OCCURRENCE AND LOAD OF MICROPOLLUTANTS DISCHARGED FROM URBAN AND INDUSTRIAL WASTEWATER TREATMENT PLANTS TO RECEIVING ENVIRONMENT IN THE YEŞİLIRMAK RIVER BASIN

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ABSTRACT

OCCURRENCE AND LOAD OF MICROPOLLUTANTS DISCHARGED FROM URBAN AND INDUSTRIAL WASTEWATER TREATMENT PLANTS TO RECEIVING ENVIRONMENT IN THE YEŞİLIRMAK BASIN

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The occurrence of micropollutants in the aquatic environment is an emerging topic. It is known that the wastewater treatment plants (WWTPs) are the main point sources of the micropollutants. With this regard, the purpose of the study is to determine the occurrence of micropollutants in the WWTPs, to detect the significant discharges, and to analyze the impacts of these discharges on the receiving bodies. A 2-year monitoring study was conducted in Yeşilırmak River Basin and 6 urban WWTPs (UWWTPs), 14 industrial WWTPs (IWWTPs), and related 22 surface water stations were analyzed for 45 priority substances defined by the EU Water Framework Directive (WFD) and 250 specific pollutants. The analysis results showed that the average concentrations of 22 and 38 micropollutants exceed the environmental quality standards (EQSs) in the effluents of UWWTPs and IWWTPs, respectively. Process contributions (PC) of these micropollutants were calculated and significant discharges were identified. The impacts of significant discharges were assessed by comparison of the pollution loads in the upstream and downstream of the related WWTP and results revealed that the Çorum UWWTP, Samsun OIZ, Turhal Sugar, and Özdemir Antimony Mine IWWTPs had the most significant effects on the downstreams, especially for metals. Additionally, the micropollutant removal efficiencies of 5 WWTPs were investigated, and the results showed that the WWTPs were not highly effective in micropollutants removal. This study provides comprehensive results to understand the conditions and effects of the WWTPs in the basin for competent authorities.

Keywords: Micropollutants, Wastewater Treatment Plants, Environmental Quality Standards, Process Contribution, Micropollutant Removal Efficiency

ÖZ

YEŞİLIRMAK HAVZASI'NDA EVSEL VE ENDÜSTRİYEL ATIKSU ARITMA TESİSLERİNDEN KAYNAKLANAN MİKROKİRLETİCİLERİN ALICI ORTAMDAKİ OLUŞUMU VE YÜKÜ

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Sucul ortamlarda mikrokirletici oluşumu yakın zamanlarda yükselen bir konudur. Mikrokirleticilerin en önemli noktasal kaynaklarının atıksu arıtma tesisleri (AAT) olduğu bilinmektedir. Bu bağlamda, mevcut çalışmanın amacı, AAT'lerde mikrokirleticilerin varlığını belirlemek, dikkat edilmesi gereken deşarjları tespit etmek ve bu deşarjların alıcı ortamlar üzerindeki etkilerini analiz etmektir. Yeşilırmak Havzası'nda 2 yıllık bir izleme çalışması yürütülmüş ve 6 kentsel AAT (KAAT), 14 endüstriyel AAT (EAAT) ve ilgili 22 yüzey suyu istasyonu, AB Su Çerçeve Direktifi (SÇD) tarafından tanımlanan 45 öncelikli madde ve 250 ulusal belirli kirleticiler açısından analiz edilmiştir. Analiz sonucu, 22 ve 38 mikrokirleticilerin konsantrasyonlarının sırasıyla KAAT ve EAAT çıkış sularında Çevresel Kalite Standartlarını (ÇKS) geçtiğini göstermiştir. Bu kirleticiler için proses katkıları hesaplanmış ve dikkat edilmesi gereken deşarjlar tespit edilmiştir. Bu önemli deşarjların etkileri, ilgili AAT'nin memba ve mansabındaki kirlilik yüklerinin karşılaştırılmasıyla değerlendirilmiştir ve sonuçlar, Çorum KAAT, Samsun OSB, Turhal Şeker ve Özdemir Antimon Madenleri EAAT'lerinin özellikle metaller için mansaplarına büyük oranda etkilerinin olduğunu açığa çıkarmıştır. Ayrıca, 5 AAT'nin mikrokirletici giderim verimlilikleri araştırılmış ve AAT'lerin

mikrokirleticilerin giderilmesinde çok etkili olmadığı görülmüştür. Bu çalışma, yetkililere, havzadaki AAT'lerin koşullarını ve etkilerini anlamak için kapsamlı sonuçlar sunmaktadır.

Anahtar Kelimeler: Mikrokirleticiler, Atıksu Arıtma Tesisleri, Çevresel Kalite Standartları, Proses Katkısı, Mikrokirletici Giderim Verimliliği

To My Beloved Family

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LIST OF ABBREVIATIONS

A2O	Anaerobic/Anoxic/Aerobic Biological Process
AA-EQS	Annual Average Environmental Quality Standard
BNR	Biological Nutrient Removal
DEM	Digital Elevation Model
DSİ	Directorate General for State Hydraulic Works
EC	European Commission
EDC	Endocrine Disruptive Chemical
EQO	Environmental Quality Objective
EQS	Environmental Quality Standard
EQSD	Environmental Quality Standards Directive
EU	European Union
GC	Gas Chromatography
GIS	Geographical Information Systems
HPLC	High-Performance Liquid Chromatography
HRT	Hydraulic Retention Time
IPM	Iopromide
IWWTP	Industrial Wastewater Treatment Plant
LOD	Limit of Detection
LOQ	Limit of Quantification
MAC-EQS	EQS expressed as Maximum Allowable Concentration
MBR	Membrane Bioreactor
MoFWM	Ministry of Forestry and Water Management
MS	Mass Spectrometry
NBC	Natural Background Concentration
PAH	Polycyclic Aromatic Hydrocarbons
PC	Process Contribution
PCB	Polychlorinated Biphenyls

