the SEL. The concentrations of other heavy metals were found to be below the pollution criteria.

It was found that the concentration of TKN in the sediment sample was above the LEL and the total phosphorus value was relatively low. The TOC value was higher than the LEL level. Similar to other lake sediment samples, these parameters indicate the pollution in the sediment. In other words, the accumulation of these nutrients on the sediment is clearly seen.

Kemer reservoir lake (BML07) contained PAHs like Acenaphthene, Acenaphthylene and Phenanthrene at a concentration above ISQG critic level but lower than PEL critic concentrations. It was also found that the concentration of Fluorene was above the PEL. The total PAH concentration, obviously, resulted in higher than LEL. The sediment sample resulted in DDD and DDE at low concentrations but above the LEL. Among the heavy metals detected in the sediment sample, it was found that chromium was above SEL and PEL, nickel was above SEL and iron was above LEL. The concentrations of other heavy metals were below the pollution criteria. TKN concentration in the sediment sample was slightly above the LEL and the total phosphorus value was relatively low. The TOC value was found to be slightly below the LEL level.

BML10 Çine Adnan Menderes reservoir lake sediment sample resulted in Acenaphthene, Acenaphthylene, Fluorene and Phenanthrene. The concentrations were above ISQG levels but all concentrations were lower than PEL. The total PAH concentration was at the lowest level compared to the sediment samples taken from other lakes. However, it is still above the LEL. Four of the analyzed pesticide species (Aldrin, Dieldrin, Endrin and Heptachlor epoxide) could not be detected and only 3 (DDD, DDE and DDT) were detected at very low concentrations, but above the LEL. The concentrations of all heavy metal species analyzed were below the pollution criteria. In this case, station BML10 is the best station in terms of heavy metal pollution. TKN and total phosphorus concentration in the sediment sample was above LEL. The TOC value in the sediment was found to be well above the LEL means that there is organic pollution in this station as observed in sediment samples from the other lakes.

BML12- Topçam reservoir lake sediment analysis showed Acenaphthene, Acenaphthylene, Fluorene and Phenanthrene with the concentrations exceeding ISQG levels. On the other hand, the concentrations of these PAHs were lower than PEL value. Total PAH concentration at this station was the lowest level compared to the sediment samples from other lakes but they are still above the LEL. Sediment samples contained only DDE and DDT at very low concentrations but above the LEL. The heavy metal species in the sediment sample determined were arsenic, above PEL, iron and nickel, above LEL. The other heavy metal species were below the pollution criteria. TKN in the sediment sample was very close to the SEL and the total phosphorus concentration was relatively lower. The TOC value was well above the LEL as it was observed in other sediment samples.

Yaylakavak reservoir lake was the station BML12. The PAH analysis in sediment taken from BML13 station resulted in Acenaphthene, Acenaphthylene, Fluorene and Phenanthrene with the concentrations higher than ISQG levels but lower than PEL. The total PAH concentration was again, above, LEL. Most of the pesticide species could not be detected. Only DDE was detected at very low concentrations but above the LEL. Arsenic exceeded the ISQG level, while the concentrations of other heavy metal species were below the pollution criteria. TKN concentration was above LEL level and total phosphorus concentration was very close to LEL level. The TOC value was higher than the LEL.

BML16 station was Bafa Lake, a natural lake despite to slight hydro morphologically modifications. Acenaphthene, Acenaphthylene, Fluorene and Phenanthrene were the PAH species above ISQG levels. The individual concentrations of these PAHS were lower than PEL. But total PAH calculation resulted in above LEL. Five of the analyzed pesticide species were not detected in the sediment. The only pesticides found on the sediment were DDE and DDT at very low concentrations but above the LEL. Arsenic and nickel exceeded the ISQG level and the concentrations of other heavy metals were below the pollution criteria. The physicochemical parameters in the sediment sample resulted in TKN concentration above SEL, total phosphorus concentration close to LEL level.

BML17-İkizdere reservoir lake sediment sample resulted in PAHs as Acenaphthene, Acenaphthylene and Phenanthrene with the concentrations above ISQG levels. Fortunately, the individual concentrations of all detected PAHs were lower than PEL criteria. But the only PAH above the PEL was Fluorene. The total PAH concentration was above the LEL. Five of the analyzed pesticide species were not detected. DDE and DDT were the only pesticides found on the sediment at very low concentrations but above the LEL. Arsenic and chromium exceeded ISQG level, nickel was above SEL and iron was above LEL. The concentrations of other heavy metals were found to be below the pollution criteria. TKN was slightly above LEL and total phosphorus value was well above SEL. This was the highest phosphorus concentration encountered in the sediment samples from the basin. The TOC value was found to be slightly above the LEL, as similar to other sediment samples.

BML20 Karakuyu was the most polluted one among the other monitored lakes. According to the PAH analyzes, the detected ones were Acenaphthene, Acenaphthylene, Benzo (a) anthracene, Benzo (a) pyrene, Chrysene, Dibenzo (a,h) anthracene, Fluoranthene, Fluorene and Phenanthrene and all they were exceeding ISQG levels. Total PAH concentration was above the LEL. This station had the highest PAHs concentration on the sediment. Aldrin, Dieldrin, Endrin and Heptachlor epoxide were not detected on the sediments. DDD, DDE and DDT were found at very low concentrations but above the LEL. Arsenic and nickel exceeded ISQG and LEL, respectively, while concentrations of other heavy metals were below the pollution criteria. It was determined that the concentration of TKN in the sediment samples was slightly above LEL and total phosphorus value was well above SEL. The TOC value was found to be slightly above the LEL level.

BML22 Gökpınar lake station sediment samples PAH analysis resulted in Acenaphthene, Acenaphthylene, Fluorene and Phenanthrene. The concentrations were higher than ISQG value but lower than PEL. The total PAH concentration was higher than LEL again. Four of the analyzed pesticide species (Aldrin, Dieldrin, Endrin and Heptachlor epoxide) were not detected. But DDD, DDE and DDT were above the LEL even though their concentrations were very low. The heavy metals in the sediment samples were chromium exceeding ISQG level and nickel above SEL. The concentrations of other heavy metal species were below pollution criteria. It was determined that TKN, total phosphorus and TOC value were either close or above LEL.

BMR20 was the river station called Middle Büyük Menderes. The PAHs detected in the station were Acenaphthene, Acenaphthylene, Anthracene, Benzo (a) anthracene, Chrysene, Fluoranthene, Fluorene and Phenanthrene with the concentrations exceeding the ISQG level. However, the total PAH concentration was lower than the PEL but above the LEL in this case. The pesticides detected on the sediment were DDD, DDE and DDT at a very low concentration but above the LEL level. Among the heavy metals analyzed in the sediment sample, it was found that chromium exceeded ISQG level, nickel was above SEL, and concentrations of other heavy metal species were below the pollution criteria. Similar to other sediment samples, TKN concentration was above the LEL, the total phosphorus concentration was approaching to the LEL, but the TOC value was below the LEL.

BMR55 called Aşağı BM-1 was another river station where sediment sample was collected. Acenaphthene, Acenaphthylene, Dibenzo (a, h) anthracene, Fluorene and Phenanthrene were the PAHs that exceeded ISQG levels but the concentrations were lower than PEL value. The total PAH concentration was above the LEL. Four of the analyzed pesticide species (Aldrin, Dieldrin, Endrin and Heptachlor epoxide) were not found. Only DDD, DDE and DDT were detected at very low concentrations but above the LEL. Arsenic and chromium exceeded ISQG level and nickel concentration was above LEL. The concentrations of other heavy metals were found to be below the pollution criteria. TKN was above the LEL, the total phosphorus value was relatively low. The TOC value was found to be below the LEL.

Another river station was BMR56 called Aşağı BM-2. The PAHS detected in sediment taken from BMR56 station point were Acenaphthene, Acenaphthylene, Fluorene and Phenanthrene and their concentrations were above ISQG levels but lower than PEL concentrations. The total PAH concentration, which was the lowest one among the other sediment samples, was again above the LEL. The pesticide found at this station were DDD, DDE and DDT. Only DDE concentration exceeded ISQG level. It was found that chromium was above ISQG level, nickel concentration was above SEL. The concentrations of other heavy metals were found to be below the pollution criteria. Similar to other sediment samples, TKN was above the LEL level. The total phosphorus concentration was below the ISQG value although the highest concentration was observed. TOC value was found to be below the LEL level.

The summary of the results obtained from the sediment quality monitoring study in 12 lakes and 3 rivers in the BM Basin are listed below.

- Acenaphthene, Acenaphthylene, Fluorene and Phenanthrene were the main PAH species found on the sediment samples among the 14 PAHs analyzed. The concentrations of these PAHs were above the ISQG value at all stations. The Fluorene was the other PAH observed on the sediment samples from BML07 and BML17. The detected concentration was above PEL. Finally, Dibenzo [a, h] anthracene, Benzo [a] anthracene, Chrysene, Pyrene and Benzo [a] pyrene were the other PAHs detected rarely at the stations.

- Aldrin, Dieldrin, Endrin and Heptachlor epoxide were not detected at any station. DDD (p, p and o, p) DDE (p, p and o, p) DDT (p, p and o, p) were the common pesticides exist on the sediments. However, only DDE (p, p and o, p) were detected above the ISQG in BMR56 station.

- The most commonly detected heavy metals were nickel (13 stations, 12 of them above ISQG and 1 above PEL), arsenic (10 stations, 9 of them above ISQG, 1 above PEL), chromium at (9 stations, 7 of them above ISQG, 2 above PEL), and iron at 3 stations with all of them above LEL. Cadmium and mercury were not evaluated because the LOD value of the method used was higher than the evaluation criterion. There was no result above the LOD value for these two species. The concentrations of cobalt, copper, lead and zinc were found to be below the criterion values at all points.

- Among the physicochemical parameters analyzed, the high TOC concentration was detected at 10 stations, 9 of them were above LEL and one of them was above SEL. TKN concentration was high as well. The LEL and SEL values were exceeded at 13 stations and 2 stations, respectively. TP concentration was relatively mild at the sediments. The concentrations were higher at, only, one station for both LEL and SEL.

- BML20 and BML17 were the most polluted ones among the 12 lakes in BMRB. BML07, BML10 and BML13 were the least polluted ones.

- The river sediment status revealed that BMR20 was the highly polluted one compared to BMR55 and BMR56.

3.1.5.1 Water Quality Evaluation in Lakes Along Water Column

Water samples along the depth of the lakes were taken in parallel to sediment samples. The samples were coded as 1-surface, 2-middle depth, 3-bottom. The results of the analysis were given in Appendix 2 (Table A.4). The data obtained from the study was evaluated in accordance with the Chemical and Physicochemical Quality Criteria presented in Table 2 in Annex-5 of the Regulation for Surface Water Quality.

The water quality was Class I in most of the lakes based on the physicochemical parameters. However, Cindere Adıgüzel-2, Kemer, Yaylakavak and Bafa lakes resulted in Class II or Class III water quality due to high concentrations of nitrogen and phosphorus. The water quality of Yaylakavak Dam was Class II due to the Color parameter (Res (436nm)).

Heavy metals analyzed in water samples were boron, aluminum, silicon, vanadium, chrome, iron, cobalt, nickel, copper, zinc, arsenic, selenium, tin, antimony, barium, lead, titanium and mercury. The evaluation was made according to Table 2 given in Quality Criteria for the Classification of Continental Surface Water Resources (published on 15th April 2015 which is not currently in use) in Annex 5 of the Regulation on Surface Water Quality.

The variations of Boron concentration along the depth at the stations were given in Figure 3.143. The water quality of the lakes in terms of Boron pollution was determined as Class I. Lake Bafa was the most Boron polluted one among the other lakes. Similarly, boron concentration was high in transitional and coastal waters. The junction between transition or coastal water with the Bafa Lake could be the main reason for the boron pollution in the lake. It was also observed that boron concentration was high due to geothermal waters discharged to the river.

Figure 3.144. depicts the Aluminum concentrations observed along the depth of the lakes. Aluminum has been determined in Class I water quality values except for BML10, BML13 and BMTW1. At BML10, BML13 and BMTW1, Aluminum was found to be in Class 2 water quality values. Al, Fe (Figure 3.148) and Si (Figure 3.145) are abundant in the earth's crust (Şahinci, 1991). Therefore, high concentrations of these elements in waters, where there is no anthropogenic effect in the region, are likely to have developed due to the rock-water interaction process associated with the geological units outcropping in the region.

Chromium concentrations obtained in the lakes were given in Figure 3.147. The observed concentrations correspond to Class I. However, it was higher in the river water than in lakes. Cobalt (Figure 3.149), Nickel (Figure 3.150) and Copper (Figure 3.151) concentrations stated Class I water quality at all lake and river sampling points.

The concentration of Zinc increases along the depth in all stations apart from BML03 (Figure 3.152). As a result, water quality decreases from Class I to Class II from surface to the depth water. It seems that Zinc tends to accumulate in sediment. BMTW1 and BMR56 station concentrations have exceeded Class II water quality, too.

Arsenic concentration corresponds to Class I water quality limit values at all lake stations (Figure 3.153). In addition, the river stations of BMR20 and BMR55 were identified as Class II and BMR56 was close to Class II concentration, too. Arsenic concentrations at BML01, BML03, BML13 and BML16 were higher than those of other lakes.

Selenium was detected at very low concentration at all sampling points except for Lake Bafa (Figure 3.154). Coastal and transitional waters qualities were determined to be Class I. The quality of Bafa lake in terms of selenium was Class IV. The high concentration of selenium could be due to the junction of Bafa Lake with the sea in the past.

Barium (Figure 3.157) and Lead (Figure 3.158) were determined below Class I water quality limit values at all sampling points. Mercury (Figure 3.160) was not detected above the LOD value in any inland waters, coastal and transitional waters. Although there is no comparison criteria for vanadium (Figure 146), tin (Figure 3.155), antimony (Figure 3.156), titanium (Figure 3.159), most of the results obtained for these metals were below the LOD value.

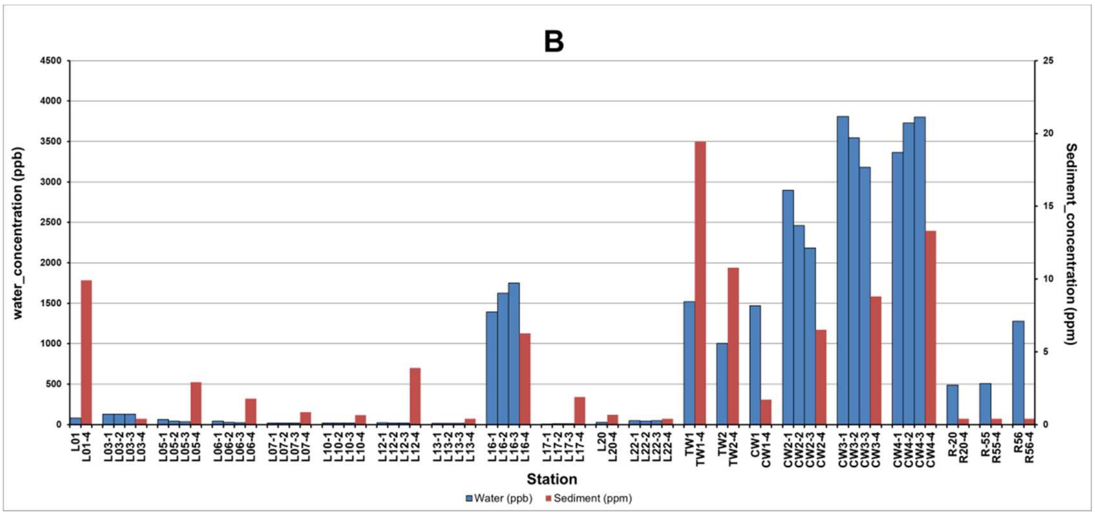

Figure 3.143 Variation of Boron concentration along the depth and on the sediment in the sediment sampled stations

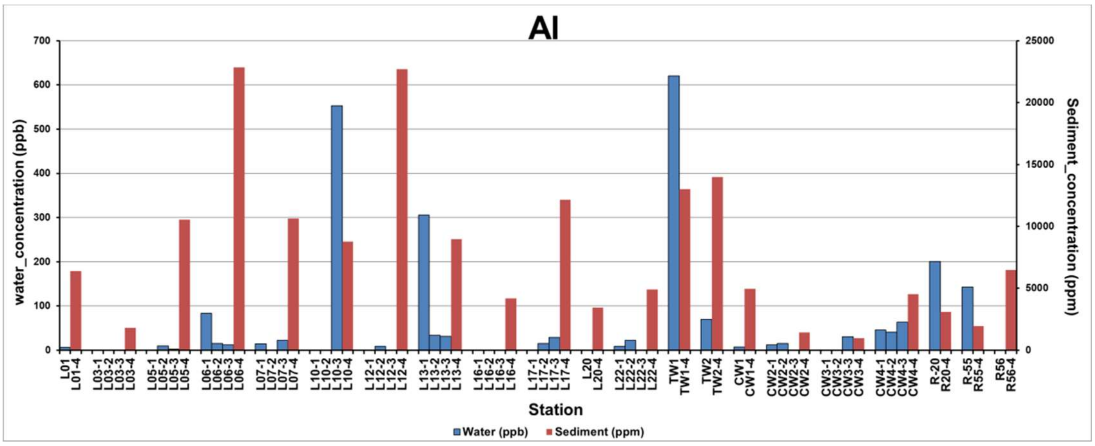

Figure 3.144 Variation of Aluminum concentration along the depth and on the sediment in the sediment sampled stations

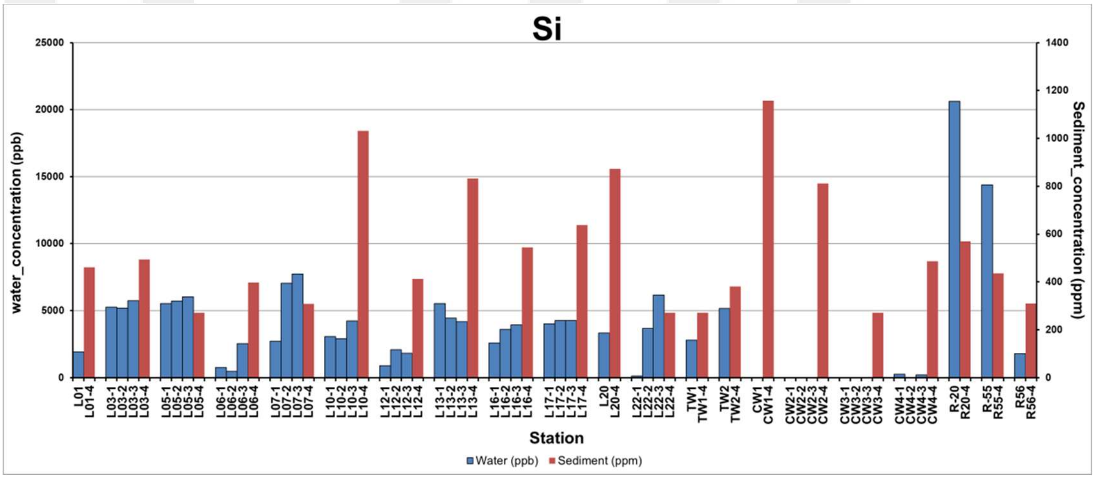

Figure 3.145 Variation of Silicon concentration along the depth and on the sediment in the sediment sampled stations

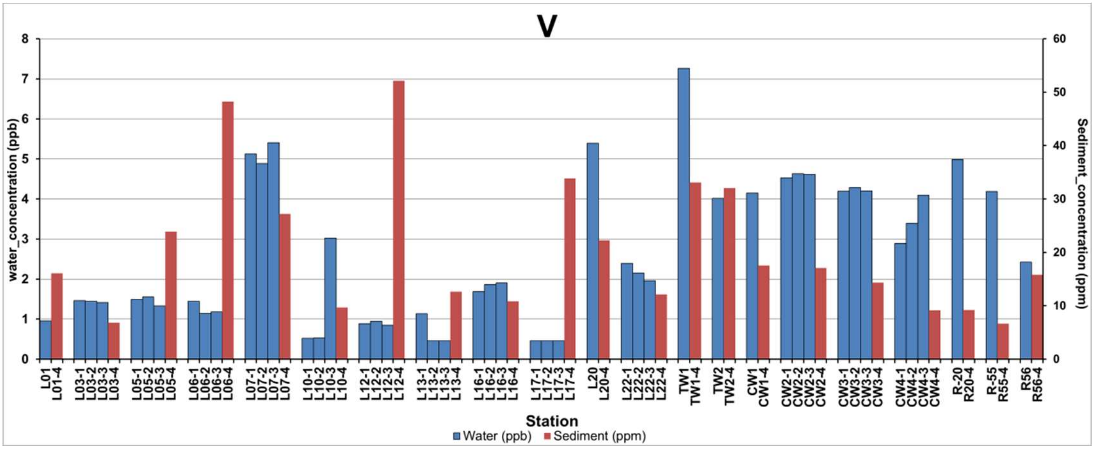

Figure 3.146 Variation of Vanadium concentration along the depth and on the sediment in the sediment sampled stations

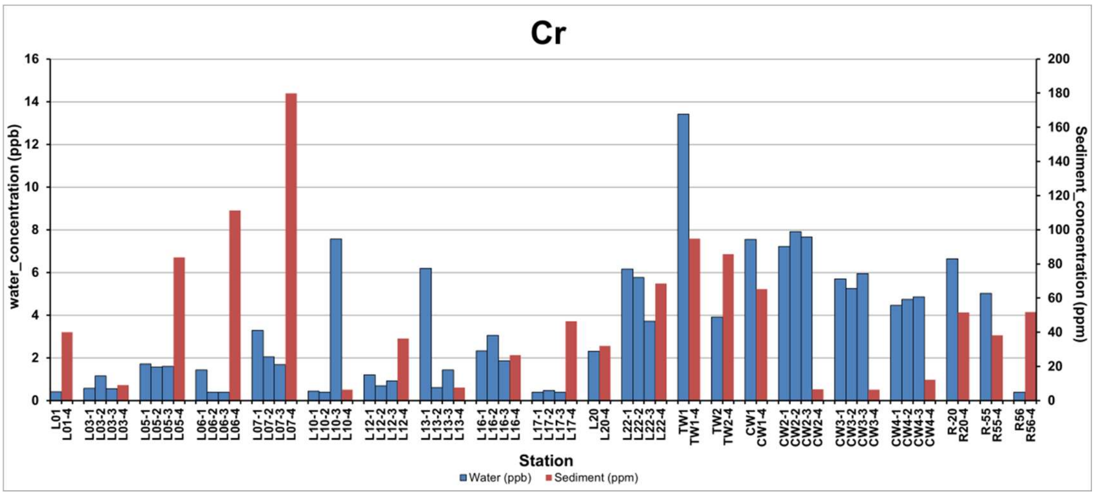

Figure 3.147 Variation of Chromium concentration along the depth and on the sediment in the sediment sampled stations

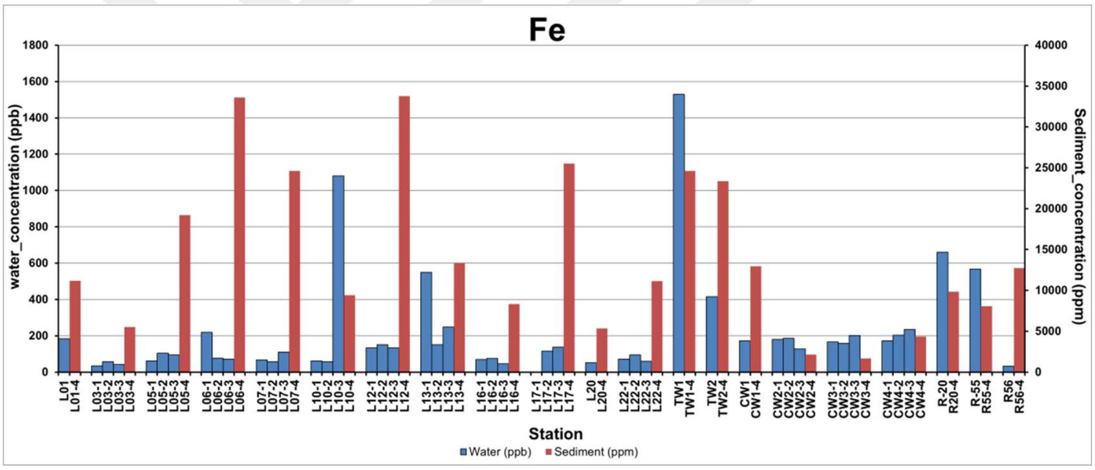

Figure 3.148 Variation of Iron concentration along the depth and on the sediment in the sediment sampled stations

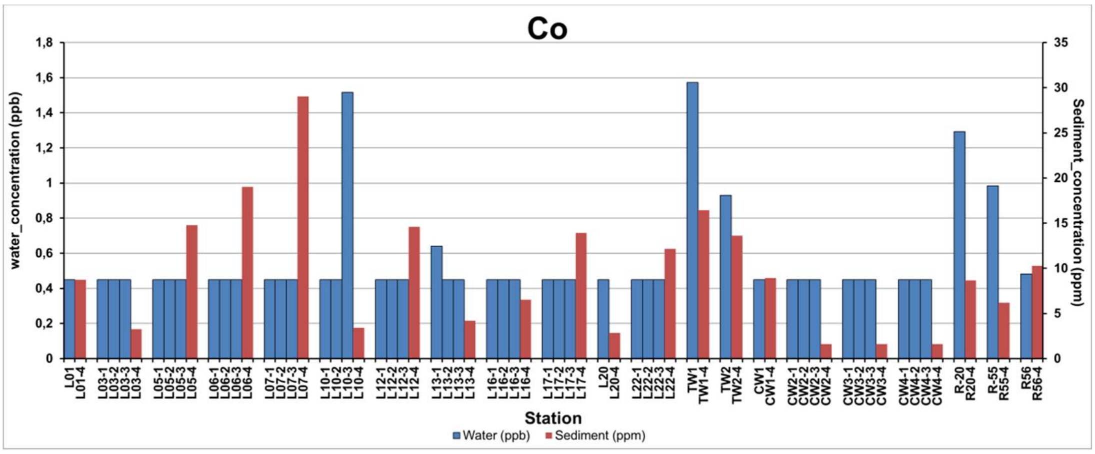

Figure 3.149 Variation of Cobalt concentration along the depth and on the sediment in the sediment sampled stations

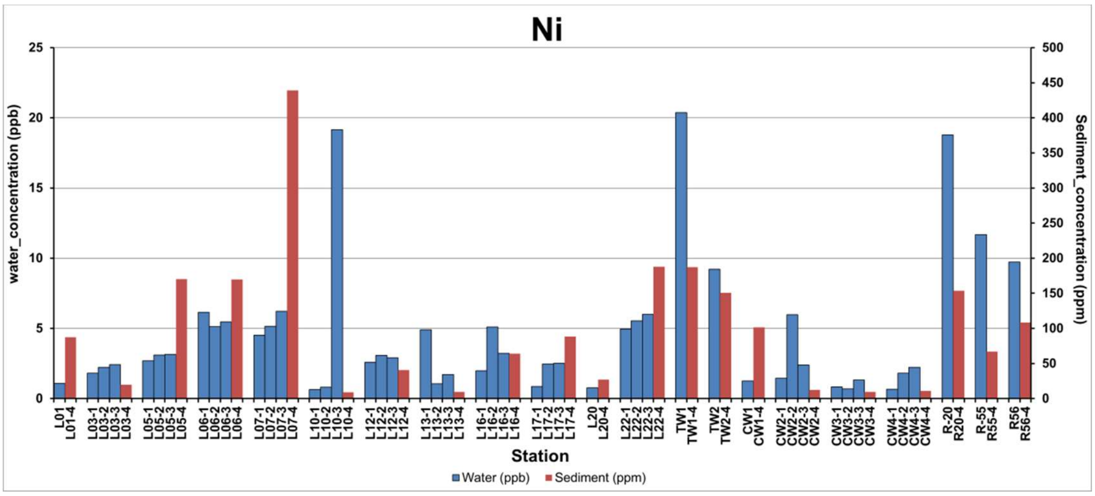

Figure 3.150 Variation of Nickel concentration along the depth and on the sediment in the sediment sampled stations

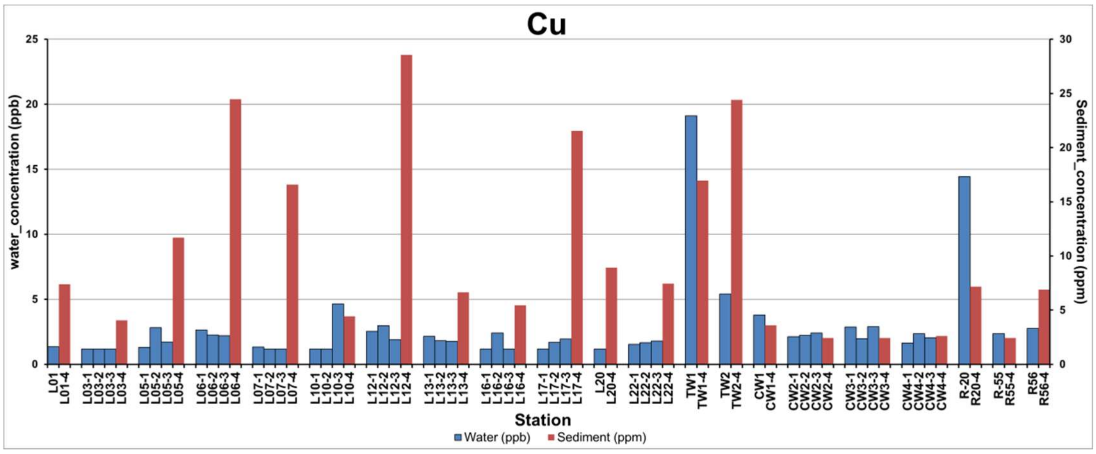

Figure 3.151 Variation of Copper concentration along the depth and on the sediment in the sediment sampled stations

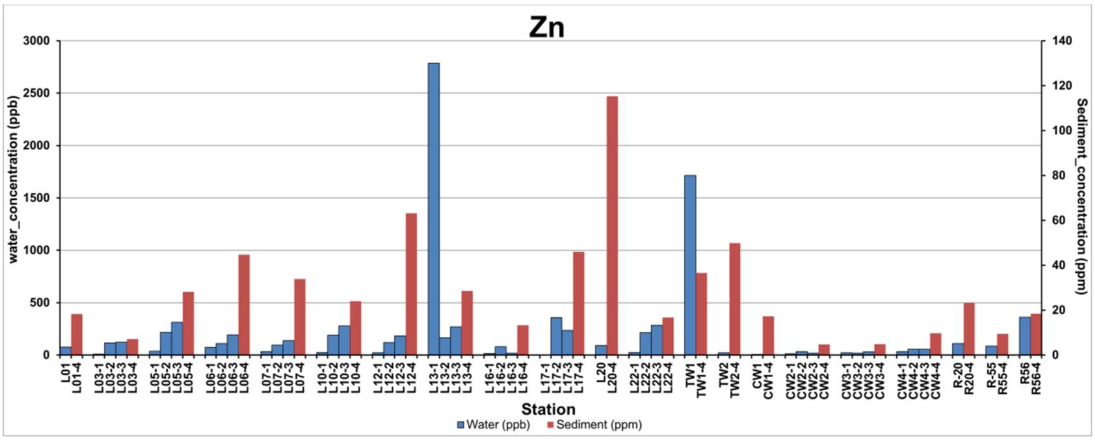

Figure 3.152 Variation of Zinc concentration along the depth and on the sediment in the sediment sampled stations

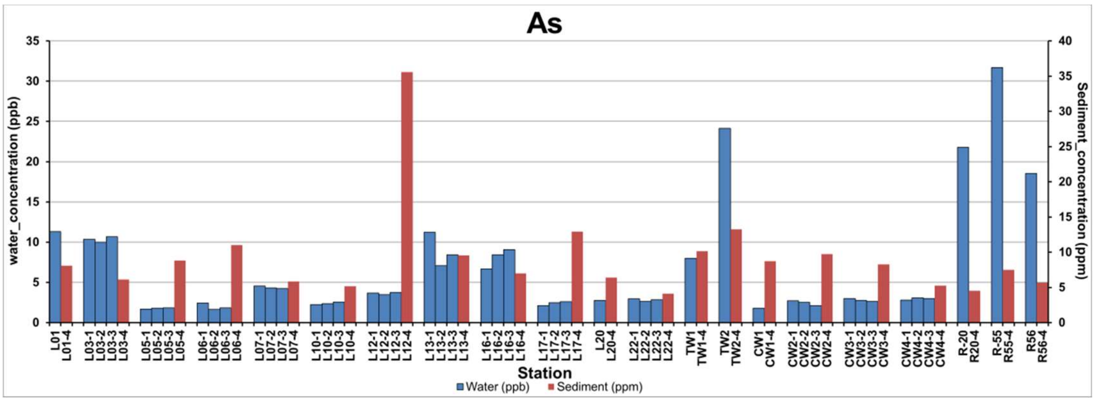

Figure 3.153 Variation of Arsenic concentration along the depth and on the sediment in the sediment sampled stations

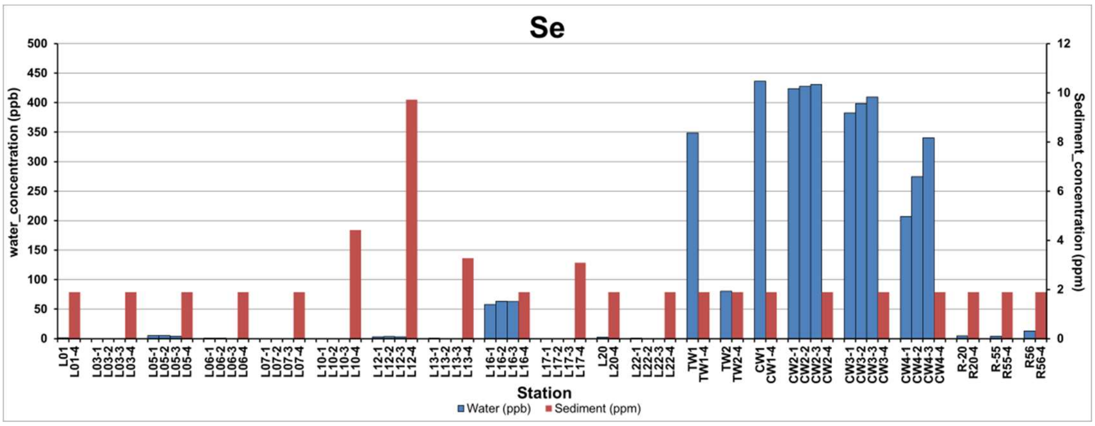

Figure 3.154 Variation of Selenium concentration along the depth and on the sediment in the sediment sampled stations

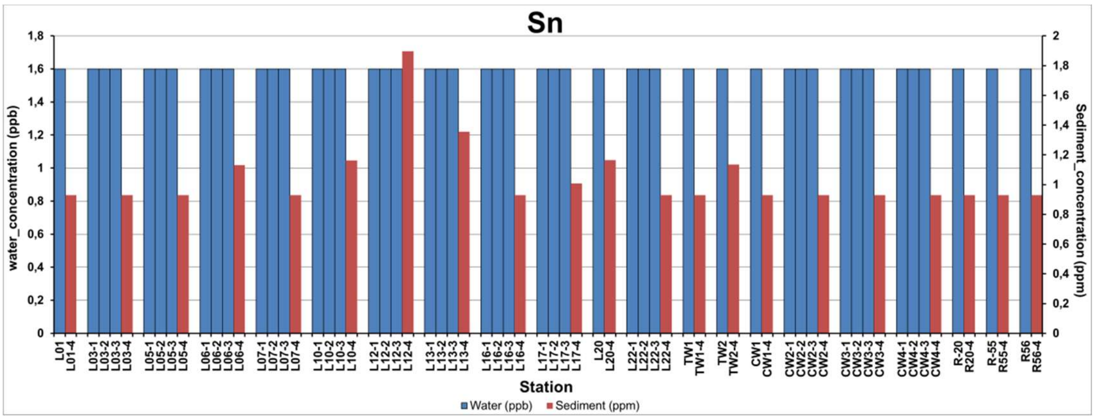

Figure 3.155 Variation of Tin concentration along the depth and on the sediment in the sediment sampled stations

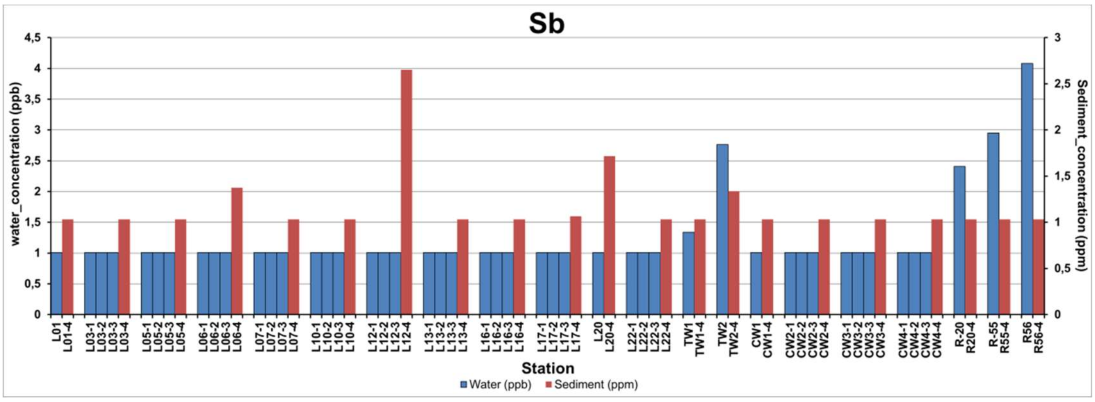

Figure 3.156 Variation of Antimony concentration along the depth and on the sediment in the sediment sampled stations

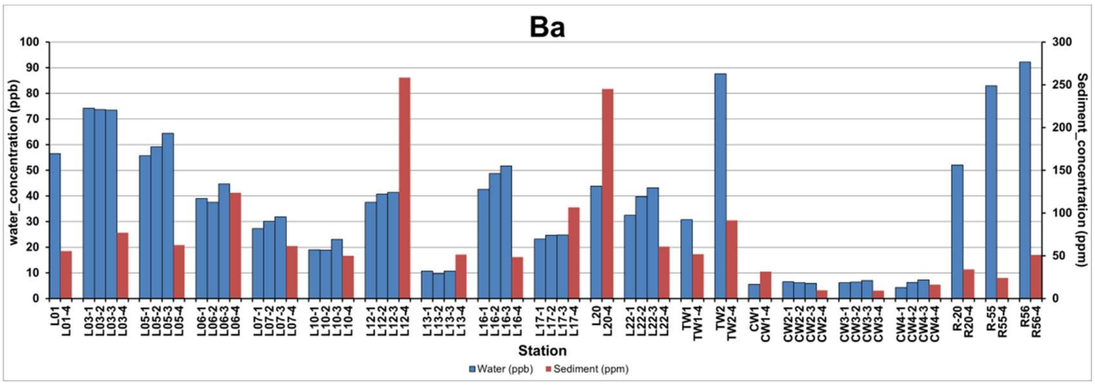

Figure 3.157 Variation of Barium concentration along the depth and on the sediment in the sediment sampled stations

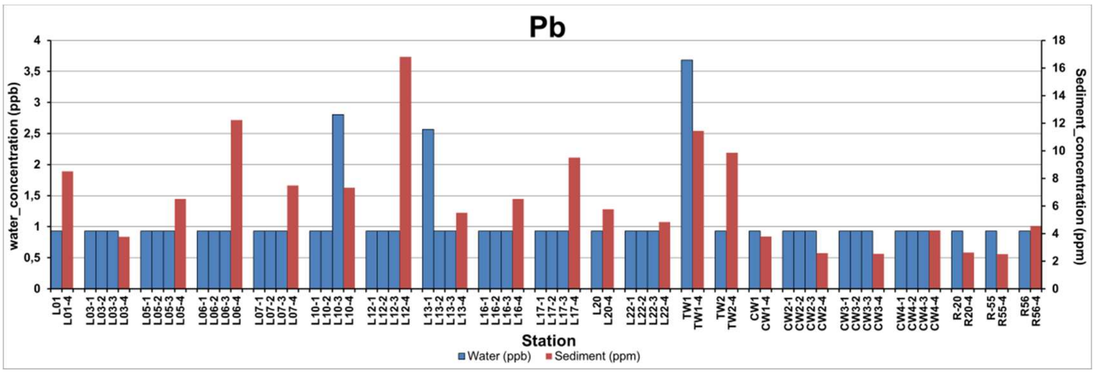

Figure 3.158 Variation of Lead concentration along the depth and on the sediment in the sediment sampled stations

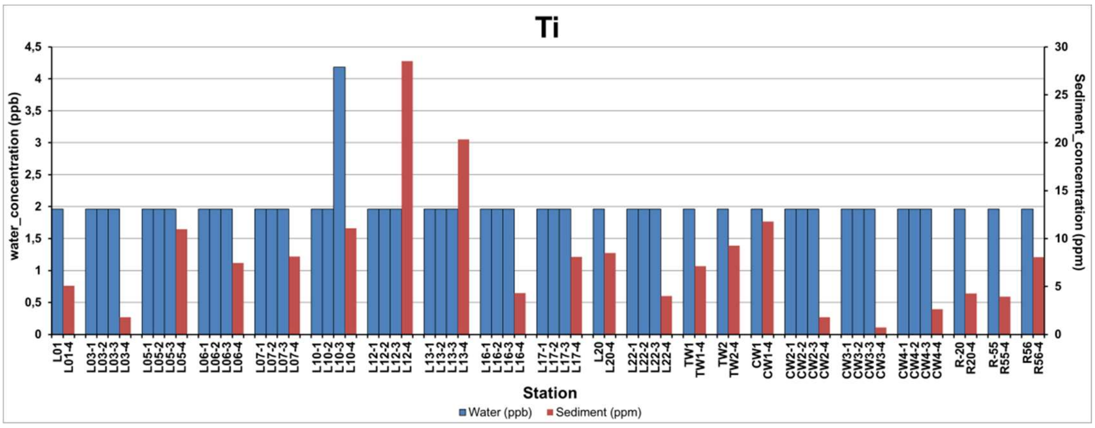

Figure 3.159 Variation of Titanium concentration along the depth and on the sediment in the sediment sampled stations

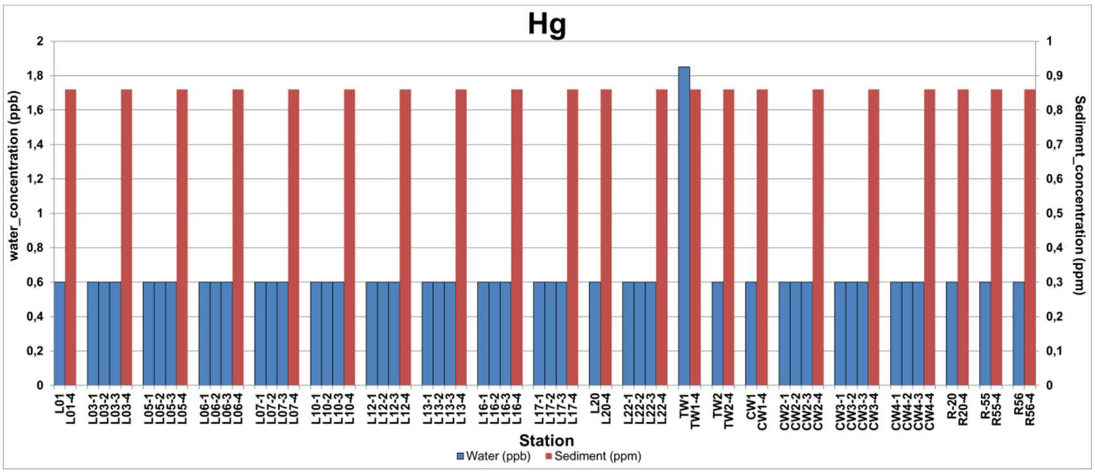

Figure 3.160 Variation of Mercury concentration along the depth and on the sediment in the sediment sampled stations

3.2 Determination of Water Quality Classes

3.2.1 Physicochemical Classification

Physicochemical monitoring was performed for four periods as September 2015-October 2015, January 2016, April 2016. The annual averages of the physicochemical parameters, which is the mean of the detected concentrations for four sampling periods, were determined. The results of four-period monitoring were presented in Appendix 3. The min (LOD), the maximum and the annual average of observed concentration of pollutants were given in Appendix 4.

The physicochemical water quality classification of the basin was determined according to Surface Water Quality Regulation of the Ministry (SWQR) and Water Framework Directive (WFD). Table 3.1 and Table 3.2 depicts the water quality classifications according to SWQR and WFD, respectively. Surface Water Quality Regulation of the Ministry was updated after the monitoring was almost completed. Some of the parameters were removed from the list while some new ones were added. The ranges for the classes were revised as well. These changes in the regulation were not adapted in the thesis.

The water quality class determined according to Surface Water Quality Regulation revealed that 16 of the sampling points were in the state of Class IV water quality and the remaining 23 sampling points have Class III quality.

COD (Figure 3.161) is one of the significant parameters in water quality determination. The highest annual averages for COD were in the range of 50-150.0 mg / L which were observed at stations BMR03 and BMR05 in Uşak region. The annual averages for COD at the other stations were less than 25.0 mg /L.

The other significant pollutant parameter in water quality determination is nitrogen. TKN (Figure 3.162), NH_4-N (Figure 3.163), NO_3-N (Figure 3.164) and NO_2-N (Figure 3.165) were the nitrogen forms monitored in the basin. NH_4-N reaches maximum levels (38.0 mg / L) in BMR05 in the vicinity of Uşak Organized Industrial Zone which is a highly polluted station by the industrial discharge. The annual average concentration for NH_4-N at this station was 13.0 mg / L which leads to Class IV water quality. NO_3-N was observed at high concentrations in BMR02, BMR03 and BMR05 to which there were industrial discharges. NO_3-N concentration in lake waters and transition waters were relatively high, especially, in January 2016. The annual average concentrations of NO_3-N reached maximum levels (12 mg / L) in BMR05 which resulted in Class III water quality. When phosphorus (Figure 3.166), TKN (total Kjeldahl nitrogen) and BOD (Figure 3.167) parameters were evaluated, high concentrations were obtained in, again, BMR03 and BMR05. The water quality regarding to these parameters was determined as Class IV.

For the assessment of physicochemical parameters according to the Water Framework Directive, Twinning Project commissioned by the Ministry was used. The four water quality classes used in SWQR were converted into three water quality classes in WFD. In this case, Class I water quality in the Surface Water Quality Regulation corresponds to “Very Good” water class according to WFD. However, Class II is equivalent to “Good Water” class according to WFD. Water Class III and IV in the Surface Water Quality Regulation are equivalent to “Moderate Water” quality in the Directive. The annual average values were evaluated according to these classifications. It was found that 35 of the 42 sampling points had “Moderate Water”. Only, 4 sampling points had “Good” water quality. Since no water was collected at two sampling points (BML19 and BMR33) and just one sampling at BMR29 station, no classification was determined for these stations.

The stations identified as reference in the Twinning project were BMR15, BMR 27, BMR32, BMR36, BMR47, BMR48 and BMR49. Unfortunately, none of the reference station resulted in either Class I or Very Good water quality based on the SWQR or WFD, respectively. The reference stations BMR27, BMR32, BMR47, BMR48 and BMR49 were in Class III quality. The other reference stations BMR15 and BMR36 were in Class IV status. In the assessment of water qualities according to WFD, all reference points in terms of physicochemical parameters fall into the

“Moderate Water” quality class. The water quality classification maps of physicochemical parameters according to SWQR and WFD were given in Figure 3.174 and Figure 3.175, respectively (Yerüstü, Kıyı ve Geçiş Suları için Çevresel Hedeflerin Belirlenmesine Yönelik Metodolojinin Geliştirilmesi: Büyük Menderes Havzası Pilot Çalışması Projesi, 2018).

Table 3.1 The water quality parameters monitored according to SWQR (Yerüstü, Kıyı ve Geçiş Suları için Çevresel Hedeflerin Belirlenmesine Yönelik Metodolojinin Geliştirilmesi: Büyük Menderes Havzası Pilot Çalışması Projesi, 2018)

WATER QUALITY PARAMETER	**LOD (mg/L)**	**I**	**II**	**III**	**IV**
COD	6.07	<25	25-50	50-70	>70
NH_4-N	0.24	<0.2	0.2-1	1-2	>2
NO_3-N (*)	0.06	<3	3-10	10-20	> 20
P (*)	0.08	<0.08	0.08-0.16	0.16-0.65	> 0.65
TKN	0.98	<0.5	1.5	5	>5
BOI	3.8	<4	4-8	8-20	>20
Ni	0.65 E-3	≤20	20-50	50-200	>200
Cu	1.18 E-3	≤20	20-50	50-200	>200
Zn	0.79 E-3	≤200	200-500	500-2000	>2000
Cd	0.36 E-3	≤2	2-5	5-7	>7
Pb	0.00269	≤10	10-20	20-50	>50
Hg	0.0006	<0.1	0.1-0.5	0.5-2	>2
436 RES, m^{-1}		1.5	3	4.3	5
525 RES, m^{-1}		1.2	2.4	3.7	4.2
620 RES, m^{-1}		0.8	1.7	2.5	2.8
pH	0.08	6.5-8.5	6.5-8.5	6.0-9.0	6.0-9.0 except
Temperature		≤25	≤25	≤30	>30
Conductivity	-	<400	400-1000	1001-3000	>3000
Dissolved oxygen (mg O_2/L)	-	> 8	6-8	3-6	<3
Oxygen saturation (%)	-	>90	70-90	40-70	<40
Fecal coliform (EMS/100 mL)		≤10	10-200	200-2000	>2000
Total coliform (EMS/100 mL)		≤100	100-20000	20000-100000	>100000

Table 3.2 The water quality parameters monitored according to WFD (Yerüstü, Kıyı ve Geçiş Suları için Çevresel Hedeflerin Belirlenmesine Yönelik Metodolojinin Geliştirilmesi: Büyük Menderes Havzası Pilot Çalışması Projesi, 2018)

WATER QUALITY PARAMETER	**LOD (mg/L)**	**Very Good**	**Good**	**Moderate**
COD	6.07	< 25	25-50	>50
NH_4-N	0.24	< 0.2	0.2-1	>1
NO_3-N (*)	0.06	< 3	3-20	>20
P (*)	0.08	< 0.08	0.08-0.8	>0.8
TKN	0.98	<0.5	0.5-5	>5
BOI	3.8	< 4	4-8	>8
Ni	$0.65\ E^{-3}$	≤20	20-50	>50
Cu	$1.18\ E^{-3}$	≤20	20-50	>50
Zn	$0.79\ E^{-3}$	≤200	200-500	>500
Cd	$0.36\ E^{-3}$	≤ 2	2-5	>5
Pb	0.00269	≤10	10-20	>20
Hg	0.0006	< 0.1	0.1-0.5	>0.5
436 RES, m^{-1}	-	<1.5	1.5-4.3	>4.3
525 RES, m^{-1}	-	<1.2	1.2-3.7	>3.7
620 RES, m^{-1}	-	<0.8	0.8-2.5	>2.5
pH	0.08	6.5-8.5	6.5-8.5	6.0-9.0
Temperature	-	≤ 25	≤ 25	≥25
Conductivity	-	<400	400-1000	>1000
Dissolved oxygen (mg O_2/L)	-	> 8	6-8	<6
Oxygen saturation (%)	-	>90	70-90	<70
Fecal coliform (EMS/100 mL)		≤10	10-200	>200
Total coliform (EMS/100 mL)		≤100	100-20000	>20000

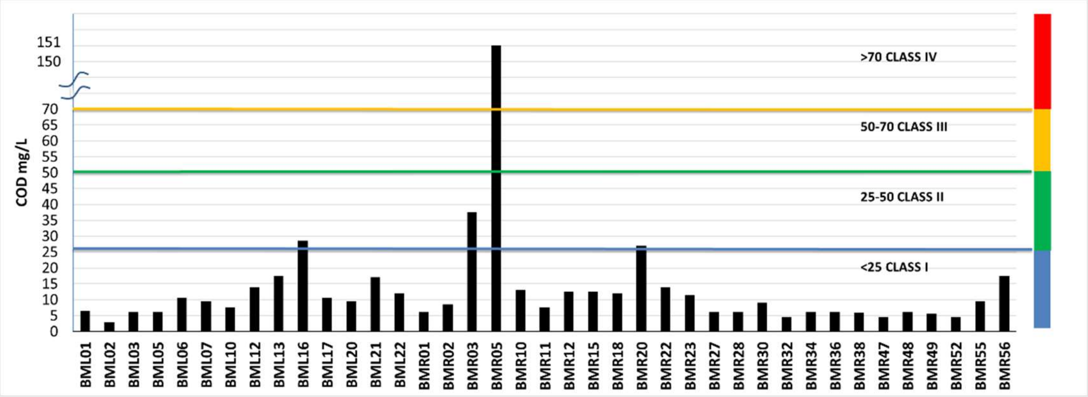

Figure 3.161 Classification of water quality in BMRB according to COD parameter

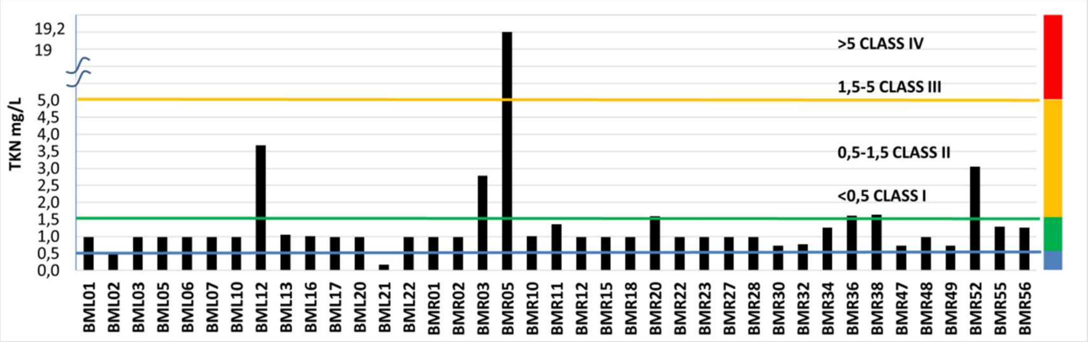

Figure 3.162 Classification of water quality in BMRB according to TKN parameter

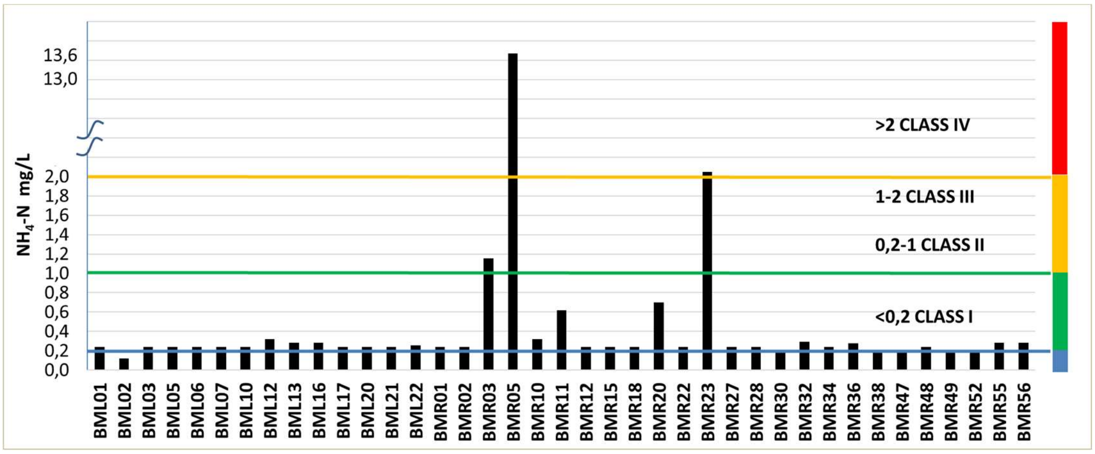

Figure 3.163 Classification of water quality in BMRB according to NH_4-N parameter

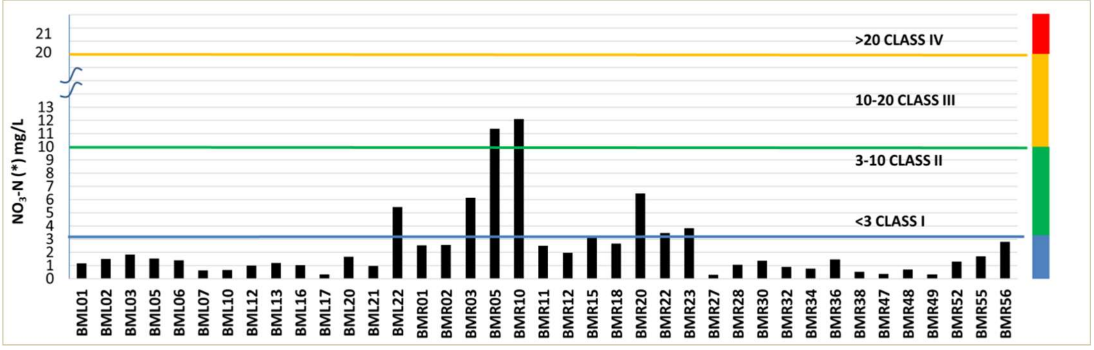

Figure 3.164 Classification of water quality in BMRB according to NO_3-N parameter

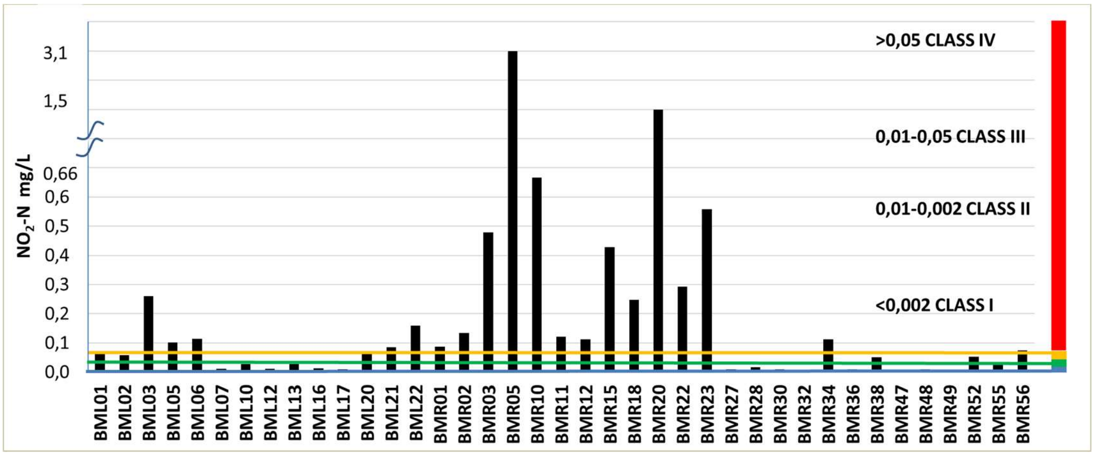

Figure 3.165 Classification of water quality in BMRB according to NO$_2$-N parameter

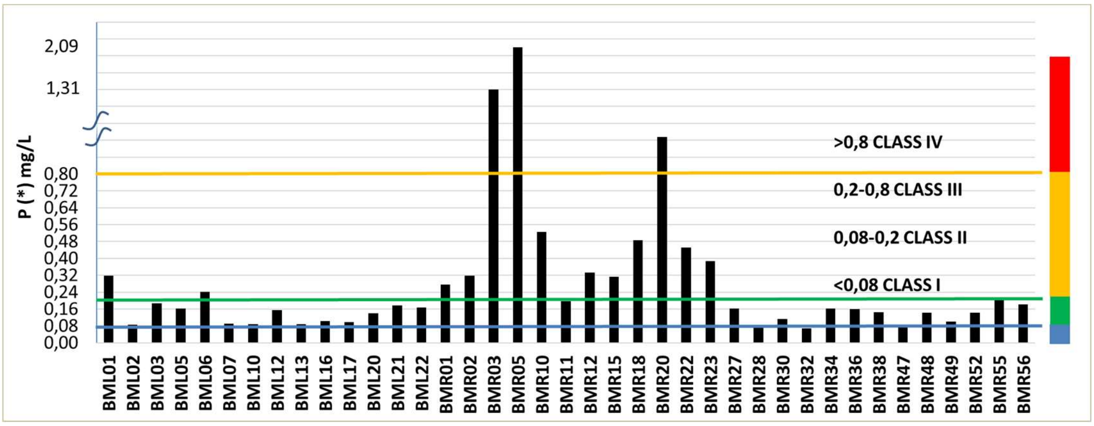

Figure 3.166 Classification of water quality in BMRB according to P parameter

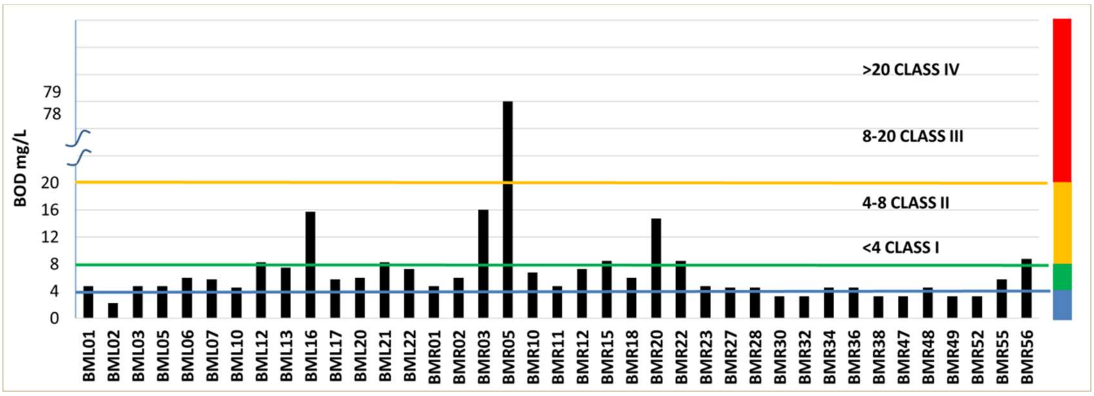

Figure 3.167 Classification of water quality in BMRB according to BOD parameter

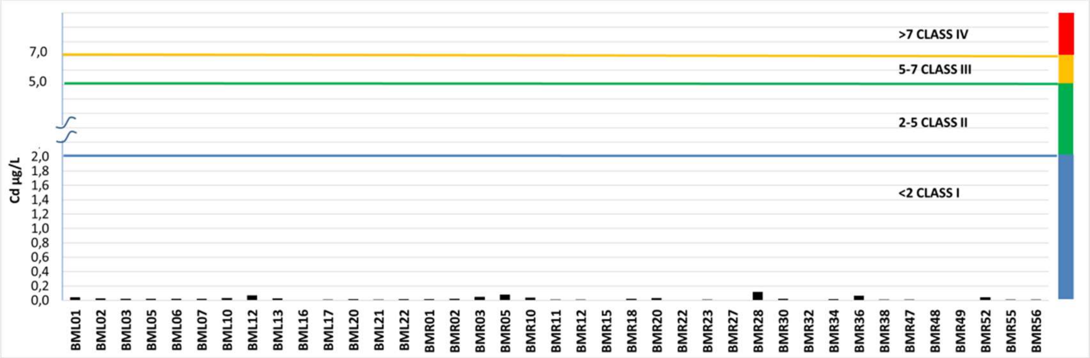

Figure 3.168 Classification of water quality in BMRB according to Cd parameter

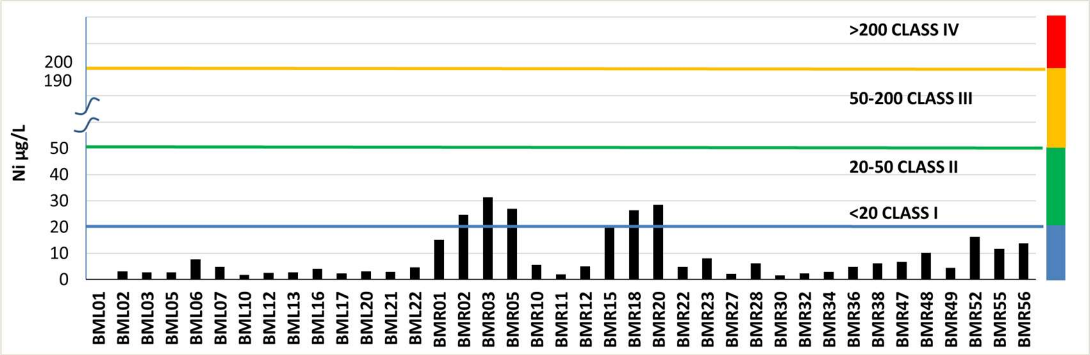

Figure 3.169 Classification of water quality in BMRB according to Ni parameter

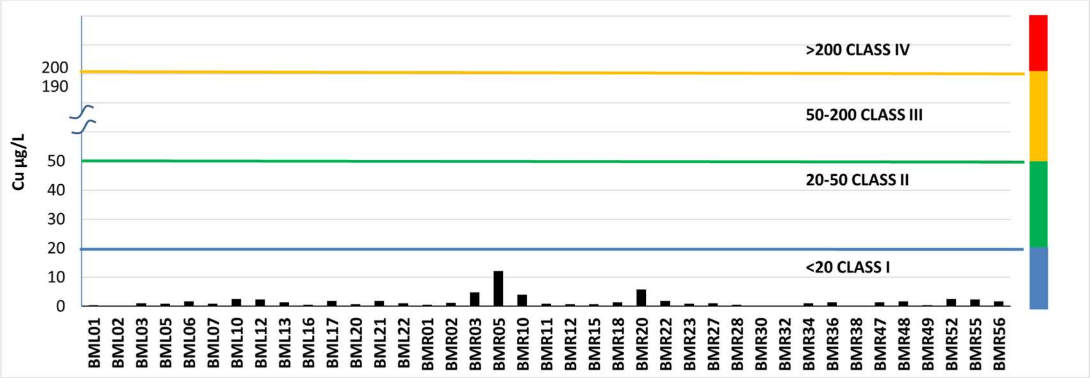

Figure 3.170 Classification of water quality in BMRB according to Cu parameter

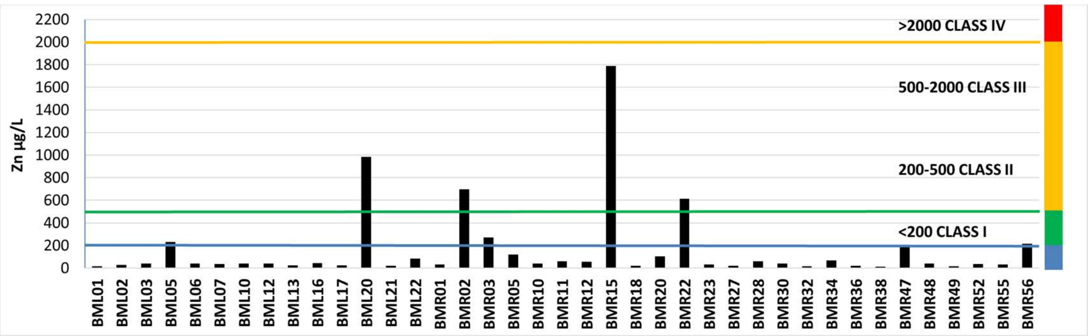

Figure 3.171 Classification of water quality in BMRB according to Zn parameter

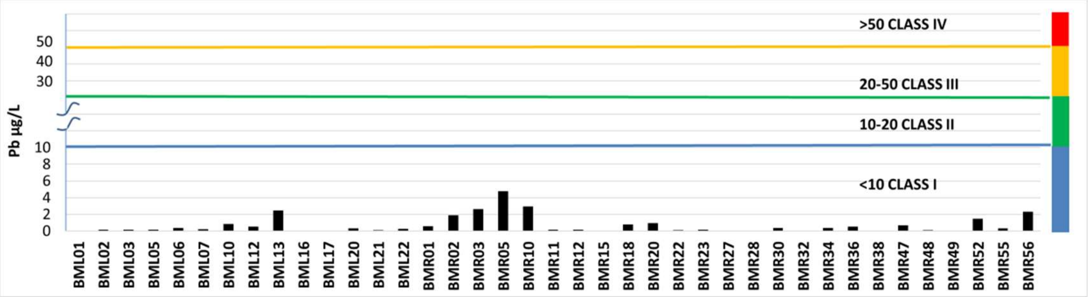

Figure 3.172 Classification of water quality in BMRB according to Pb parameter

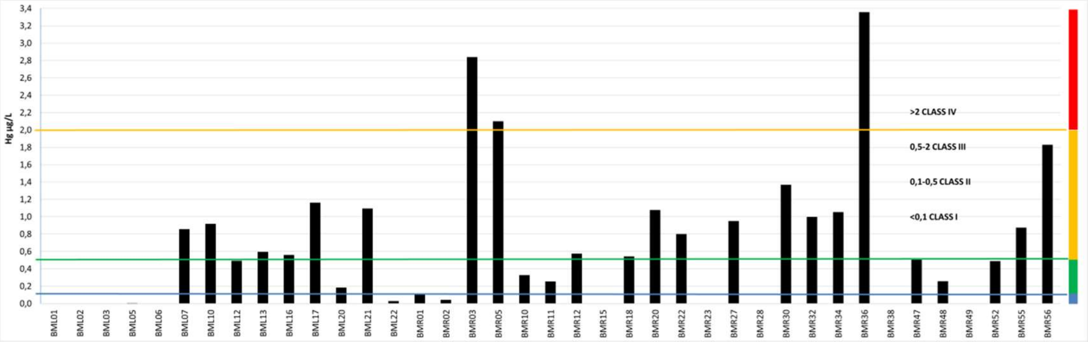

Figure 3.173 Classification of water quality in BMRB according to Hg parameter

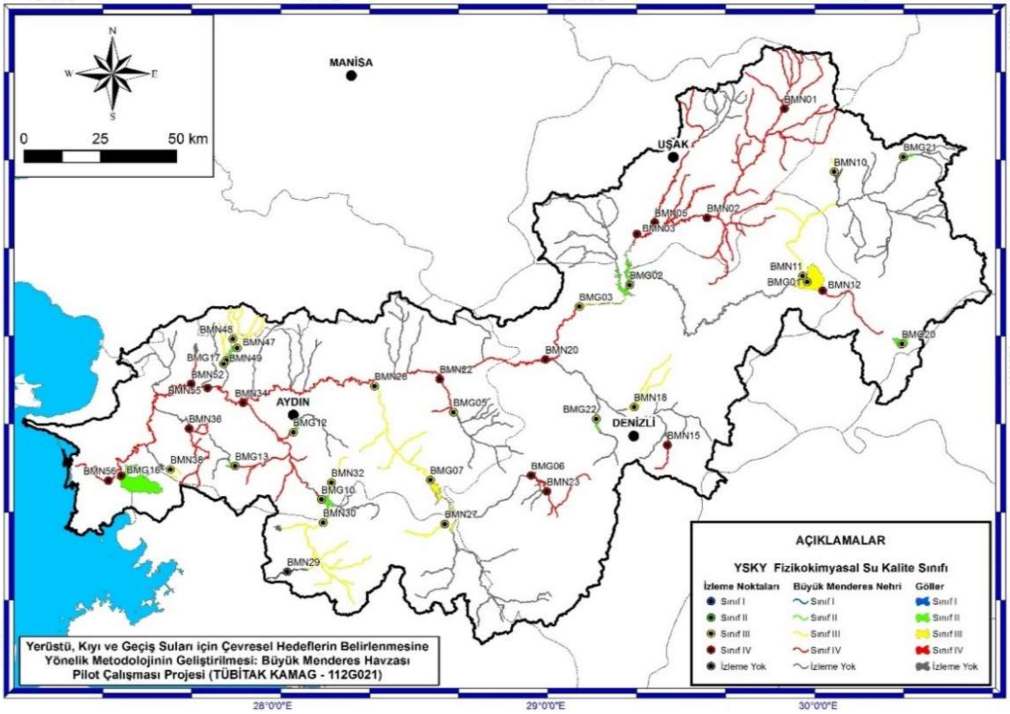

Figure 3.174 Water quality classifications in BMRB according to SWQR (Yerüstü, Kıyı ve Geçiş Suları için Çevresel Hedeflerin Belirlenmesine Yönelik Metodolojinin Geliştirilmesi: Büyük Menderes Havzası Pilot Çalışması Projesi, 2018)

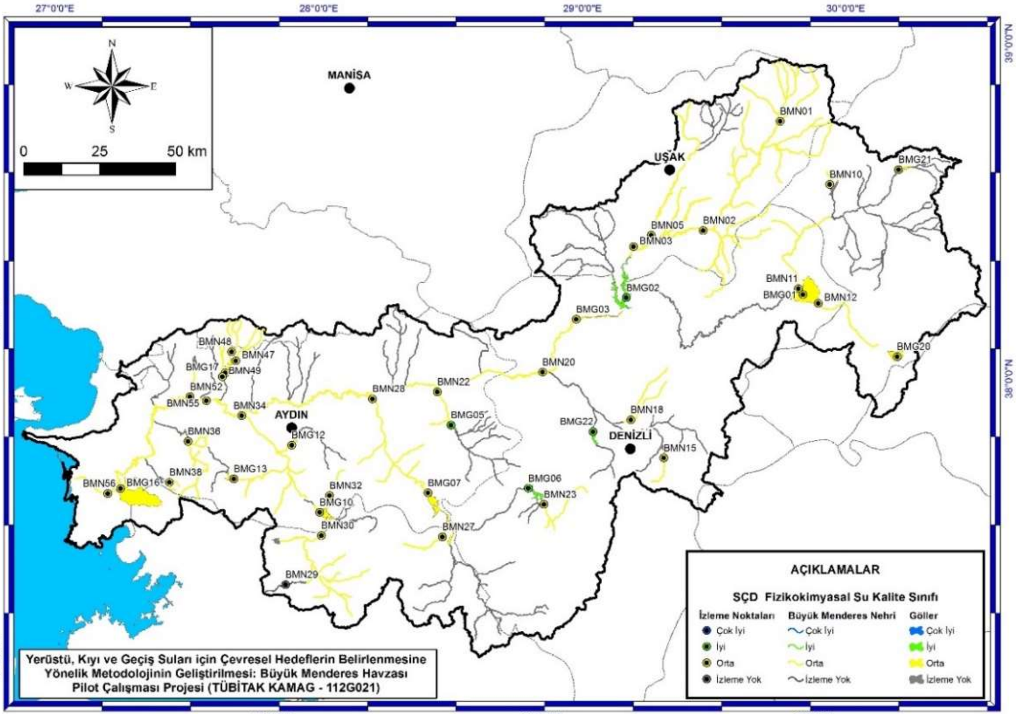

Figure 3.175 Water quality classifications in BMRB according to WFD (Yerüstü, Kıyı ve Geçiş Suları için Çevresel Hedeflerin Belirlenmesine Yönelik Metodolojinin Geliştirilmesi: Büyük Menderes Havzası Pilot Çalışması Projesi, 2018)

3.2.2 Determination of Chemical Status of BMRB

The methodology used in determination of chemical status for all stations according to WFD was mentioned in the Introduction section of the thesis. The status of the stations for physicochemical, specific and priority pollutants according to SWQR and WFD were summarized in Table 3.3 The final decision about the chemical status of the stations according to WFD were given in Table 3.4. The list of priority and specific pollutants obtained in water bodies above the EQS were given in Table 3.5.

Table 3.3 Water quality evaluation of all stations

Station Number	**AA-EQS_wRivers/Lakes (ppb) Priority**	**AA-EQS_wRivers/Lakes (ppb) Specific**	**SWQR general physicochemical**	**WFD general physicochemical**
BML01	Bad	Moderate	Class III	Moderate
BML02	Bad	Moderate	Class III	Moderate
BML03	Bad	Moderate	Class III	Moderate
BML05	Bad	Moderate	Class III	Moderate
BML06	Bad	Moderate	Class IV	Moderate
BML07	Bad	Moderate	Class III	Moderate
BML10	Bad	Moderate	Class III	Moderate
BML12	Bad	Moderate	Class III	Moderate
BML13	Bad	Moderate	Class III	Moderate
BML16	Bad	Moderate	Class IV	Moderate
BML17	Bad	Moderate	Class III	Moderate
BML20	Bad	Moderate	Class III	Moderate
BML21	Bad	Moderate	Class III	Moderate
BML22	Bad	Moderate	Class III	Moderate
BMR01	Bad	Moderate	Class IV	Moderate
BMR02	Bad	Moderate	Class IV	Moderate
BMR03	Bad	Moderate	Class IV	Moderate
BMR05	Bad	Moderate	Class IV	Moderate
BMR10	Bad	Moderate	Class III	Moderate
BMR11	Bad	Moderate	Class III	Moderate
BMR12	Bad	Moderate	Class IV	Moderate
BMR15	Bad	Moderate	Class IV	Moderate
BMR18	Bad	Moderate	Class III	Moderate
BMR20	Bad	Moderate	Class IV	Moderate

Table 3.3 continues

Station Number	AA-EQS$_w$Rivers/Lakes (ppb) Priority	AA-EQS$_w$Rivers/Lakes (ppb) Specific	SWQR general physicochemical	WFD general physicochemical
BMR22	Bad	Moderate	Class IV	Moderate
BMR23	Bad	Moderate	Class IV	Moderate
BMR27	Bad	Moderate	Class IV	Moderate
BMR28	Bad	Moderate	Class III	Moderate
BMR29	Bad	Moderate	Class III	Moderate
BMR30	Bad	Moderate	Class III	Moderate
BMR32	Bad	Moderate	Class III	Moderate
BMR34	Bad	Moderate	Class IV	Moderate
BMR36	Bad	Moderate	Class IV	Moderate
BMR38	Bad	Moderate	Class III	Moderate
BMR47	Bad	Moderate	Class III	Moderate
BMR48	Bad	Moderate	Class III	Moderate
BMR49	Bad	Moderate	Class III	Moderate
BMR52	Bad	Moderate	Class IV	Moderate
BMR55	Bad	Moderate	Class IV	Moderate
BMR56	Bad	Moderate	Class IV	Moderate

Table 3.4 Chemical status of the stations evaluated according to WFD

Station Code	Priority Pollutants	Specific Pollutants	Station Code	Priority Pollutants	Specific Pollutants	Station Code	Priority Pollutants	Specific Pollutants	Station Code	Priority Pollutants	Specific Pollutants
BML01	Bad	Moderate	**BMR01**	Bad	Moderate	**BMR30**	Bad	Moderate	**BMTW01**	Bad	Moderate
BML02	Bad	Moderate	**BMR02**	Bad	Moderate	**BMR32**	Bad	Moderate	**BMTW02**	Bad	Moderate
BML03	Bad	Moderate	**BMR03**	Bad	Moderate	**BMR33**	Bad	Moderate	**BMCW01**	Bad	Moderate
BML05	Bad	Moderate	**BMR05**	Bad	Moderate	**BMR34**	Bad	Moderate	**BMCW02**	Bad	Moderate
BML06	Bad	Moderate	**BMR10**	Bad	Moderate	**BMR36**	Bad	Moderate	**BMCW03**	Bad	Moderate
BML07	Bad	Moderate	**BMR11**	Bad	Moderate	**BMR38**	Bad	Moderate	**BMCW04**	Bad	Moderate
BML10	Bad	Moderate	**BMR12**	Bad	Moderate	**BMR47**	Bad	Moderate			
BML12	Bad	Moderate	**BMR15**	Bad	Moderate	**BMR48**	Bad	Moderate			
BML13	Bad	Moderate	**BMR18**	Bad	Moderate	**BMR49**	Bad	Moderate			
BML16	Bad	Moderate	**BMR20**	Bad	Moderate	**BMR52**	Bad	Moderate			
BML17	Bad	Moderate	**BMR22**	Bad	Moderate	**BMR55**	Bad	Moderate			
BML19	Bad	Moderate	**BMR23**	Bad	Moderate	**BMR56**	Bad	Moderate			
BML20	Bad	Moderate	**BMR27**	Bad	Moderate						
BML21	Bad	Moderate	**BMR28**	Bad	Moderate						
BML22	Bad	Moderate	**BMR29**	Bad	Moderate						

Table 3.5 Substances exceeding AA-EQS and MAC-EQS in stations

Substances exceeding AA-EQS value		**Substances exceeding MAC-EQS value**		
Aldrin	Cobalt	Aluminum	Diflubenzuron	Silicon
Aluminum	Chromium	Arsenic	Fenpropathrin	Cobalt
Antimony	Lead and compounds	Acenaphthene	Fluoranthene	Titanium
Arsenic	Nickel and Compounds	Copper	Silver	Vanadium
Copper	C10-13-chloroalkanes those	Zinc	Iron	Boron
PCB 138	PCB 153	PCB 138	PCB 153	PCB 52
Boron	Titanium	Cypermethrin	Mercury and compounds	
Zinc	Cadmium and its compounds	Chlorfenvinphos	Benzo-ghi-perylene	
Iron	Cypermethrin	Chromium	Lead and compounds	
Silver	Thiabendazole	Beryllium	Nickel and Compounds	
Silicon	Fluoranthene	Benzo (k) fluoranthene		
Perfluorooctanesulfonicacid and derivatives (PFOS)		C10-13-chloroalkanes those		

CHAPTER FOUR
CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

Büyük Menderes River is a valuable water resource for being protected against pollution. Revealing the currents water quality status of this water resource is a kind of must to be aware of the pollution and to be able to take the measures for the improvements. This thesis may help develop a road map to determine what kinds of measures can be taken for the improvements of the water quality for both physicochemical and other hazardous or toxic chemical pollutions present in the basin. Based on the monitoring and the water quality classifications conducted at BMRB, the following evaluations and comments were drawn.

The stations which need special consideration or at which urgent measures to be taken can be determined according to the water quality classification. BMR01 and BMR03 monitoring stations with the junction point of BML02 have "Medium" class water quality. BMR04, BMR05, BMR06 and BMR07 were classified as "Bad". These stations are located in Uşak and surface water from these stations join to the Büyük Menderes River through Dokuzsele Creek. There is non-point pollution due to intensive agricultural and animal activities. The "Bad" water quality is mainly due to industrial discharges at this region. Therefore, it can be concluded that basin is under pressure especially from industrial activities.

The surface waters from stations BMR14, BMR15, BMR16, BMR17, BMR18 and BML22 flow toward the monitoring station BMR19. The chemical status of this station was determined as "Bad". This region is located within the boundaries of Denizli province and it is connected to BMR by Çürüksu Stream. This region contains active industries and densely populated with heavy domestic wastewater generation. However, not all the domestic sources have UWTP. In addition, there are intensive livestock and agricultural activities. In summary, "bad" water quality can be attributed to all these point and non-point sources. But the main pressure on the basin is the industrial activities.

BMR55, BMR55, BMR45, BMR42, BMR43, BMR44, BMR42, BMR43, BMR41, BMR44, BMR42, BMR43, BMR41, BMR44, BML17 monitoring. The assessment was determined in the "bad" class. This region is located within the borders of Aydın province, is on the main branch of BMR and is called Lower Büyük Menderes. This main branch is under the pressure of point and non-point sources of pollution carried by other branches from the upstream. However, the region in question is both an agricultural and industrial area. The population in this region is intense and KAAT is required.

The pollutant types that exist in the basin help the determination of what type of measures should be taken and also analysis of the pollution sources. Pesticides are one of the largest pollutant groups in both priority and specific pollutant list. Their sources are mostly non-point or they are diffused sources which are the most difficult ones to take measures in order to improve the quality of the water. The pesticides that exceeded the AA-EQS$_W$ value in the basin are Aldrin, Cypermethrin and Thiabendazole. Pesticides with concentrations exceeding the MAC-EQS$_W$ value are Diflubenzuron, Fenpropatrin, Chlorfenvinphos and Cypermethrin. The other pesticides were detected at either low concentrations or below the WFD pollution criteria. Although the number of pesticides that must be controlled in the basin is relatively low, still measures have to be taken to improve the water quality and to reach the good water status as stated in WFD.

PAHs were detected in many stations, even at low concentrations. This shows that there is significant PAH pollution in BMRB. PAH exceeding the MAC-EQS$_W$ value Benzo (k) fluoranthene. Pyrene poses a risk factor with the concentration close to the MAC-EQS$_W$ value. There is a significant seasonal variation in PAH concentration and variation from station to station. The most significant PAH to be considered according to AA-EQS$_W$ criteria is Fluoranthene. Its concentration in both coastal, lakes and rivers is high enough to take measures. In summary, the PAHs that must be controlled at point and non-point sources, if possible, are primarily Benzo (k) fluoranthene, Benzo (ghi) perylene and Pyrene, Fluoranthene.

Chloralkanes are one of the other pollutants for which some measures must be taken. Although the concentrations below 0.05 ppb were generally observed in the basin, around 5 ppb Chloroalkane concentration was observed in BML20 and above the MAC-EQS$_w$ and AA-EQS$_w$ value of 0.4 ppb.

PFOS was only observed in the monitoring of November 2015 and March 2016 in the BMR10, BMR11 and BMR12 around 0.0035 ppb. The PFOS concentrations determined were significantly lower than the limit values. However, it was detected only once at 0.004 ppb concentration in PFOS BMR10 station. The source of PFOS can be determined and control of PFOS pollution can be achieved.

PCB pollution was detected at stations BMR29 and BMR55 with the concentrations above MAC-EQS$_w$. Di (2-ethylhexyl) phthalate (DEHP) is commonly observed in the basin with the maximum concentration of 0.6 ppb which is lower than quality criteria. Dibutyl phthalate (DBP) was measured at a concentration as high as 8 ppb, but, less than EQS values. Similarly, the detected concentration of alkyl phenols was 0.7 ppb obtained at BMR05, Octyl phenol (OP) concentration which is a priority pollutant, was around 0.5 ppb. These concentrations are not at dangerous levels. But special attention must be given to them due to their endocrine-disrupting nature on the aquatic organisms. Because their threshold concentration that causes endocrine-disrupting effect is not well known yet.

Heavy metals are most commonly observed pollutants in the basin. Among the 21 different metals listed as priority and specific pollutants in WFD and SWQR, respectively, the ones which are over its own MAC-EQS$_w$ value were aluminum, arsenic, copper, beryllium, boron, mercury, zinc, iron, silver, cadmium, cobalt, chromium, lead, nickel, silicon, titanium and vanadium. In terms of the frequency of exceeding the MAC-EQS$_w$ value, the prominent metals in the basin are aluminum, copper, iron and silicon. Metals exceeding AA-EQS$_w$ value are aluminum, antimony, arsenic, copper, boron, zinc, iron, silver, cadmium and compounds, cobalt, chromium, lead and compounds, nickel and compounds, silicon and titanium. In this respect, it can be said that iron, silicon, aluminum and copper pollution is a significant level in the basin. However, silicone and aluminum are the natural metals in the soil. The high concentrations of these metals in the basin should be accepted. The background concentrations can be determined and their EQA values can be revised. The metals that do not exceed the MAC-EQS_w value in stations and periods are antimony, barium, tin and selenium. The stations where metal pollution was most frequently observed are BMR01, BMR02, BMR03, BMR05, BMR20, BMR52, BMR55.

The stations identified as reference were BMR15, BMR 27, BMR32, BMR36, BMR47, BMR48 and BMR49. Unfortunately, none of the reference station resulted in either Class I or Very Good water quality based on the SWQR or WFD, respectively. The reference stations BMR27, BMR32, BMR47, BMR48 and BMR49 were in Class III quality. The other reference stations BMR15 and BMR36 were in Class IV status. In the assessment of water qualities according to WFD, all reference points in terms of physicochemical parameters fall into the “Moderate Water” quality class.

Sediment analysis revealed Acenaphthene, Acenaphthylene, Fluorene and Phenanthrene were the main PAHs on the sediment. The concentrations of these PAHs were above the ISQG value at all stations means that there is accumulation of these PAHs on the sediment and their adverse effect on the aquatic life can be severe. Dibenzo [a, h] anthracene, Benzo [a] anthracene, Chrysene, Pyrene and Benzo [a] pyrene were the other PAHs detected rarely at the stations, but measures for these PAHs must be taken as well.

It is a fortunate not to detect Aldrin, Dieldrin, Endrin and Heptachlor epoxide on the sediments. But it is unfortunate to have already abandoned pesticide (DDT) derivates as DDD (p, p and o, p) DDE (p, p and o, p) DDT (p, p and o, p). Although only DDE (p, p and o, p) detected above the ISQG in BMR56 station, other derivates could exist at high levels when multiple sediment samples were taken.

The most commonly detected heavy metals were nickel, arsenic, chromium and iron at high concentrations. But all the monitored metals were over LEL means that there is an accumulation of metals on the sediment at e level that could be dangerous for the aquatic organisms and through them to the human. The concentrations of cobalt, copper, lead and zinc were found to be below the criterion values at all points.

Among the physicochemical parameters analyzed, TOC and TKN concentrations were mostly above the quality criteria. TP concentration was relatively mild at the sediments. BML20 and BML17 were the most polluted ones and BML07, BML10 and BML13 were the least polluted ones among the 12 lakes in BMRB. The river sediment status revealed that BMR20 was the highly polluted one.

4.2 Recommendations

A detailed study was conducted in this thesis to determine the types of pollutants in the basin and water quality classes of each station as well as the whole basin. The following studies are recommended for the use of data generated in this study in order to enhance the impact of the study.

- A relationship between the pollutant profile and pollutant sources can be established to be able to take the correct and necessary measures,
- The background concentrations of the metals can be determined to understand if the detected high concentrations above the WFD criteria are due to pollution or natural,
- The effect of these organic and inorganic pollutants on the biological quality elements can be evaluated,
- A mathematical model can be developed to predict the concentration profile of any pollutant along the basin.

- The discharge standards of the pollutants that lead to “bad” water quality can be determined.

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APPENDICES

APPENDIX 1: Sample Transport and Protection Conditions

Table A.1 Techniques for storage and protection of surface and groundwater samples - Chemical analysis

Analysis	**Reference International Standard**	**Type of container**	**Protection and Storage conditions**	**Maximum retention time before analysis**
Acidity and alkalinity		P or C	Samples containing high concentrations of dissolved gas are preferably analyzed in situ. Reduction or oxidation that may occur during storage may alter the sample.	14 days
	ISO 9963-1: 1994 No reference to ISO 5667-3	PE, BC	Samples containing high concentrations of dissolved gas are preferably analyzed in situ.	
Absorbable organic halides (AOX)	ISO 9562: 2004 No reference to ISO 5667-3	P or C Glass is used if the concentration is suspected to be low.	HNO3 is acidified to pH 1-2, stored in the dark or dark bottles are used. If the sample is chlorinated, footnote (b) is applied.	5 days
		P	It is frozen below -18 ˚C.	1 month
Aluminum	ISO 15586: 2003 Reference is made to ISO 5667-3.	PE,PP,FEP	Acidify to pH 1-2 with HNO_3.	1 month
	ISO 11885: 2007 Reference is made to ISO 5667-3.	For normal concentrations: PE-HD, PTFE For low concentrations: PFA, FEP		
	ISO 17294-2: 2003 Reference is made to ISO 5667-3.			
	ISO 12020: 1997 No reference is made to ISO 5667-3.	Suitable plastics do not contain polyolefin (may contain trace amounts of Al)		
	ISO 10566: 1994 Reference is made to ISO 5667-3: 1994.	PE		
Ammonium		P or C	Samples are filtered in situ. Acidify to pH 1-2 with H_2SO_4.	21 days
	ISO 7150-1: 1984 No reference is made to ISO 5667-3.	P or C	Samples are filtered in situ.	1 day
	ISO 14911: 1998 Reference is made to ISO 5667-3.	PE	Samples are filtered in situ. Acidify to pH 3 ± 0.5 with HNO_3.	14 days
	ISO 11732: 2005 Reference is made to ISO 5667-3.	C, Polyolefin, PTFE	Samples are filtered in situ. Acidify with H_2SO_4 to pH 1-2. Samples are stored in the dark or dark bottles are used.	

Table A.1 continues

Analysis	Reference International Standard	Type of container	Protection and Storage conditions	Maximum retention time before analysis
		P	Samples are filtered in situ. Freeze below -18 ° C.	1 month
Antimony	ISO 15586: 2003 Reference is made to ISO 5667-3.	PE,PP,FEP	Acidify to pH 1-2 with HCl or HNO_3. If the hydrate technique is used for analysis, HCl is used.	1 month
	ISO 11885: 2007 Reference is made to ISO 5667-3.	For normal concentrations: PE-HD, PTFE For low concentrations: PFA, FEP		
	ISO 17294-2: 2003 Reference is made to ISO 5667-3.			
Arsenic	ISO 15586: 2003 Reference is made to ISO 5667-3.	PE,PP,FEP	Acidify to pH 1-2 with HCl or HNO_3. If the hydrate technique is used for analysis, HCl is used.	6 months
	ISO 11885: 2007 Reference is made to ISO 5667-3.	For normal concentrations: PE-HD, PTFE For low concentrations: PFA, FEP		
	ISO 17294-2: 2003 Reference is made to ISO 5667-3.			
	ISO 11969: 1996 Reference is made to ISO 5667-3: 1994.	PE washed with BC HNO3 (10% by volume)		
Barium	ISO 11885: 2007 Reference is made to ISO 5667-3.	For normal concentrations: PE-HD, PTFE For low concentrations: PFA, FEP	Acidify to pH 1-2 with HNO_3.	1 month
	ISO 17294-2:2003 ISO 5667-3			
	ISO 14911: 1998 Reference is made to ISO 5667-3.	PE	Acidify to pH 3 ± 0.5 with HNO_3.	
Beryllium	ISO 11885: 2007 Reference is made to ISO 5667-3.	For normal concentrations: PE-HD, PTFE For low concentrations: PFA, FEP	Acidify to pH 1-2 with HNO_3.	1 month
	ISO 17294-2: 2003 Reference to ISO 5667-3			
Biochemical oxygen demand (BOD)		P or C	Samples are stored in the dark or dark bottles are used. Freeze below -18 ° C. Samples are stored in the dark or dark bottles are used.	1 day
		P		1 month (if> 50 mg / l 6 months)

Table A.1 continues

Analysis	**Reference International Standard**	**Type of container**	**Protection and Storage conditions**	**Maximum retention time before analysis**
Boron	ISO 11885: 2007 Reference is made to ISO 5667-3.	For normal concentrations: PE-HD, PTFE For low concentrations: PFA, FEP	Acidify to pH 1-2 with HNO_3.	6 months
	ISO 17294-2: 2003 Reference is made to ISO 5667-3.			
Bromide	ISO 15061: 2001 Reference is made to ISO 5667-3: 1194.	PE	Ozone is removed from the sample. For example; Immediately after sampling, 50 mg of ethylenediamine is added for 1 liter of sample.	1 month
Bromide and bromine compounds	ISO 10304-1: 2007 Reference is made to ISO 5667-3.	PE or C		1 month
Bromine ruins		Dark P or C	Samples are analyzed in situ.	5 minutes
Cadmium	ISO 15586: 2003 Referenced in ISO 5667-3.	PE, PP, FEP	Acidify to pH 1-2 with HNO_3.	6 months
	ISO 5961: 1994 Reference is made to ISO 5667-3.	PA, BC		
	ISO 11885: 2007 Reference is made to ISO 5667-3.	For normal concentrations: PE-HD, PTFE For low concentrations: PFA, FEP		
	ISO 17294-2: 2003 Reference is made to ISO 5667-3.			
Calcium	ISO 7980: 1986 No reference is made to ISO 5667-3.	PE, PP	Acidify to pH 1-2 with HNO_3.	1 month
	ISO 11885: 2007 Reference is made to ISO 5667-3.	For normal concentrations: PE-HD, PTFE For low concentrations: PFA, FEP		
	ISO 17294-2: 2003 Reference is made to ISO 5667-3.			
	ISO 14911: 1998 Reference is made to ISO 5667-3..	PE	Acidify to pH 3 ± 0.5 with HNO_3.	
Carbon dioxide	ISO 9439 No reference is made to ISO 5667-3.	P or C	Samples are analyzed in situ.	1 day

Table A.1 continues

Analysis	**Reference International Standard**	**Type of container**	**Protection and Storage conditions**	**Maximum retention time before analysis**
Carbon, Total Organic Carbon (TOC)	ISO 8245 Reference is made to ISO 5667-3.	P or C	Acidify with H_2SO_4 to pH 1-2. Acidification is not appropriate if the loss of volatile organic compounds is suspected due to carbon dioxide removal by acidification. Cooling and analysis are performed within 8 hours. Freeze below -18 ° C.	7 days
		P		1 month
Dissolved Organic Carbon (DOC)	ISO 8245 Reference is made to ISO 5667-3.	P or C	Filter before acidification to pH 1-2 with H_2SO_4 or H_3PO_4.	7 days
			Freeze below -18 ° C.	1 month
Chemical Oxygen Demand (COD)	ISO 15705: 2002 Reference is made to ISO 5667-3: 1994.	P or C	Acidify with H_2SO_4 to pH 1-2.	6 day
		PP, C P		
		P		
			Freeze below -18 ° C.	6 months
Chloramine		P or C in dark color	Samples are analyzed in situ.	5 minutes
Chlorate	ISO 10304-4: 1997 Reference is made to ISO 5667-3: 1994.	P or C	NaOH is added such that the pH is 10 ± 0.5.	7 day
Chloride	ISO 15682-2: 2000 Reference to ISO 5667-3	PE or C	Since common techniques do not have a negative effect, special protection and storage conditions are not required.	1 month
	ISO 10304-4: 1997 Reference is made to ISO 5667-3: 1994	P or C		
Chlorinated solvents: *See Volatile Organic Compounds*				
Chlorine dioxide		P or C in dark color	Special protection and storage conditions are not required. Samples are analyzed in situ.	5 minutes
Chlorine, residue		P or C in dark color	Samples are analyzed in situ.	5 minutes
chloride	ISO 10304-4: 1997 Reference is made to ISO 5667-3: 1994	P or C in dark color	NaOH is added such that the pH is 10 ± 0.5.	7 minutes
Chlorophyll	ISO 10260: 1992 Reference is made to ISO 5667-3: 1994	P or C	The samples are preferably filtered in situ. Samples are stored in the dark or dark bottles are used.	1 day

Table A.1 continues

Analysis	**Reference International Standard**	**Type of container**	**Protection and Storage conditions**	**Maximum retention time before analysis**
Chlorophyll	ISO 10260: 1992 Reference is made to ISO 5667-3: 1994	P or C	After filtration and extraction with hot ethanol, it is frozen below -18 ° C.	1 month in case of extraction
			After filtration, it is frozen below -18 ° C.	14 days in case of filtering
			After filtration, it is frozen below -80 ° C.	1 month in case of filtration
Chromium	ISO 15586: 2003 Reference is made to ISO 5667-3.	PE,PP,FEP	Acidify to pH 1-2 with HNO3.	6 months
	ISO 11885: 2007 Reference is made to ISO 5667-3.	For normal concentrations: PE-HD, PTFE For low concentrations: PFA, FEP		
	ISO 17294-2: 2003 Reference is made to ISO 5667-3.			
Chrome (VI)	ISO 23913: 2006 Reference is made to ISO 5667-3.	P or BC		24 hours
	ISO 18412: 2005 Reference is made to ISO 5667-3.	P or BC		4 days
Cobalt	ISO 15586: 2003 Reference is made to ISO 5667-3.	PE,PP,FEP	Acidify to pH 1-2 with HNO3.	1 month
	ISO 11885: 2007 Reference is made to ISO 5667-3.	For normal concentrations: PE-HD, PTFE For low concentrations: PFA, FEP		
	ISO 17294-2: 2003 Reference is made to ISO 5667-3.			
Color	ISO 7887: 2011 Reference is made to ISO 5667-3.	P or C	Samples are stored in the dark or dark bottles are used.	5 days
			On-site analysis is performed for groundwater rich in iron (II).	5 minute
Conductivity	ISO 7888: 1985 Reference is made to ISO 5667-3.	P or C except soda glass	Preferably, it is analyzed in situ.	1 day
Copper	ISO 15586: 2003 Reference is made to ISO 5667-3.	PE,PP,FEP	Acidify to pH 1-2 with HNO3.	6 months

Table A.1 continues

Analysis	**Reference International Standard**	**Type of container**	**Protection and Storage conditions**	**Maximum retention time before analysis**
Copper	ISO 11885: 2007 Reference is made to ISO 5667-3.	For normal concentrations: PE-HD, PTFE For low concentrations: PFA, FEP	Acidify to pH 1-2 with HNO3.	6 months
	ISO 17294-2: 2003 Reference is made to ISO 5667-3.			
Cyanide which can be easily released		P or C	NaOH is added to pH> 12. Samples are stored in the dark or dark bottles are used.	7 days (1 day if containing sulfur)
	ISO 14403: 2012 Reference is made to ISO 5667-3.			3 days
Total cyanide		P or C	NaOH is added to pH> 12. Samples are stored in the dark or dark bottles are used.	14 days (1 day if containing sulfur)
	ISO 14403: 2012 Reference is made to ISO 5667-3.			3 days
Cyano chloride		P		1 day
Detergents: *See surfactants.*				
Dissolved solids (dry residue): *See total solids (total residues)*				
Extracted organic halides (EOH) in surface water or waste water		C	If the sample is chlorinated, footnote (b) is applied.	4 days
Extracted organic halides (EOH) in underground or drinking water		C	If the sample is chlorinated, note (b).	1 month
Extracted organic halides (EOH)		C	If the sample is chlorinated, footnote (b) is applied. Acidify to pH 1-2 with HNO3 or H2 SO4.	14 days
Fluorides	ISO 10304-1: 2007 Reference is made to ISO 5667-3.	PTFE non-P		1 month
	ISO 10359-1: 1992 Reference is made to ISO 5667-3.			
	ISO 10359-2: 1994 Reference is made to ISO 5667-3: 1994.			

Table A.1 continues

Analysis	**Reference International Standard**	**Type of container**	**Protection and Storage conditions**	**Maximum retention time before analysis**
Hydrazine		C	Acidify with HCl to 1 mol / L. Samples are stored in the dark or dark bottles are used.	1 day
Hydrocarbons		C	HCl is acidified to pH 1-2 with HNO_3 or H_2SO_4.	1 month
	ISO 9377-2: 2000 Reference is made to ISO 5667-3: 1994.	Glass cover or PTFE coated screw cover glass		4 days
Hydrogen carbonates	*See acidity and alkalinity.*			
Iodide	ISO 10304-3: 1997 Reference is made to ISO 5667-3: 1994.	PE or C		1 month
Iodine		C	Samples are stored in the dark or dark bottles are used.	1 day
Iron (II)		P or BC	Acidified to pH 1-2 with HCl	7 days
Iron	ISO 15586: 2003 Reference is made to ISO 5667-3.	PE,PP,FEP	Acidify to pH 1-2 with HNO_3.	1 month
	ISO 11885: 2007 Reference is made to ISO 5667-3.	For normal concentrations: PE-HD, PTFE For low concentrations: PFA, FEP		
	ISO 17294-2: 2003 Reference is made to ISO 5667-3.			
Kjeldahl Nitrogen		P or C or BC	It is frozen below -18 ˚C.	6 months
	ISO 5663: 1984 No reference is made to ISO 5667-3.	P or C or BC	Acidify with H_2SO_4 to pH 1-2.	1 month
Plumbic	ISO 15586: 2003 Reference is made to ISO 5667-3.	PE, PP, FEP	Acidify to pH 1-2 with HNO_3.	6 month
	ISO 11885: 2007 Reference is made to ISO 5667-3.	For normal concentrations: PE-HD, PTFE For low concentrations: PFA, FEP		
	ISO 17294-2: 2003 Reference is made to ISO 5667-3.			
Lithium	ISO 11885: 2007 Reference is made to ISO 5667-3.	For normal concentrations: PE-HD, PTFE For low concentrations: PFA, FEP	Acidify to pH 1-2 with HNO_3.	1 month
	ISO 17294-2: 2003 Reference is made to ISO 5667-3.			
	ISO 14911: 1998 Reference is made to ISO 5667-3.	PE	Acidify to pH 3 ± 0.5 with HNO_3.	

Table A.1 continues

Analysis	**Reference International Standard**	**Type of container**	**Protection and Storage conditions**	**Maximum retention time before analysis**
Magnesium	ISO 7980: 1986 No reference is made to ISO 5667-3.	PE, PP	Acidify to pH 1-2 with HNO_3.	1 month
	ISO 11885: 2007 Reference is made to ISO 5667-3.	For normal concentrations: PE-HD, PTFE For low concentrations: PFA, FEP		
	ISO 17294-2: 2003 Reference is made to ISO 5667-3.			
	ISO 14911: 1998 Reference is made to ISO 5667-3.	PE	Acidify to pH 3 ± 0.5 with HNO_3.	
Manganese	ISO 15586: 2003 Reference is made to ISO 5667-3.	PE, PP,FEP	pH 1-2 adjustment with HNO_3	1 month
	ISO 11885: 2007 Reference is made to ISO 5667-3.	For normal concentrations: PE-HD, PTFE For low concentrations: PFA, FEP		
	ISO 17294-2: 2003 Reference is made to ISO 5667-3.			
	ISO 14911: 1998 Reference is made to ISO 5667-3.	PE	Acidify to pH 3 ± 0.5 with HNO_3.	
Mercury		P or BC	Acidify to pH 1-2 with HNO_3.	6 months
	ISO 17852: 2006 Reference is made to ISO 5667-3.	PTFE, FEP, BC, Quartz		
	ISO 12846: 2012 Reference is made to ISO 5667-3.	P or BC	1 ml / 100 ml HCl is added. Maximum care is taken to ensure that the sample is not contaminated.	2 day
			In the laboratory, it is stabilized by decomposition with potassium bromide-potassium bromate reagents.	1 month
Molybdenum	ISO 15586: 2003 Reference is made to ISO 5667-3.	PE, PP, FEP	Acidify to pH 1-2 with HNO_3.	1 month
Monocyclic aromatic hydrocarbons: *See volatile organic compounds*				
Nickel	ISO 15586: 2003 Reference is made to ISO 5667-3.	PE, PP, FEP	Acidify to pH 1-2 with HNO_3.	6 months
	ISO 11885: 2007 Reference is made to ISO 5667-3.	For normal concentrations: PE-HD, PTFE For low concentrations: PFA, FEP		
	ISO 17294-2: 2003 Reference is made to ISO 5667-3.			
Nitrate - in all waters		P or C		1 day
	ISO 13395: 1996 Reference is made to ISO 5667-3.	PE or C		1 day
		PE or C	It is frozen below -18 ˚C.	8 day

Table A.1 continues

Analysis	**Reference International Standard**	**Type of container**	**Protection and Storage conditions**	**Maximum retention time before analysis**
Nitrate - in all waters	ISO 13395: 1996 Reference is made to ISO 5667-3.	PE or C	Acidify with HCl to pH 1-2.	7 days
		P	It is frozen below -18 ˚C.	1 month
Nitrite - all waters **Nitrite- wastewater and surface water**	ISO 13395: 1996 Reference is made to ISO 5667-3.	P or C	The samples are preferably analyzed in situ.	1 day
		P or C	Samples are filtered in situ.	4 day
Total Nitrogen	ISO 29441: 2010 Reference is made to ISO 5667-3.	P or C	Acidify with H_2SO_4 to pH 1-2.	1 month
		P	It is frozen below -18 ˚C.	1 month
Smell		C	On-site qualitative analysis.	6 hours
Oil and Grease		C	Acidify to pH 1-2 with H_2SO_4or HCl or HNO_3. Approximately 90% of the bottle is filled, leaving a sufficient volume of space at the top.	1 month
Organic chlorine		C	Acidify to pH 1-2 with H_2SO_4 or HCl or HNO_3.	1 month
Organochlorinated compounds	ISO 17353: 2004 Reference is made to ISO 5667-3.	C	Samples are stored in the dark or dark bottles are used.	1 day
		C		7 days
Dissolved organophosphates: *See dissolved phosphates*				
Oxygen		P or C	Oxygen is fixed in place. Samples are stored in dark or dark bottles.	4 days
		P or C	The electrochemical method can also be used for in situ analysis. Samples are stored in dark or dark bottles.	1 day
	ISO 5814: 2012 Reference is made to ISO 5667-3.	P or C	Protection and storage cannot be performed but analyzed on-site.	
Permanganate Index (CODMn)	ISO 8467: 1993 No reference is made to ISO 5667-3.	P or C	Acidify with H_2SO_4 to pH 1-2.	2 day
		P or C	Samples are stored in the dark.	2 day
		P	It is frozen below -18 ˚C.	1 month
Carbamate pesticides		C	If the sample is chlorinated, footnote (b) is applied.	14 day
		P	It is frozen below -18 ˚C.	1 month

Table A.1 continues

Analysis	Reference International Standard	Type of container	Protection and Storage conditions	Maximum retention time before analysis
Pesticides, phenoxyalkanoic herbicides **Alkylhalogen phenoxy acids, hydroxybenzonitriles and bentazone**		C with PTFE cover or septum	Acidify to pH 1-2 with H_2SO_4 or HCl or HNO_3.	14 days
			It is acidified to pH 3-4 with methanoic acid.	
	ISO 15913: 2000 Reference is made to ISO 5667-3.	C, dark colored		3 days
Organochlorinated pesticides and chlorbenzenes **α-endosulfan, β-endosulfan, endosulfan sulfate, cis-chlordane, trans-klord valve, cis-heptachlorpoxide, transheptachlorpoxide, heptachlor, α-HCH, β-HCH, γ-HCH, δ-HCH, aldrin, dieldrin, endrin, isodrin, telodrine, hexachlorobutadiene,** **o, p’-DDD, o, p’-DDE, o, p’-DDT, p, p’-DDD, p, p’-DDE, p, p’-DDT,** **1,2,3-trichlorobenzene,** **1,2,4-trichlorobenzene,** **1,3,5-trichlorobenzene,** **1,2,3,4-tetrachlorobenzene,** **1,2,3,5, tetrachlorobenzene,** **1,2,4,5-tetrachlorobenzene,** **pentachlorobenzene,** **hexachlorobenzene**	ISO 6468: 1996 No reference is made to ISO 5667-3.	Dark C with PTFE cover	The endosulfan sample is kept separately at pH> 2 and the others at pH 5-7.5. If the pH is out of range, extraction is performed within 24 hours.	1 day
		Dark C with PTFE cover		7 days

Table A.1 continues

Analysis	**Reference International Standard**	**Type of container**	**Protection and Storage conditions**	**Maximum retention time before analysis**
Organophosphorus pesticides	ISO 10695: 2000 No reference is made to ISO 5667-3.	Dark C with PTFE cover	Some organophosphorus compounds can be rapidly reduced in aqueous medium. Therefore, if this is the case, extraction of phosphorus compounds is carried out within 1 day after sampling.	1 day
Organophosphorus pesticides **chlorpyrifos-ethyl, chlorpyrifos-methyl, diazinon, dichlorvos, dimethoate, disulfoton, fenthion, malathion mevinfos, parathion-ethyl, parathionmethyl**		Dark C with PTFE cover		7 days
Organophosphorus pesticides glyphosate	ISO 21458: 2008 No reference is made to ISO 5667-3.	P, for example polyolefin		6 days
			It is frozen below -18 ˚C.	1 month
Organoazot pesticides	ISO 10695: 2000 No reference is made to ISO 5667-3.	Dark C with PTFE cover	Some organic nitrogen compounds can be rapidly reduced in aqueous medium. Therefore, if this is the case, the nitrogen compounds are extracted within 2 days after sampling..	2 days
Organoazot pesticides	ISO 11369: 1997 Reference is made to ISO 5667-3.	Dark C with PTFE cover		7 days
Organoazot pesticides Atrazine, propazine, simazine, terbutyrine		Dark C with PTFE cover		1 month
Petroleum and derivatives: *See hydrocarbons*				
pH	ISO 10523: 2008 Reference is made to ISO 5667-3.	P or C	Preferably, it is analyzed in situ.	1 day
pH - (anaerobic groundwater)	ISO 10523: 2008 Reference is made to ISO 5667-3.	P or C. Specially shaped stopper prevents air ingress.		
Phenol index		C	H_3PO_4 or H_2SO_4 are used to adjust pH < 4	21 days
	ISO 14402: 1999 Reference is made to ISO 5667-3.	PTFE, C	Acidify with H_3PO_4 or H_2SO_4 to pH <4. Samples are stored in dark or dark bottles.	21 days

Table A.1 continues

Analysis	**Reference International Standard**	**Type of container**	**Protection and Storage conditions**	**Maximum retention time before analysis**
phenols	ISO 8165-1: 1992 Reference is made to ISO 5667-3: 1985.	Glass or borosilicate glass with PTFE cover	Acidify with H3PO4 or H2SO4 to pH <4.	21 days
	ISO 8165-2: 1999 Reference is made to ISO 5667-3: 1994.	C, dark colored	pH < 2	7 days
Phenols, alkylated	ISO 11857-1: 2005 Reference is made to ISO 5667-3.	C	Acidified to pH 2 with HCl or H_2SO_4.	14 days
	ISO 11857-2: 2009 Reference is made to ISO 5667-3.	Glass cover or PTFE coated screw cover glass		
Phenols, chlorinated	ISO 8165-1: 1992 Reference is made to ISO 5667-3: 1985.	Glass cover or PTFE coated screw cover glass	If the sample is chlorinated, footnote (b) is applied.	2 days
	ISO 8165-2: 1999 Reference is made to ISO 5667-3: 1994.			
Phosphorus, dissolved		P veya C veya BC	Water is filtered in situ.	1 month
		P	It is frozen below -18 ˚C.	
	ISO 11885: 2007 Reference is made to ISO 5667-3.	For normal concentrations: PE-HD, PTFE For low concentrations: PFA, FEP	Acidify to pH 1-2 with HNO_3.	
	ISO 17294-2: 2003 Reference is made to ISO 5667-3.			
	ISO 6878: 2004 No reference is made to ISO 5667-3.	Preferably C, or PE, PVC		
Total Phosphorus		P, C or BC	Acidify to pH 1-2 with H_2SO_4 or HNO_3.	1 month
	ISO 15681-1: 2003 Reference is made to ISO 5667-3.	P, C or BC		
	ISO 15681-2: 2003 Reference is made to ISO 5667-3.			
	ISO 11885: 2007 Reference is made to ISO 5667-3.	At normal concentration: PE-HD, PTFE Low Concentration: PFA, FEP		
	ISO 17294-2: 2003 Reference is made to ISO 5667-3.			

Table A.1 continues

Analysis	**Reference International Standard**	**Type of container**	**Protection and Storage conditions**	**Maximum retention time before analysis**
Total Phosphorus	ISO 6878: 2004 No reference is made to ISO 5667-3.	PE, PVC, preferably without C		
		P	It is frozen below -18 ˚C.	6 months
Phthalates	ISO 18856: 2004 Reference is made to ISO 5667-3.	C	Stored in dark or dark bottle.	4 days
Polychlorinated Biphenyls (PCBs)	ISO 6468: 1996 No reference is made to ISO 5667-3.	C with PTFE cover	The pH is adjusted to 5-7.5. If the pH is out of range, the sample is extracted within 24 hours. If the sample is chlorinated, note (b).	1 day
				7 days
Polycyclic Aromatic Hydrocarbons (PAHs)	ISO 17993: 2002 Reference is made to ISO 5667-3. ISO 28540: 2011 Reference is made to ISO 5667-3.	C with PTFE cover	If the sample is chlorinated, note (b).	7 days 4 days only for Naphthalene
Potassium	ISO 11885: 2007 Reference is made to ISO 5667-3.	At normal concentration: PE-HD, PTFE	Acidify to pH 1-2 with HNO_3.	1 month
	ISO 17294-2: 2003 Reference is made to ISO 5667-3.	Low Concentration: PFA, FEP		
	ISO 9964-3: 1993 No reference is made to ISO 5667-3.	PE		
	ISO 14911: 1998 Reference is made to ISO 5667-3.		Acidify to pH 3 ± 0.5 with HNO_3.	
Selenium	ISO 15586: 2003 Reference is made to ISO 5667-3.	PE , PP , FEP	Acidify to pH 1-2 with HNO3. HCl is used for analysis by hydride technique.	1 month
	ISO 11885: 2007 Reference is made to ISO 5667-3.	Normal concentration: PE-HD, PTFE		
	ISO 17294-2: 2003 Reference is made to ISO 5667-3.	Low Concentration: PFA, FEP		
Silicates, dissolved		P	Samples are filtered in situ.	1 month
	ISO 16264: 2002 No reference is made to ISO 5667-3.	P	Samples are filtered in situ. Analyze as quickly as possible.	5 minutes
Silicates, total		P		1 month
Silver	ISO 15586: 2003 Reference is made to ISO 5667-3.	PE , PP , FEP	Acidify to pH 1-2 with HNO3.	1 month

Table A.1 continues

Analysis	**Reference International Standard**	**Type of container**	**Protection and Storage conditions**	**Maximum retention time before analysis**
Silver	ISO 11885: 2007 Reference is made to ISO 5667-3. ISO 17294-2: 2003 Reference is made to ISO 5667-3.	Normal concentration: PE-HD, PTFE Low Concentration: PFA, FEP	Acidify to pH 1-2 with HNO3.	1 month
Sodium	ISO 11885: 2007 Reference is made to ISO 5667-3.	Normal concentration: PE-HD, PTFE Low Concentration: PFA, FEP	Acidify to pH 1-2 with HNO_3.	1 month
	ISO 17294-2: 2003 Reference is made to ISO 5667-3.			
	ISO 9964-3: 1993 No reference is made to ISO 5667-3.	PE		
	ISO 14911: 1998 Reference is made to ISO 5667-3.	PE	Acidify to pH 3 ± 0.5 with HNO_3.	
Suspended Solid		P or C		2 days
Sulfate	ISO 10304-1: 2007 Reference is made to ISO 5667-3.	P or C		1 month
Sulfur (easily released)		P	As soon as the sample is taken, 2 mL of zinc acetate solution is added and stored in the field. If the pH is not between 8.5 and 9.0, NaOH is added.	7 days
			If the sample is chlorinated, note (b).	
Sulphite	ISO 10304-3: 1997 Reference is made to ISO 5667-3: 1994.	P or C	For each 100 mL of the sample, 1 ml of EDTA solution is added and stored in the field.	2 days
Surfactants, anionic		C		3 days
			Formaldehyde solution is added.	4 days
			It is frozen below -18 ˚C.	1 month
Surfactants, cationic		C		2 days
Surfactants, nonionic		C	Formaldehyde solution is added.	1 month
Tin	ISO 11885: 2007 Reference is made to ISO 5667-3.	Normal concentration: PE-HD, PTFE Low Concentration: PFA, FEP	Acidify to pH 1-2 with HCl or HNO_3. HCl is used for analysis by hydride technique.	1 month
	ISO 17294-2: 2003 Reference is made to ISO 5667-3.			

Table A.1 continues

Analysis	**Reference International Standard**	**Type of container**	**Protection and Storage conditions**	**Maximum retention time before analysis**
Total Hardness: See Calcium				
Total solids (Total precipitate, dry extract)		P or C		7 days
Trihalomethanes: See Volatile Organic Compounds				
Blur	ISO 7027: 1999 Reference is made to ISO 5667-3: 1994.	C or P	Samples are stored in the dark or dark bottles are used. Preferably, it is analyzed in the field.	1 day
Uranium		P or BC	Acidify to pH 1-2 with HNO3.	1 month
Vanadium	ISO 15586: 2003 Reference is made to ISO 5667-3.	PE , PP , FEP	Acidify to pH 1-2 with HNO3.	1 month
	ISO 11885: 2007 Reference is made to ISO 5667-3.	Normal concentration: PE-HD, PTFE Low Concentration: PFA, FEP		
	ISO 17294-2: 2003 Reference is made to ISO 5667-3.			
Volatile Organic Compounds **Other solvents such as halogenated hydrocarbons, monocyclic aromatic hydrocarbons, organic carbon**		C or PTFE cap bottle with PTFE cap	HCl is acidified to pH 1-2 with HNO3 or H2SO4. If the sample is chlorinated, footnote (b) is applied. HCl interventions can be seen with the removal and retention.	7 days
	ISO 15680: 2003 Reference is made to ISO 5667-3.			5 days
	ISO 11423-1: 1997 No reference is made to ISO 5667-3.			2 days
	ISO 11423-2: 1997 No reference is made to ISO 5667-3.			2 days
				1 day
Zinc	ISO 15586: 2003 Reference is made to ISO 5667-3.	PE , PP , FEP	Acidify to pH 1-2 with HNO_3.	6 months
	ISO 11885: 2007 Reference is made to ISO 5667-3.	Normal concentration: PE-HD, PTFE Low Concentration: PFA, FEP		
	ISO 17294-2: 2003 Reference is made to ISO 5667-3.			

[a]: According to ISO 15813: 2000

[b]: If the sample is suspected to be chlorinated, 80 mg $Na_2S_2O_3.5H_2O$ is added to the sample cup for each 1000 mL sample after sampling (sampling).

Abbreviations:

P: Plastic, C: Glass, BC: Borosilicate glass, FEP: Perfluoro (ethylene / propylene), PE: Polyethylene, PE-HD: High density polyethylene, PET: Polyethylene terephthalate, PFA: Perfluoroalkoxy (polymer), PP: Polypropylene, PTFE: Polytetrafluoroethylene, PVC: Poly (vinylchloride)

Table A.2 Types of bottle, protection and storage conditions for different analysis applied in sediment

Analysis	Container Type[a]	Minimum sample quantity[b] (g)	Protection and Storage Conditions	Retention periods	Comment
Acidity	P or C	50	1 ° C to 5 ° C Dark and stuffy	14 days	
Thealkalinity	P or C	50	1 ° C to 5 ° C Dark and stuffy	14 days	
AmmoniaNitrogen	P or C	50	1 ° C to 5 ° C Dark and stuffy	24 hours	Sludgeparameter
Cations (Cl, Br, F and SO_4)	P or C	50	1 ° C to 5 ° C Dark and stuffy	1 month	
Absorbableorganicallyboundhalogens (AOX)	P or C	50	1 ° C to 5 ° C Dark andstuffy	7 days	
Biodegradation	P or C	50	1 ° C to 5 ° C Dark and stuffy	24 hours	
BiologicalOxygenDemand (BOD)	P or C	50	1 ° C to 5 ° C Dark andstuffy	24 hours	
			<-18°C	1 month	
Capillarysuction time	P or C	1000	1 ° C to 5 ° C Dark and stuffy	24 hours	Sludgeparameter
Conductivity	P or C	50	1 ° C to 5 ° C Dark andstuffy	24 hours	
Chrome (VI)	P or C	50	1 ° C to 5 ° C Dark and stuffy	24 hours (mud) 1 day (sediment)	
Cyanide	P	50	<-18°C	1 month	
	C	50	1 ° C to 5 ° C Dark and stuffy	4 days	
DryMatter (Drymass)	P or C	50	1 ° C to 5 ° C Dark and stuffy	7 days	For the determination of the dry weight in the Sub-Sampling, the storage condition is unlimited.
Extractableorganichalogens (EOX)	Seeabsorbableorganicallyboundhalogens (AOX).				
KjeldahlNitrogen	P or C	50	1 ° C to 5 ° C Dark andstuffy	24 hours (mud) 7 days (sediment)	
Mercury (Non-Volatile)	P or C	50	1 ° C to 5 ° C Dark and stuffy	1 month	
			<-18 ° C Dark and stuffy	1 month	
Mercury (Volatile)	P or C	50	1 ° C to 5 ° C Dark and stuffy	4 days	
Metals	P or C	50	1 ° C to 5 ° C Dark and stuffy	1 month	
	P or C		<-18 ° C Dark and stuffy	6 months	
			It is dried at about 60 ° C and the ambient temperature is maintained; Dry and airless	6 months	Not suitable for mercury

Table A.2 continues

Analysis	**Container Type**[a]	**Minimum sample quantity (g)**	**Protection and Storage Conditions**	**Retention periods**	**Comment**
Microscopic Analysis	C	10	1°C to 5°C	24 hours	
Mineral Oil (hydrocarbons C10-C40)	C	100	1 ° C to 5 ° C Dark and stuffy	1 month	
	P		<-18°C	6 months	
	C		25 g of sodiumsulfate (Na_2SO_4) is added to 50 g of thesample.	6 months	
Nitrate	P or C	50	1 ° C to 5 ° C Dark andstuffy	24 hours (mud) 7 days (sediment)	
Nitrification	P or C	50	1 ° C to 5 ° C Dark andstuffy	Preferably on-site, but at least 24 hours	
Oiland Grease	C	100	1 ° C to 5 ° C Dark and stuffy	1 month	
	P		<-18°C	6 months	
	C		25 g of sodiumsulfate (Na_2SO_4) is added to 50 g of the sample.	6 months	
Organoazotandorganophosphoruspesticides	Glass container with PTFE-coatedlid	50 per group	It is extracted and stored at 1 ° C to 5 ° C. Dark and stuffy	1 month	
Organocalizedcompounds	C	50	1 ° C to 5 ° C Dark and stuffy	7 days	
			<-18 ° C Dark and stuffy	6 month	
Orthophosphate	P or C	50	1 ° C to 5 ° C Dark and stuffy	24 hours (mud) 2 days (sediment)	
Particle Size Distribution	P or C	1000 (mud) 100 (sediment)	1 ° C to 5 ° C Dark andstuffy	24 hours (mud) 2 days (sediment)	No protection
PCB, PAH, chloropesticides	Glasscontainerwith PTFE-coatedlid	50 pergroup	1 ° C to 5 ° C Dark andstuffy	1 month	
pH (in thefield)	Samplingdevice	50	Wetintactsample	None	Determined in the field
pH (in thelaboratory)	P or C	50	1 ° C to 5 ° C Dark and stuffy	24 hours	
Phosphorus (Total)	P or C	50	1 ° C to 5 ° C Dark and stuffy	24 hours (mud) 1 month (sediment)	
Respiratory	P or C	50	1 ° C to 5 ° C Dark and stuffy	24 hours	

Table A.2 continues

Analysis	**Container Type[a]**	**Minimum sample quantity[b] (g)**	**Protection and Storage Conditions**	**Retention period[c]**	**Comment**
Semi-volatileandnon-volatileorganiccompounds	Glasscontainerwith PTFE-coatedlid	50 pergroup	It is extractedandstored at 1 ° C to 5 ° C. Dark andstuffy	1 month	
			Extractandstore at <-18 ° C. Dark andstuffy	6 month	
Solubility / darkening	P or C	5000	1 ° C to 5 ° C, Airless	24 hours	Sludge parameter
Resistancetofiltration	P or M	2500	1 ° C to 5 ° C, Airless	24 hours	Sludge parameter
Sulfur	P or C	50	ph>10.5; 1 ° C to 5 ° C, Dark, airlessandoxygen-free	24 hours	
			5 ml of 10% zincacetate is added.	7 day	
Total OrganicCarbon (TOC) / InorganicCarbon (IC)	Glasscontainerwith PTFE-coatedlid	25	1 ° C to 5 ° C Dark andstuffy	1 month	
			<-18 ° C darkandairless	6 month	
VolatileOrganic	Glasscontainerwith PTFE-coatedlid	50	1 ° C to 5 ° C Dark andstuffy	4 day	
			Extractedwithmethanoland 1 ° C to 5 ° C, Stored in darkandairlessenvironment.	1 month	
			It is extractedwithmethanolandstored in a darkandairlessenvironment at <-18 ° C.	6 month	

[a] P: plastic, eg PE (polytetrafluorethylene), PTFE (polytetrafluorethylene), PVC [poly (vinylchloride)], PET [poly (ethyleneterephthalate)]
C: Glass
BC: Borosilicateglass

[b] The minimum amount of sample in thefieldrequiredforthedetermination of theparticularanalytedepends on thewetsample. Whereseveralanalytesfromthesamefieldsampleareto be analyzed, the total amount of samplerequiredmay be lessthanthe total amount of samplerequiredforeachanalysis.

[c] Including transport time

APPENDIX 2: The Results of The Analysis of Sediment Samples

Table A.3 The evaluation of sediment quality in lakes and rivers in BMR

Parameters	Ontario Sediment Quality Guidelines^{I} (ppm) **LEL**	**SEL**	Canadian Freshwater Sediment Quality Guidelines^{II} (µg/kg) **ISQG**	Probable Effect Levels^{II} (µg/kg) **PEL**	**LOD**	L01 Işıklı	L03 Cindere Adıgüzel 2	L05 Karacasu Barajı	L06 Tavas Yenidere	L07 Kemer	L10 Çine Adnan Menderes	L12 Topçam	L13 Yaylakavak	L16 Bafa Gölü	L17 İkizdere	L20 Karakuyu	L22 Gökpınar	R20 Orta BM	R55 Aşağı BM-1	R56 Aşağı BM-2
Acenaphthene			6.71	88.9	**2.06**	9.88	10.32	13.78	10.18	26.56	8.965	26.91	20.42	14.25	25.23	9.308	21.64	42.1	9.777	12.47
Acenaphthylene			5.87	128	**1.99**	18.17	21.13	23.68	22.4	54.67	19.36	57.97	45.11	22.6	53.09	24.58	45.28	23.95	17.36	19.88
Aldrin	0.002	8			**0.12**	T.E.	T.E.	T.E.	T.E.	T.E.	T.E.	T.E.	T.E.	T.E.	T.E.	T.E.	T.E.	T.E.	T.E.	T.E.
Anthracene	0.22	370	46.9	245	**0.45**	7.031	5.811	7.486	6.586	13.2	4.924	10.77	10.7	8.052	12.41	31.4	9.547	102.9	9.07	6.872
Arsenic ppm	6	33	5.9 mg/kg	17 mg/kg	**0.88**	8.109	6.142	8.798	11.00	5.861	5.184	35.57	9.560	6.975	12.92	6.377	4.124	4.516	7.510	5.680
Benzo(a)anthracene	0.32	1480	31.7	385	**0.03**	7.914	1.044	2.878	4.747	1.851	1.756	1.893	2.316	1.429	1.646	64.09	2.865	91.29	29.83	1.491
Benzo(k)fluoranthene	0.24	1340			**0.03**	15.49	0.777	4.203	5.817	2.522	2.974	3.261	5.176	3.941	1.597	52.69	5.637	22.64	27.82	1.884
Benzo(g,h,i)perylene	0.17	320			**0.03**	11.54	1.357	6.246	6.179	3.885	4.038	4.959	4.372	2.323	2.501	33.75	6.25	5.49	21.82	2.248
Benzo(a)pyrene	0.37	1440	31.9	782	**0.03**	11.71	0.869	5.732	3.96	1.567	1.962	1.907	2.832	1.821	1.708	40.2	3.131	2.261	29.17	1.476
Cadmium ppm	0.6	10	0.6 mg/kg	3.5 mg/kg	**5.17**	5.17	5.17	5.17	5.17	5.17	5.17	5.17	5.17	5.17	5.17	5.17	5.17	5.17	5.17	5.17
Carbon, Total Organic (TOC)	1%	10%			**782**	5240	10611	67502	16574	8423	52657	56720	32306	21639	29566	145586	20627	9595	2158	4996
Chromium	26	110	37.3 mg/kg	90 mg/kg		39.95	8.957	83.85	111.3	179.9	6.44	36.26	7.671	26.64	46.47	31.89	68.59	51.62	38.15	51.82
Chrysene	0.34	460	57.1	862	**0.37**	15.86	3.079	8.11	10.23	6.454	6.709	7.376	10.66	5.662	6.137	120.5	10.89	131.4	56.19	6.414
Cobalt	50^{vI}				**1.6**	8.735	3.274	14.79	19.02	29.03	3.402	14.59	4.183	6.542	13.93	2.833	12.14	8.652	6.189	10.26
Copper	16	110	35.7 mg/kg	197 mg/kg	**2.44**	7.369	4.071	11.70	24.48	16.58	4.424	28.55	6.638	5.443	21.54	8.930	7.441	7.158	2.440	6.906
DDD (*p,p*- and *o,p*-)	0.008	6	3.54	8.51	**0.04**	0.042	T.E.	0.216	0.075	T.E.	0.058	T.E.	T.E.	T.E.	T.E.	0.33	0.299	0.053	T.E.	0.778
DDE (*p,p*- and *o,p*-)	0.005	19	1.42	6.75	**0.03**	0.334	0.147	0.841	0.793	0.341	0.352	0.298	0.035	0.183	0.456	0.756	0.897	0.162	0.149	1.565
DDT (*p,p*- and *o,p*-)	0.008 (total-0.007)	71 (total-12)	1.19	4.77	**0.03**	0.212	T.E.	0.405	0.238	0.366	0.186	0.308	T.E.	0.1	0.188	0.581	0.405	0.13	0.099	0.574
Dibenzo(a,h)anthracene	0.06	130	6.22	135	**0.03**	34.34	0.396	12.37	6.257	4.317	2.86	3.729	3.238	2.074	1.497	11.96	2.491	2.859	6.308	0.71
Dieldrin	0.002	91	2.85	6.67	**0.11**	T.E.	T.E.	T.E.	T.E.	T.E.	T.E.	T.E.	T.E.	T.E.	T.E.	T.E.	T.E.	T.E.	T.E.	T.E.
Endrin	0.003	130	2.67	62.4	**0.2**	T.E.	T.E.	T.E.	T.E.	T.E.	T.E.	T.E.	T.E.	T.E.	T.E.	T.E.	T.E.	T.E.	T.E.	T.E.
Fluoranthene	0.75	1020	111	2355	**1.74**	23.84	16.65	21.08	21.94	29.83	18.76	31.28	32.04	19.35	34	154	35.68	443.5	62.6	16.42
Fluorene	0.19	160	21.2	144	**4.69**	47.59	60.1	70.83	56.44	159	48.57	136.6	124.7	73.62	182.5	56.59	123.9	77.73	58.18	63.79
Heptachlor epoxide	0.005	5	0.6	2.74	**0.05**	T.E.	T.E.	T.E.	T.E.	T.E.	T.E.	T.E.	T.E.	T.E.	T.E.	T.E.	T.E.	T.E.	T.E.	T.E.
Indeno(1,2,3-c,d) pyrene	0.2	320			**0.03**	15.67	0.635	7.9	4.937	3.68	2.977	2.949	3.287	3.529	1.956	25.16	4.746	3.322	18.17	1.393
Iron	2%	4%			**1404**	11153	5504	19189	33608	24621	9411	33752	13379	8316	25518	5341	11136	9824	8050	12745
Lead	31	250	35 mg/kg	91.3 mg/kg	**0.99**	8.509	3.757	6.501	12.23	7.474	7.325	16.80	5.519	6.504	9.499	5.771	4.828	2.619	2.503	4.556
Mercury	0.2	2	0.17 mg/kg	0.486 mg/kg	**0.86**	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86
Nickel	16	75			**0.69**	87.44	19.43	170.3	169.6	439.1	9.029	40.63	9.467	64.05	88.36	26.89	187.7	153.5	66.85	108.3
Nitrogen (total kjeldahl) (TKN)	550	4800				3220	1120	1740	2170	840	2240	4340	1680	6860	980	7840	910	700	560	1400
PAH (total)	4	10000				369	293	386	355	663	287	650	594	344	728	1033	601	1395	577	296
Phenanthrene	0.56	950	41,9	515	**13.2**	115.8	157.5	176.5	168.2	329.5	143.6	332.9	297.7	167.3	377.5	246.4	293.3	193.2	148.8	144.2
Phosphorus (total)	600	2000			**346.6**	382.8	271.7	332.8	397.6	414.9	899.9	517.4	279.9	462.1	7951	184.4	327.2	303.0	271.9	541.3
Pyrene	0.49	850	53	875	**1.37**	18.8	11.96	16.33	19.6	21.54	13.28	22.04	22.96	12.77	23.2	113	25.19	226.1	50.31	13.59
Zinc	120	820	123 mg/kg	315 mg/kg	**4.76**	18.29	7.144	28.18	44.72	33.85	24.04	63.18	28.58	13.33	45.99	115.2	16.69	23.11	9.380	18.38
PAH	**Pesticide**	**Heavy Metal**	**Organic Substance**																	

Table A.4 Water quality evaluation in lakes along water column

STATION NAME	**ISIKLI**	**CINDERE-ADIGUZEL 2**			**KARACASU BARAJI**			**TAVAS-YENIDERE**		**KEMER**			**CINE ADNAN MENDERES**			**TOPCAM**			**YAYLAKAVAK**			**BAFA**		
PARAMETER NAME	BML01	BML03-1	BML03-2	BML03-3	BML05-1	BML05-2	BML05-3	BML06-2	BML06-3	BML07-1	BML07-2	BML07-3	BML10-1	BML10-2	BML10-3	BML12-1	BML12-2	BML12-3	BML13-1	BML13-2	BML13-3	BML16-1	BML16-2	BML16-3
Depth (m)	1.00	0.78	10.81	19.80	0.66	16.04	26.42	4.53	8.37	0.73	19.36	37,80	0.98	16.65	26.31	0.67	15.44	25.93	0.54	20.94	38.20	1.07	2.98	5.68
COD	8	12	<6.07	<6.07	8	<6.07	<6.07	<6.07	<6.07	<6.07	<6.07	<6.07	<6.07	<6.07	<6.07	<6.07	<6.07	<6.07	<6.07	<6.07	<6.07	<8.76	<8.76	<8.76
SS	3	<2.95	<2.95	<2.95	11	8	8	<2.95	<2.95	12	4	5	16	7	3	<2.95	<2.95	<2.95	<2.95	<2.95	<2.95	<2.95	<2.95	<2.95
Turbidity	1.53	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.58	0.58	<0.1	<0.1	1.75	1.22	1.22	1.22	<0.1	<0.1	<0.1	<0.1
SO_4	148	123	122	126	138	136	142	32	36	39	38	40	52	56	50	28	26	30	102	104	108	2650	2596	2658
Cl	30	68	72	75	35	35	35	35	35	50	52	54	28	28	30	30	30	30	32	30	30	10500	10500	10500
NH_3	0.28	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	0.35	0.35
NO_2-N	0.135	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.07	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.095	0.035	0.015
NO_3-N	0.35	0.86	0.78	0.97	1.62	1.21	1.63	0.87	1.19	0.45	0.72	0.81	1.21	1.13	1.06	1.36	2	1.82	1.89	2.72	2.72	0.97	0.85	0.97
PO_4	< 0.08	0.14	0.17	0.32	0.081	< 0.08	< 0.08	<0.08	< 0.08	0.09	< 0.08	0.16	0.12	0.096	0.1	< 0.08	0.12	0.11	0.13	0.21	0.22	0.19	0.2	0.18
P	<0.08	<0.08	<0.08	0.13	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	0.096	0.11	0.09	<0.08	<0.08
Alkalinity	230	245	250	260	198	225	215	190	200	250	265	260	150	160	150	85	60	66	45	36	36	180	190	180
TKN	<0.98	<0.98	<0.98	<0.98	<0.98	<0.98	<0.98	<0.98	<0.98	<0.98	<0.98	<0.98	<0.98	<0.98	<0.98	<0.98	<0.98	<0.98	<0.98	<0.98	<0.98	<0.98	<0.98	<0.98
BOI	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
HCO_3	281	299	305	318	250	275	262	232	244	305	323	317	183	195	183	104	73	81	55	44	44	220	232	220
Oil-grease	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4
Hydrocarbon	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4
Res (436 nm)	0.36	0.46	0.58	0.46	0.44	0.42	0.44	0.48	0.52	0.48	0.54	0.56	0.52	0.54	0.48	0.96	0.94	0.52	0.54	1.92	1.8	0.52	0.48	0.46
Res (525 nm)	<0.56	<0.56	<0.56	<0.56	<0.56	<0.56	<0.56	<0.56	<0.56	<0.56	<0.56	<0.56	<0.56	<0.56	<0.56	<0.56	<0.56	<0.56	<0.56	<0.56	<0.56	<0.56	<0.56	<0.56
Res (620 nm)	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62
Phenol	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14
Total CN	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002

-1: Surface, -2: Moderate -3: Deep

Table A.4 continues

STATION NAME	**IKIZDERE**			**KARAKUYU**	**GOKPINAR**			**BM NEHIR-AGZI**	**BM LAGUN**	**BM KIYI SUYU 1**	**BM KIYI SUYU 2**			**BM KIYI SUYU 3**			**BM KIYI SUYU 4**			**ORTA BUYUK MENDERES**	**ASAGI BUYUK MENDERES-1**	**ASAGI BUYUK MENDERES-2**
PARAMETER NAME	BML17-1	BML17-2	BML17-3	BML20	BML22-1	BML22-2	BML22-3	BMTW1	BMTW2	BMCW1	BMCW2-1	BMCW2-2	BMCW2-3	BMCW3-1	BMCW3-2	BMCW3-3	BMCW4-1	BMKS4-2	BMKS4-3	BMR20	BMR55	BMR56
Depth (m)	1.00	25.30	44.90	1.00	0.59	7.53	13.30	1.33	1.50	0.76	0.79	6.20	14.34	0.90	4.28	8.50	0.81	4.22	9.62	-	-	-
COD	<6.07	<6.07	<6.07	<6.07	<6.07	<6.07	8	32	28	<8.76	<8.76	<8.76	<8.76	<8.76	<8.76	<8.76	<8.76	<8.76	<8.76	44	16	20
SS	8	5	3	<2.95	15	11	8	30	38	<2.95	<2.95	<2.95	<2.95	<2.95	<2.95	<2.95	<2.95	<2.95	<2.95	49	32	13
Turbidity	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.58	1.11	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	9.11	1.95	51.5
SO_4	154	152	158	26	162	158	164	3040	1822	2152	2750	2784	2765	3092	3100	3098	2765	2802	2788	452	504	403
Cl	875	925	980	24	35	35	35	27000	5500	24400	29500	29730	29820	29820	29820	29880	30050	30050	30050	355	165	325
NH_3	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	0.35	0.28	<0.24
NO_2-N	0.046	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.24	<0.01	0.113	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	0.01
NO_3-N	1.43	1.43	0.62	2.2	3.63	2.39	2.72	1	4.06	0.53	0.39	0.45	0.43	0.47	0.37	0.39	0.45	0.43	0.56	6.8	3.78	2.82
PO_4	<0.08	0.081	0.1	<0.08	0.1	<0.08	<0.08	0.1	1.9	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	1.12	1.28	0.44
P	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	0.47	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	0.44	0.46	0.18
Alkalinity	150	165	160	180	190	220	230	165	410	130	135	140	145	140	145	140	145	140	142	500	435	440
TKN	<0.98	<0.98	<0.98	<0.98	<0.98	<0.98	<0.98	<0.98	<0.98	<0.98	<0.98	<0.98	<0.98	<0.98	<0.98	<0.98	<0.98	<0.98	<0.98	<0.98	<0.98	<0.98
BOI	<5	<5	<5	<5	<5	<5	<5	15	15	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	20	8	10
HCO_3	183	201	195	220	232	268	281	201	500	159	165	171	177	171	177	171	177	171	176	610	530	537
Oil-grease	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4
Hydrocarbon	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4
Res (436 nm)	0.52	0.48	0.52	0.48	0.46	0.42	0.42	0.82	0.42	<0.42	<0.42	<0.42	<0.42	<0.42	<0.42	<0.42	<0.42	<0.42	<0.42	2.1	0.52	0.94
Res (525 nm)	<0.56	<0.56	<0.56	<0.56	<0.56	<0.56	<0.56	<0.56	<0.56	<0.56	<0.56	<0.56	<0.56	<0.56	<0.56	<0.56	<0.56	<0.56	<0.56	1.46	<0.56	<0.56
Res (620 nm)	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	0.72	<0.62	<0.62
Phenol	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14
Total CN	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002

-1: Surface, -2: Moderate -3: Deep

APPENDIX 3: The Results of Physicochemical Classification for SWQR and WFD

Table A.5 Surface water quality classification according to SWQR

WATER QUALITY PARAMETER	LOD (mg/L)	I	II	III	IV	BML01	BML02	BML03	BML05	BML06	BML07	BML10	BML12	BML13	BML16	BML17	BML19	BML20	BML21	BML22	BMR01	BMR02	BMR03	BMR05	BMR10	BMR11	BMR12	BMR15	BMR18	BMR20	BMR22	BMR23	BMR27	BMR28	BMR29	BMR30	BMR32	BMR33	BMR34	**BMR36**	**BMR38**	**BMR47**	**BMR48**	**BMR49**	**BMR52**	**BMR55**	**BMR56**
COD	6.07	<25	25-50	50-70	>70	I	I	I	I	I	I	I	I	I	II	I		I	I	I	I	I	II	IV	I	I	I	I	I	II	I	I	I	I	I	I	I		I	I	I	I	I	I	I	I	I
NH_4-N	0.24	<0.2	0.2-1	1-2	>2	I	I	I	I	I	I	I	II	II	II	I		I	I	II	I	I	III	IV	II	II	I	I	I	II	I	IV	I	I	I	II	I		I	II	I	I	I	I	II	II	I
NO_3-N (*)	0.06	<3	3-10	10-20	> 20	I	I	I	I	I	I	I	I	I	I	I		I	I	II	I	I	II	III	III	I	I	II	I	II	II	II	I	I	I	I	I		I	I	I	I	I	I	I	I	I
P (*)	0.08	<0.08	0.08-0.16	0.16-0.65	> 0.65	III	III	III	III	III	II	I	II	I	II	II		II	II	III	III	III	IV	IV	III	III	III	III	III	IV	IV	IV	IV	I	I	II	I		III	II	III	II	III	I	III	III	II
TKN	0.98	<0.5	1.5	5	>5	I	I	I	I	I	I	I	III	II	II	I		I	I	I	I	I	III	IV	II	II	I	I	I	III	I	I	I	I	I	II	I		II	III	III	III	I	I	III	II	II
BOI	3.8	<4	4-8	8-20	>20	I	I	I	I	II	II	II	III	II	III	II		II	II	II	I	II	III	IV	II	II	II	II	II	III	II	II	I	I	I	I	I		I	I	I	I	I	I	II	II	II
Ni	0.65E-3	≤20	20-50	50-200	>200	I	I	I	I	I	I	I	I	I	I	I		I	I	I	I	I	II	II	I	I	I	I	II	II	I	I	I	I	I	I	I		I	I	I	I	I	I	II	I	I
Cu	1.18E-3	≤20	20-50	50-200	>200	I	I	I	I	I	I	I	I	I	I	I		I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I		I	I	I	I	I	I	I	I	I
Zn	0.79E-3	≤200	200-500	500-2000	>2000	I	I	I	II	I	I	I	I	I	I	I		III	III	I	I	III	II	I	I	I	I	III	I	I	III	I	I	I	I	I	I		I	I	I	I	I	I	I	I	II
Cd	0.36E-3	≤2	2-5	5-7	>7	I	I	I	I	I	I	I	I	I	I	I		I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I		I	I	I	I	I	I	I	I	I
Pb	0.00269	≤10	10-20	20-50	>50	I	I	I	I	I	I	I	I	I	I	I		I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I		I	I	I	I	I	I	I	I	I
Hg	0.0006	<0.1	0.1-0.5	0.5-2	>2	I	I	I	I	I	III	III	II	III	III	III		III	II	I	I	I	IV	IV	III	III	III	I	III	III	III	I	IV	I	I	III	III		III	IV	I	III	III	I	III	III	IV
436 RES, m^{-1}		1.5	3	4.3	5	I	I	I	I	I	I	I	I	I	I	I		I	I	I	I	I	I	II	I	I	I	I	I	I	I	I	I	I		I	I		I	I	I	I	I	I	I	I	I
525 RES, m^{-1}		1.2	2.4	3.7	4.2	I	I	I	I	I	I	I	I	I	I	I		I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I		I	I		I	I	I	I	I	I	I	I	I
620 RES, m^{-1}		0.8	1.7	2.5	2.8	I	I	I	I	I	I	I	I	I	I	I		I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I		I	I		I	I	I	I	I	I	I	I	I
pH	0.08	6.5-8.5	6.5-8.5	6.0-9.0	6.0-9.0 except	I	I	I	I	I	I	I	I	I	I	III		I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I		I	I		I	I	I	I	I	III	I	I	I
Temperature		≤25	≤25	≤30	>30	I	I	I	I	I	I	I	I	I	I	I		I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I		I	I		I	I	I	I	I	I	I	I	I
Conductivity	-	<400	400-1000	1001-3000	>3000	I	II	II	II	II	II	I	I	I	IV	I		I	III	II	II	II	III	III	II	II	II	II	III	III	II	II	II	II		II	I		II	I	I	II	II	II	III	III	IV
Dissolvedoxygen (mg O_2/L)	-	> 8	6-8	3-6	<3	I	I	I	I	I	II	I	I	I	III	I		III	I	I	I	I	II	III	I	II	III	I	I	III	I	II	I	I		I	I		I	I	I	I	I	I	I	II	II
Oxygensaturation (%)	-	>90	70-90	40-70	<40	I	I	I	I	I	II	I	II	I	III	I		III	I	I	I	I	II	III	I	I	III	I	I	III	I	I	I	I		I	I		I	I	I	I	I	I	I	II	II
Fecalcoliform (EMS/100 mL)		≤10	10-200	200-2000	>2000	III	II	III	II	II	III	II	III	III	III	III		III	III	II	IV	IV	IV	IV	III	II	III	IV	III	IV	IV	IV	III	III		III	II		IV	IV	III	III	III	III	IV	IV	IV
Total coliform (EMS/100 mL)		≤100	100-20000	20000-100000	>100000	III	II	III	II	IV	III	II	II	II	II	II		II	II	II	III	III	III	IV	II	II	IV	III	II	IV	IV	II	II	III		II	II		II	IV	II	II	III	II	IV	IV	III
Final Classification						III	III	III	III	IV	III	III	III	III	IV	III		III	III	III	IV	IV	IV	IV	III	III	IV	IV	III	IV	IV	IV	III	III		III	III		IV	**IV**	**III**	**III**	**III**	**III**	**IV**	**IV**	**IV**

I: Class I, II: Class II, III: Class III, IV: Class IV

Table A.6 Surface water quality classification according to WFD

WATER QUALITY PARAMETER	**COD**	**NH_4-N**	**NO_3-N (*)**	**P (*)**	**TKN**	**BOI**	**Ni**	**Cu**	**Zn**	**Cd**	**Pb**	**Hg**	**436 RES, m^{-1}**	**525 RES, m^{-1}**	**620 RES, m^{-1}**	**pH**	**Temperature**	**Conductivity**	**Dissolved oxygen (mg O_2/L)**	**Oxygen saturation (%)**	**Fecal coliform (EMS/100 mL)**	**Total coliform (EMS/100 mL)**	**Result Classification**
LOD (mg/L)	6.07	0.24	0.06	0.08	0.98	3.8	0.65 E^{-3}	1.18 E^{-3}	0.79 E^{-3}	0.36 E^{-3}	0.00269	0.0006	-	-	-	0.08	-	-	-	-			
Very Good	< 25	< 0.2	< 3	< 0.08	<0.5	< 4	≤20	≤20	≤200	≤ 2	≤10	< 0.1	<1.5	<1.2	<0.8	6.5-8.5	≤ 25	<400	> 8	>90	≤10	≤100	
Good	25-50	0.2-1	3-20	0.08-0.8	0.5-5	4-8	20-50	20-50	200-500	2-5	10-20	0.1-0.5	1.5-4.3	1.2-3.7	0.8-2.5	6.5-8.5	≤ 25	400-1000	6-8	70-90	10-200	100-20000	
Moderate	>50	>1	>20	>0.8	>5	>8	>50	>50	>500	>5	>20	>0.5	>4.3	>3.7	>2.5	6.0-9.0	≥25	>1000	<6	<70	>200	>20000	
BML01	Very Good	Very Good	Very Good	Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Moderate	Moderate	**Moderate**
BML02	Very Good	Very Good	Very Good	Moderate	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Good	Very Good	Very Good	Good	Good	**Good**
BML03	Very Good	Very Good	Very Good	Moderate	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Good	Very Good	Very Good	Moderate	Moderate	**Moderate**
BML05	Very Good	Very Good	Very Good	Moderate	Very Good	Very Good	Very Good	Very Good	Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Good	Very Good	Very Good	Good	Good	**Good**
BML06	Very Good	Very Good	Very Good	Moderate	Very Good	Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Good	Very Good	Very Good	Good	Moderate	**Good**
BML07	Very Good	Very Good	Very Good	Good	Very Good	Good	Very Good	Very Good	Very Good	Very Good	Very Good	Moderate	Very Good	Very Good	Very Good	Very Good	Very Good	Good	Good	Good	Moderate	Moderate	**Moderate**
BML10	Very Good	Very Good	Very Good	Very Good	Very Good	Good	Very Good	Very Good	Very Good	Very Good	Very Good	Moderate	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Moderate	Good	**Moderate**
BML12	Very Good	Good	Very Good	Good	Moderate	Moderate	Very Good	Very Good	Very Good	Very Good	Very Good	Good	Very Good	Very Good	Very Good	Very Good	Very Good	Good	Very Good	Good	Moderate	Good	**Moderate**
BML13	Very Good	Good	Very Good	Very Good	Good	Good	Very Good	Very Good	Very Good	Very Good	Very Good	Moderate	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Moderate	Good	**Moderate**
BML16	Good	Good	Very Good	Good	Good	Moderate	Very Good	Very Good	Very Good	Very Good	Very Good	Moderate	Very Good	Very Good	Very Good	Very Good	Very Good	Moderate	Moderate	Moderate	Moderate	Good	**Moderate**
BML17	Very Good	Very Good	Very Good	Good	Very Good	Good	Very Good	Very Good	Very Good	Very Good	Very Good	Moderate	Very Good	Very Good	Very Good	Moderate	Very Good	Very Good	Very Good	Very Good	Moderate	Good	**Moderate**
BML19																							
BML20	Very Good	Very Good	Very Good	Good	Very Good	Good	Very Good	Very Good	Moderate	Very Good	Very Good	Moderate	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Moderate	Moderate	Moderate	Good	**Moderate**
BML21	Very Good	Very Good	Very Good	Good	Very Good	Good	Very Good	Very Good	Moderate	Very Good	Very Good	Good	Very Good	Very Good	Very Good	Very Good	Very Good	Moderate	Very Good	Very Good	Moderate	Good	**Moderate**
BML22	Very Good	Good	Good	Moderate	Very Good	Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Good	Very Good	Very Good	Good	Good	**Good**
BMR01	Very Good	Very Good	Very Good	Moderate	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Good	Very Good	Very Good	Moderate	Moderate	**Moderate**
BMR02	Very Good	Very Good	Very Good	Moderate	Very Good	Good	Very Good	Very Good	Moderate	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Good	Very Good	Very Good	Moderate	Moderate	**Moderate**
BMR03	Good	Moderate	Good	Moderate	Moderate	Moderate	Good	Very Good	Good	Very Good	Very Good	Moderate	Very Good	Very Good	Very Good	Very Good	Very Good	Moderate	Good	Good	Moderate	Moderate	**Moderate**
BMR05	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Good	Very Good	Very Good	Very Good	Very Good	Moderate	Good	Very Good	Very Good	Very Good	Very Good	Moderate	Moderate	Moderate	Moderate	Moderate	**Moderate**
BMR10	Very Good	Good	Moderate	Moderate	Good	Good	Very Good	Very Good	Very Good	Very Good	Very Good	Moderate	Very Good	Very Good	Very Good	Very Good	Very Good	Good	Very Good	Very Good	Moderate	Good	**Moderate**
BMR11	Very Good	Good	Very Good	Moderate	Good	Good	Very Good	Very Good	Very Good	Very Good	Very Good	Moderate	Very Good	Very Good	Very Good	Very Good	Very Good	Good	Good	Very Good	Good	Good	**Moderate**
BMR12	Very Good	Very Good	Very Good	Moderate	Very Good	Good	Very Good	Very Good	Very Good	Very Good	Very Good	Moderate	Very Good	Very Good	Very Good	Very Good	Very Good	Good	Moderate	Moderate	Moderate	Moderate	Moderate

Table A.6 continues

WATER QUALITY PARAMETER	**COD**	**NH_4-N**	**NO_3-N (*)**	**P (*)**	**TKN**	**BOI**	**Ni**	**Cu**	**Zn**	**Cd**	**Pb**	**Hg**	**436 RES, m^{-1}**	**525 RES, m^{-1}**	**620 RES, m^{-1}**	**pH**	**Temperature**	**Conductivity**	**Dissolved oxygen (mg O_2/L)**	**Oxygen saturation (%)**	**Fecal coliform (EMS/100 mL)**	**Total coliform (EMS/100 mL)**	**Result Classification**
BMR15	Very Good	Very Good	Good	Moderate	Very Good	Good	Very Good	Very Good	Moderate	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Good	Very Good	Very Good	Moderate	Moderate	**Moderate**
BMR18	Very Good	Very Good	Very Good	Moderate	Very Good	Good	Good	Very Good	Very Good	Very Good	Very Good	Moderate	Very Good	Very Good	Very Good	Very Good	Very Good	Moderate	Very Good	Very Good	Moderate	Good	**Moderate**
BMR20	Good	Good	Good	Moderate	Moderate	Moderate	Good	Very Good	Very Good	Very Good	Very Good	Moderate	Very Good	Very Good	Very Good	Very Good	Very Good	Moderate	Moderate	Moderate	Moderate	Moderate	**Moderate**
BMR22	Very Good	Very Good	Good	Moderate	Very Good	Good	Very Good	Very Good	Moderate	Very Good	Very Good	Moderate	Very Good	Very Good	Very Good	Very Good	Very Good	Good	Very Good	Very Good	Moderate	Moderate	**Moderate**
BMR23	Very Good	Moderate	Good	Moderate	Very Good	Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Good	Good	Very Good	Moderate	Good	**Moderate**
BMR27	Very Good	Very Good	Very Good	Moderate	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Moderate	Very Good	Very Good	Very Good	Very Good	Very Good	Good	Very Good	Very Good	Moderate	Good	**Moderate**
BMR28	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Good	Very Good	Very Good	Moderate	Moderate	**Moderate**
BMR29	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good											
BMR30	Very Good	Good	Very Good	Good	Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Moderate	Very Good	Very Good	Very Good	Very Good	Very Good	Good	Very Good	Very Good	Moderate	Good	**Moderate**
BMR32	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Moderate	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Good	Good	**Moderate**
BMR33																							
BMR34	Very Good	Very Good	Very Good	Moderate	Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Moderate	Very Good	Very Good	Very Good	Very Good	Very Good	Good	Very Good	Very Good	Moderate	Good	**Moderate**
BMR36	Very Good	Good	Very Good	Good	Moderate	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Moderate	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Moderate	Moderate	**Moderate**
BMR38	Very Good	Very Good	Very Good	Moderate	Moderate	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Moderate	Good	**Moderate**
BMR47	Very Good	Very Good	Very Good	Good	Moderate	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Moderate	Very Good	Very Good	Very Good	Very Good	Very Good	Good	Very Good	Very Good	Moderate	Good	**Moderate**
BMR48	Very Good	Very Good	Very Good	Moderate	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Moderate	Very Good	Very Good	Very Good	Very Good	Very Good	Good	Very Good	Very Good	Moderate	Moderate	**Moderate**
BMR49	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Moderate	Very Good	Good	Very Good	Very Good	Moderate	Good	**Moderate**
BMR52	Very Good	Good	Very Good	Moderate	Moderate	Good	Good	Very Good	Very Good	Very Good	Very Good	Moderate	Very Good	Very Good	Very Good	Very Good	Very Good	Moderate	Very Good	Very Good	Moderate	Moderate	**Moderate**
BMR55	Very Good	Good	Very Good	Moderate	Good	Good	Very Good	Very Good	Very Good	Very Good	Very Good	Moderate	Very Good	Very Good	Very Good	Very Good	Very Good	Moderate	Good	Good	Moderate	Moderate	**Moderate**
BMR56	Very Good	Very Good	Very Good	Good	Good	Good	Very Good	Very Good	Good	Very Good	Very Good	Moderate	Very Good	Very Good	Very Good	Very Good	Very Good	Moderate	Good	Good	Moderate	Good	**Moderate**

APPENDIX 4: The Minimum, The Maximum and The Annual Averages for The Pollutant Concentrations

Table A.7 The Minimum (LOD), the maximum and the annual average of detected concentrations of Pollutants in the BMRB

PARAMETER NAME	GROUP	P/S	AA-EOSw (ppb) Rivers /lakes (µg/L)	MAC-EOSw (ppb) Rivers/ lakes (µg/L)	AA-EOSw (ppb) Coastal and Transition water (µg/L)	MAC-EOSw (ppb) Coastal and Transition water (µg/L)	Min (LOD) (ppb)	Max value	Average value
1,1-Dichloroethane	VOC	S	1000	10000	1000	10000	1.80	1.80	1.8
1,2,4,5-Tetrachlorobenzene	VOC	S	6	24	6	24	3.75	3.75	3.75
1,2,4-Trimethylbenzene	VOC	S	7.4	516	0.3	516	2.60	2.60	2.6
1,3,5-Trimethyl benzene, Mesitylene	VOC	S	9	150	0.8	150	2.60	2.60	2.6
1,3-Dichlorobenzene	VOC	S	58	599	58	599	2.69	2.69	2.69
1-2 dichloroethane	VOC	P	10.0	-	10.0	-	2.660	2.660	2.66
17α-Ethynylestradiol	Hormon	S	0.5	0.9	0.5	0.9	0.008	0.008	0.008
17-beta-estradiol	Hormon	S	0.5	0.5	0.5	0.5	0.005	0.005	0.005
1-chloronaphthalene	PAH	S	0.7	7	0.7	7	0.0061	0.0061	0.0061
1-Methylnaphthalene	PAH	S	1.5	29	1.5	29	0.017	2.7	0.03365
2-Chloronaphthalene	PAH	S	1.6	40	1	40	0.012	0.012	0.012
4-Chloroaniline	VOC	S	0.005	85	0.26	85	3.5	3.5	3.5
Acenaphthene	PAH	S	6	66	6	66	0.001	0.0028	0.00381
Acenaphthylene	PAH	S	6	66	6	66	0.006	0.134	0.01110
Acetamiprid	Pesticide	S	42	42	42	42	0.003	1.930	0.00950

P: Priority, S: Specific

Table A.7 continues

PARAMETER NAME	GROUP	P/S	AA-EOSw (ppb) Rivers /lakes (µg/L)	MAC-EOSw (ppb) Rivers/ lakes (µg/L)	AA-EOSw (ppb) Coastal and Transition water (µg/L)	MAC-EOSw (ppb) Coastal and Transition water (µg/L)	Min (LOD) (ppb)	Max value	Average value
Acetochlor	Pesticide	S	0.3	10.1	0.3	10.1	0.003	0.178	0.00832
Aclonifen	Pesticide	P	0.12	0.12	0.012	0.012	0.002	0.047	0.00201
Alachlor	Pesticide	P	0.3	0.7	0.3	0.7	0.013	0.115	0.01371
Aldrin	Pesticide	P	0.01	-	0.01	-	0.007	0.058	0.00825
Anthracene	PAH	P	0.1	0.4	0.1	0.4	0.007	0.026	0.007
Antimony	Metal	S	7.8	103	4.5	45	1.01	44.99	2.3643
Arsenic	Metal	S	53	53	10	20	0.95	3812.77	38.7537
Atrazine	Pesticide	P	0.6	2.0	0.6	2.0	0.009	0.009	0.00888
Azoxystrobin	Pesticide	S	0.2	6	0.2	6	0.002	0.062	0.00252
Cupper	Metal	S	1.6	3.1	1.3	5.7	1.18	500.6	5.75909
Barium	Metal	S	680	680	680	680	0.43	512.42	51.09735
BBP Benzyl butyl phthalate	Phthalate	S	2.7	44	2.7	27	0.003	0.009	0.00373
Benz-a-anthracene	PAH	DEU	-	-	-	-	0.0012	0.27	0.00228
Benzene	VOC	P	10	50	8	50	2.380	2.380	2.38000
Benzo a fluorene	PAH	S	0.1	1	0.1	1	0.001	0.001	0.001
Benzo-a-pyrene	PAH	P	0.00017	0.27	0.00017	0.027	0.009	0.009	0.009
Benzo-b-fluoranthene	PAH	P	-	0.017	-	0.017	0.006	0.006	0.006
Benzo-ghi-perylene	PAH	P	-	0.0082	-	0.00082	0.02	0.0253	0.02
Benzo-k-fluoranthene	PAH	P	-	0.017	-	0.017	0.012	0.012	0.012
Beryllum	Metal	S	2.5	3.9	2.5	3.9	0.15	6.58	0.21405
BHC alpha	Pesticide	P	-	-	-	-	0.002	0.008	0.00203
BHC beta	Pesticide	P	-	-	-	-	0.002	0.003	0.00197
BHC delta	Pesticide	P	-	-	-	-	0.002	0.002	0.00194
BHC gamma (lindane)	Pesticide	P	1.4	4	1.4	1.4	0.002	0.002	0.002
Bifenox	Pesticide	P	0.012	0.04	0.0012	0.012	0.012	0.012	0.012
Boscalid	Pesticide	S	19	113	19	113	0.004	0.043	0.00423
BPA Bisphenol A	Alkylphenol	S	6.5	252	6.5	65	0.003	0.221	0.00642
Buprofezine	Pesticide	S	3.5	3.5	3.5	3.5	0.003	0.018	0.00316

P: Priority, S: Specific

Table A.7 continues

PARAMETER NAME	GROUP	P/S	AA-EOSw (ppb) Rivers/lakes (μg/L)	MAC-EOSw (ppb) Rivers/lakes (μg/L)	AA-EOSw (ppb) Coastal and Transition water (μg/L)	MAC-EOSw (ppb) Coastal and Transition water (μg/L)	Min (LOD) (ppb)	Max value	Average value
Butralin	Pesticide	S	0.1	4.1	0.1	4.1	0.005	0.006	0.00502
Carbendazim	Pesticide	S	2.7	77	2.7	77	0.001	0.001	0.00556
Carbofuran	Pesticide	S	2.3	2.3	0.05	1.6	0.003	0.003	0.00309
Carbontetrachloride	VOC	S	7.2	130	7.2	130	3.248	3.248	3.24836
Chlorfenvinphos	Pesticide	P	0.1	0.3	0.1	0.3	0.018	0.018	0.018
Chloridazon	Pesticide	S	6	6	0.01	0.1	0.002	0.002	0.00253
Chloroalkanes C10-C13		P	0.4	1.4	0.4	1.4	0.1	0.177	0.09772
Chlorobenzilate	Pesticide	S	6	60	0.8	8	0.060	0.060	0.06
Chlorpyrifos	Pesticide	P	0.03	0.1	0.03	0.1	0.008	0.038	0.0081
Chrysene	PAH	S	1.9	19	1.9	19	0.002	0.369	0.00318
Mercury and compounds	Metal	P	-	0.07	-	0.07	0.6	170.110	1.09292
Clothianidin	Pesticide	S	1.2	1.2	1.2	1.2	0.005	0.017	0.00511
Cybutryne	Pesticide	P	0.0025	0.016	0.0025	0.016	0.005	0.005	0.005
Cypermethrin	Pesticide	P	0.000008	0.00006	0.000008	0.00006	0.035	0.740	0.04317
Cyprodinil	Pesticide	S	4.3	21	4.3	21	0.002	6.194	0.01819
Zinc	Metal	S	5.9	231	5.33	76	0.79	7088.810	96.79032
DBP Dibutyl phthalate	Phthalate	S	16	96	1.5	96	0.003	8.170	0.21247
DDD p p	Pesticide	S	0.025	0.025	0.01	0.025	0.015	0.015	0.01480
DDE o p	Pesticide		-	-	-	-	0.001	0.008	0.00104
DDT o p	Pesticide	P	-	-	-	-	0.001	0.044	0.00111
DDT p p	Pesticide	P	0.01	0.65	0.01	0.1	0.001	0.009	0.00105
DEHP Bis(2-ethylhexyl) phthalate	Phthalate	P	1.3	-	1.3	-	0.025	0.426	0.04627
Demeton-S	Pesticide	S	20	20	20	20	0.010	0.010	0.01003
Iron	Metal	S	36	101	36	101	0.61	24063.37	415.6142
Diazinon	Pesticide	S	0.9	4	0.9	4	0.001	0.165	0.00201
Dibenz-ah-anthracene	PAH	DEU	-	-	-	-	0.084	0.084	0.08216
Dichloromethane	VOC	P	20	-	20	-	2.95	2.950	2.95
Dichlorvos	Pesticide	P	0.00060	0.0007	0.00006	0.00006	0.017	0.017	0.01700
Dicofol	Pesticide	P	0.0013	-	0.000032	-	0.008	0.008	0.00771

P: Priority, S: Specific

Table A.7 continues

PARAMETER NAME	GROUP	P/S	AA-EOSw (ppb) Rivers /lakes (µg/L)	MAC-EOSw (ppb) Rivers/ lakes (µg/L)	AA-EOSw (ppb) Coastal and Transition water (µg/L)	MAC-EOSw (ppb) Coastal and Transition water (µg/L)	Min (LOD) (ppb)	Max value	Average value
Dieldrin	Pesticide	P	0.02	0.93	0.02	0.93	0.007	0.007	0.007
Diflubenzuron	Pesticide	S	0.13	0.13	0.02	0.02	0.002	0.258	0.01001
Dimethoate	Pesticide	S	15	15	15	15	0.003	1.340	0.00682
Dimethomorph	Pesticide	S	3.5	61	3.5	61	0.003	0.008	0.00318
Diphenylamin	Pesticide	S	37	100	44	440	0.011	0.106	0.0119
Diuron	Pesticide	P	0.2	1.8			0.004	1.194	0.00740
DNOP di-n-octyl phthalate	Phthalate	S	1680	16800	1680	16800	0.005	0.005	0.005
Endosulfan I	Pesticide	P	0.005	0.01	0.0005	0.004	0.002	0.002	0.002
Endosulfan I alfa isomer	Pesticide	P	-	-	-	-	0.005	0.005	0.005
Endosulfan II beta isomer	Pesticide	P	-	-	-	-	0.008	0.008	0.008
Endosulfan Sulfate	Pesticide	P	-	-	-	-	0.008	0.008	0.00796
Endrin	Pesticide	P	0.01	-	0.01	-	0.006	0.006	0.006
Ethoprophos	Pesticide	S	0.21	6.4	0.21	0.35	0.003	0.004	0.00305
Epoxyconazole	Pesticide	S	0.8	0.8	0.03	0.3	0.003	0.115	0.00325
Fenamiphos	Pesticide	S	0.01	0.08	0.01	0.08	0.004	0.019	0.00404
Fenhexamid	Pesticide	S	28	28	28	28	0.005	0.017	0.0051
Fenpropathrin	Pesticide	S	0.01	0.01	0.01	0.01	0.003	0.010	0.00309
Fenthion	Pesticide	S	0.05	1.1	0.05	1.1	0.001	0.001	0.001
Fluazifop-p-butyl	Pesticide	S	4.8	53	4.8	48	0.003	0.008	0.00314
Fluoranthene	PAH	P	0.0063	0.12	0.0063	0.12	0.006	0.168	0.01114
Fluorene	PAH	S	3.4	47	3.4	47	0.002	0.088	0.00608
Flutriafol	Pesticide	S	25	79	25	79	0.004	0.004	0.00399
Silver	Metal	S	1.5	1.5	1.5	1.5	0.67	407.930	3.09774
Heptachlor	Pesticide	P	-	-	-	-	0.013	0.013	0.01300

P: Priority, S: Specific

Table A.7 continues

PARAMETER NAME	GROUP	P/S	AA-EOSw (ppb) Rivers /lakes (µg/L)	MAC-EOSw (ppb) Rivers / lakes (µg/L)	AA-EOSw (ppb) Coastal and Transition water (µg/L)	MAC-EOSw (ppb) Coastal and Transition water (µg/L)	Min (LOD) (ppb)	Max value	Average value
Heptachlor endo epoxide	Pesticide	P	0.0000002	0.0003	0.00000001	0.00003	0.001	0.001	0.001
Hexachloro-benzene-HCB	Pesticide	P	-	0.05	-	0.05	0.005	0.007	0.00494
Hexachloro-butadiene	VOC	P	-	0.6	-	0.6	6.76	6.760	6.76
Hexachloro-cyclohexane	Pesticide	P	0.02	0.04	0.002	0.02	0.005	0.005	0.005
Indeno-123-cd-pyrene	PAH	P	-	-	-	-	0.019	0.125	0.01813
Isodrin	Pesticide	P	0.01	-	0.01	-	0.006	0.006	0.006
Isopropyl-benzene (Cumene)	VOC	S	35	260	35	260	2.506	2.506	2.50649
İmidacloprid	Pesticide	S	0.14	1.4	0.14	1.4	0.003	0.547	0.00616
imizalil	Pesticide	S	50	73	50	73	0.03	0.030	0.0297
İsoproturon	Pesticide	P	0.3	1	0.3	1	0.002	0.018	0.00208
Cadmium and compounds	Metal	P	<0.08 (Class 1) 0.08 (Class 2) 0.09 (Class 3) 0.15 (Class 4) 0.25 (Class 5)	< 0.45 (class 1) 0.45 (class 2) 0.6 (class 3) 0.9 (class 4) 1.5 (class 5)	0.2	< 0.45 (class 1) 0.45 (class 2) 0.6 (class 3) 0.9 (class 4) 1.5 (class 5)	0.36	23.960	0.46969
Tin	Metal	S	13	13	13	13	1.6	11.430	1.64156
Calcium		DEU	-	-	-	-	0.45	1590048.73	108848.21
Cobalt	Metal	S	0.3	2.6	0.3	2.6	0.45	27.860	1.04487
Chromium	Metal	S	1.6	142	4.2	88	0.39	384.380	5.53062
Lead and compounds	Metal	P	-	-	-	-	2.69	74.780	3.27819
Linuron	Pesticide	S	3	7	3	7	0.007	0.007	0.00700
Magnezyum		DEU	-	-	-	-	0.001	4910698.34	242427.34
Metalaxy_m	Pesticide	S	17	5320	1	10	0.002	0.023	0.00262
Methacrifos	Pesticide	S	-	-	-	-	0.002	0.041	0.00200
Methamidophos	Pesticide	S	0.2	0.2	0.2	0.2	0.002	0.028	0.00214

P: Priority, S: Specific

Table A.7 continues

PARAMETER NAME	GROUP	P/S	AA-EOSw (ppb) Rivers /lakes (µg/L)	MAC-EOSw (ppb) Rivers/ lakes (µg/L)	AA-EOSw (ppb) Coastal and Transition water (µg/L)	MAC-EOSw (ppb) Coastal and Transition water (µg/L)	Min (LOD) (ppb)	Max value	Average value
Methidathion	Pesticide	S	42	42	42	42	0.002	0.005	0.00202
Metolachlor	Pesticide	S	3.3	88	3.3	88	0.002	0.161	0.00235
Monocrotophos	Pesticide	S	0.4	45	1	45	0.004	0.059	0.00417
Musk Xylene	Pesticide /VOC	S	5.6	56	5.6	56	0.003	0.030	0.003
n propyl benzene	VOC	S	0.2	1.7	0.2	1.7	2.13	2.130	2.13000
Naphthalene	PAH	P	2	130	2	130	0.006	0.698	0.11435
n-butyltin trichloride	TBT	S	1.2	12	1.2	12	0.005	0.236	0.00820
Nickel and compounds	METAL	P	4	34	8.6	34.0	0.65	113.57	6.58536
Nitrobenzene	VOC	S	187	3516	187	3516	3.75	3.750	3.75000
NP Nonylphenol	Alkyl-phenol	P	0.3	2	0.3	2	0.01	0.742	0.01377
OP octyl phenol	Alkyl-phenol	P	0.1	-	0.01	-	0.009	0.532	0.01018
Oxadixyl	Pesticide	S	306	306	306	306	0.002	0.020	0.00213
o-xylene	VOC	S	24	585	1.8	585	2.4	2.400	2.40000
Parakloro-metakresol (4 chloro tri metyl phenol)	VOC	S	37	366	37	366	5.6	5.600	5.60000
PBDE 99	PBDE	P	-	-	-	-	0.0845	0.085	0.08448
PBDE100	PBDE	P	-	-	-	-	0.0081	0.008	0.00809
PBDE15	PBDE	S	1.5	1.5	0.004	0.07	0.049	0.049	0.04900
PBDE153	PBDE	P	-	-	-	-	0.0137	0.014	0.01370
PBDE154	PBDE	P	-	-	-	-	0.0093	0.009	0.00932
PBDE28	PBDE	P	-	-	-	-	0.0056	0.006	0.00556
PBDE47	PBDE	P	-	-	-	-	0.0047	0.005	0.00467
PCB 101	PCB	S	0.25	0.25	0.01	0.02	0.0042	0.046	0.00427
PCB 118	PCB	S	-	-	-	-	0.0047	0.144	0.00507
PCB 138	PCB	S	0.01	0.02	0.01	0.02	0.005	0.049	0.00511
PCB 153	PCB	S	0.01	0.02	0.01	0.02	0.0061	0.087	0.00632
PCB 180	PCB	S	0.01	0.02	0.01	0.02	0.0071	0.007	0.00710
PCB 28	PCB	S	0.01	0.02	0.01	0.02	0.0035	0.004	0.00349
PCB 31	PCB	S	0.01	0.02	0.01	0.02	0.0042	0.004	0.00419

P: Priority, S: Specific

Table A.7 continues

PARAMETER NAME	GROUP	P/S	AA-EOSw (ppb) Rivers /lakes (µg/L)	MAC-EOSw (ppb) Rivers/ lakes (µg/L)	AA-EOSw (ppb) Coastal and Transition water (µg/L)	MAC-EOSw (ppb) Coastal and Transition water (µg/L)	Min (LOD) (ppb)	Max value	Average value
PCB 52	PCB	S	0.01	0.02	0.01	0.02	0.004	0.031	0.00420
Penconazole	Pesticide	S	1.2	1.9	1.2	1.9	0.005	0.007	0.00497
Pentacholoro-benzen	Pesticide	P	0.007	-	0.0007	-	0.005	0.007	0.00500
Pentachloro-phenol	Pesticide	P	0.4	1	0.4	1	0.01	0.010	0.01000
Permethrin	Pesticide	S	0.12	0.12	0.12	0.12	0.013	0.013	0.01300
Perylene	PAH	S	0.6	0.6	0.01	0.03	0.042	0.042	0.04179
PFOS Perfluorooctane sulfonic acid	Surfactant	P	0.00065	36	0.00013	7.2	0.003	0.004	0.00007
Phenanthrene	PAH	S	1.4	11.2	1.4	11.2	0.0024	0.239	0.05047
Pyriproxyfen	Pesticide	S	0.02	7.5	0.02	7.5	0.005	0.005	0.00500
Prochloraz	Pesticide	S	11	13	11	13	0.004	0.022	0.00405
Propetamfos	Pesticide	S	0.05	0.7	1.5	15	0.005	0.005	0.00500
Propham	Pesticide	S	1	989	1	10	0.006	0.460	0.00615
Propiconazole	Pesticide	S	0.7	50	0.7	50	0.011	0.012	0.01092
Propamocarb	Pesticide	S	2240	3914	185	3914	0.004	0.040	0.00595
Pyrene	PAH	S	0.1	0.4	0.02	0.4	0.005	0.510	0.06212
Quinoxyfen	Pesticide	P	0.15	2.7	0.015	0.540	0.003	0.003	0.003
Silicon	Metal	S	1830	1830	610	6891	2.75	568772.82	9256.44
Simazine	Pesticide	P	1	4	1	4	0.003	0.003	0.00301
Sodium		DEU	-	-	-	-	47	46200450.83	1934186.67
Styrene	VOC	S	6.3	575	5.1	575	2.66	2.660	2.66
Tebuconazole	Pesticide	S	23	121	1.6	121	0.004	0.004	0.00401
Terbuthylazine	Pesticide	S	0.2	3.5	0.01	3.5	0.004	0.048	0.00441
Terbutryne	Pesticide	P	0.0650	0.34	0.0065	0.034	0.005	0.007	0.005
Thiabendazole	Pesticide	S	0.5	28	0.5	28	0.006	6.517	0.0373
Thiacloprid	Pesticide	S	0.13	2	0.13	2	0.004	0.523	0.00514
Thiamethoxam	Pesticide	S	20	20	20	20	0.002	0.003	0.00201
Thiaphonate-Methyl	Pesticide	S	42	42	42	42	0.005	0.006	0.005
Titanum	Metal	S	26	42	26	42	1.96	414.420	5.40457

P: Priority, S: Specific

Table A.7 continues

PARAMETER NAME	GROUP	P/S	AA-EOSw (ppb) Rivers /lakes (µg/L)	MAC-EOSw (ppb) Rivers/ lakes (µg/L)	AA-EOSw (ppb) Coastal and Transition water (µg/L)	MAC-EOSw (ppb) Coastal and Transition water (µg/L)	Min (LOD) (ppb)	Max value	Average value
Total Hydrocarbons		S	96	100	96	100	4	4.000	4.0
Triadimenol	Pesticide	S	32	250	1.5	15	0.04	0.040	0.04
Tributyltin compounds	TBT	P	0.0002	0.0015	0.0002	0.0015	0.005	0.005	0.005
Trichlorobenzene	VOC	P	0.4	-	0.4	-	2.68	2.680	2.68
Triclosan	Pesticide	S	0.12	1.1	0.12	1.1	0.2	0.200	0.20
Trichloromethane (CHLOROFORM)	VOC	P	2.5	-	2.5	-	2.57	2.570	2.57
Trifluralin	Pesticide	P	0.03	-	0.03	-	0.003	0.006	0.00301
Trichloroethylene (TRI)	VOC	S	177	8163	177	8163	27.52	27.520	27.52
Vanadium	Metal	S	1.6	97	1.6	16	0.46	439.160	4.4893

P: Priority, S: Specific