PE	Population Equivalent
PPCPs	Pharmaceuticals and Personal Care Products
RO	Reverse Osmosis
SRT	Solids Retention Time
SWQR	Surface Water Quality Regulation
TBT	Tributyltin Compounds
TÜBİTAK	The Scientific and Technological Research Council of Turkey
TÜBİTAK MRC	TÜBİTAK Marmara Research Center
UASB	Anaerobic Sludge Blanket Reactor
USEPA	United States Environmental Protection Agency
UWWTP	Urban Wastewater Treatment Plant
VOC	Volatile Organic Compound
WFD	Water Framework Directive
WWTP	Wastewater Treatment Plant

CHAPTER 1

INTRODUCTION

1.1 General

The occurrence of micropollutants that include natural and synthetic organic compounds in ground and surface waters has recently become an emerging global environmental concern. The increasing use of personal care products, medicines, biocides, etc. leads to the appearance of these new pollutants in water. Therefore, the studies on the occurrence, fate, treatment, and environmental effects of micropollutants in the environment have been increasing drastically in recent years. Yet, the United States Environmental Protection Agency (USEPA) had reported the first pharmaceuticals and personal care products (PPCPs) occurrence in US water in 1975 [1]. The reason why micropollutants have gained attention recently is not only because the use of chemicals has increased, but also because these micropollutants are being regulated and measured in waters. With the developing science and technology and increasing population, the production and consumption rate of food (agricultural products), drugs, cosmetics, detergents, and industrial chemicals are increasing. Naturally, this demand comes with some consequences such as heavy metal toxicity, high emission of greenhouse gases, spillage of oil, increased amount of non-biodegradable materials, high pesticide and fertilizers usage. These impurities in the natural cycle spoil the water and environment. Although micropollutants, as the name implies, exist in the water at very low concentrations, ranging from ng/L to µg/L, the impact of these components on the environment and human health is not known well and their toxicity and adverse effects are estimated as significant because of their non-biodegradability and bioaccumulation potential. For example, a pharmaceutical compound, which is used for the recovery of a target organism, may affect a non-target organism negatively, even though exposure concentration is low.

This example is also valid for all other micropollutants like pesticides and steroid hormones. Some expected consequences of the micropollutants for human health and the environment can be listed as nervous system syndrome, memory disruption, cancer, anemia, toxicity in nature, oxidative stress, etc. [2].

Micropollutants are mainly found in water bodies because their life cycle eventually ends up in the water through several pathways. These pathways are as follows [3];

- atmospheric deposition,
- leakage to soil and then groundwater from landfills or uncontrolled dumping sites,
- runoff from agricultural or urban areas,
- direct wastewater or treated water discharge to water bodies.

It is known that treated water effluents from wastewater treatment plants (WWTPs) are one of the main sources of the micropollutants. Therefore, the occurrence and fate of the micropollutants in WWTPs have been frequently investigated in scientific studies. Conventional WWTPs, which are designed to reduced macro pollutants such as suspended solids, nutrients, and some trace elements, are not effective in the removal of micropollutants. Micropollutants may stay unchanged all through the primary and secondary treatment process or be removed at very low rates. For the treatment of micropollutants, advanced treatment systems must be developed and used. However, advanced treatment may also not be a complete solution for the removal of the micropollutants because each of them has specific and different physical and chemical properties. A developed technique may be effective for the removal of some micropollutants while removing others at low rates or not having any effect [4].

In most cases, treated wastewater from WWTPs is discharged directly into receiving water bodies. Therefore, the micropollutants that cannot be removed by conventional techniques applied in conventional WWTPs end up in the environment and then in the human body and other living organisms. In order to prevent the enrichment of adverse effects of micropollutants, some legal provisions have been adopted in the

European Union (EU). A relevant major piece of EU Environmental Legislation is the Water Framework Directive (WFD, 2013/39/EU). The WFD has introduced an integrated river basin management concept with the purpose of reaching good status in all surface and groundwaters. Good status represents the ecological and chemical conditions of the water. Relatedly, European Commission (EC) included in the WFD a list of priority substances that are seen as a threat to the surface and groundwater. The list has 45 priority substances and related Environmental Quality Standards (EQS) for these substances in surface and coastal-transitional waters. In addition, the WFD required each EU Member State to have a list of river basin specific pollutants that have potential risks at the national scale, define EQS values for these pollutants, and monitor these pollutants within a defined monitoring program in all surface and coastal waters [5], [6], [7].

Turkey, as a candidate country, has also conducted similar studies within the scope of the EU harmonization process. The Surface Water Quality Regulation (SWQR) was published by the Ministry of Forestry and Water Management (MoFWM) on November 30th, 2012 in the Official Gazette, and a list of 33 priority substances was included as the dangerous substances to be controlled in water bodies. In August 2016, some amendments were made in the SWQR, and published in the Official Gazette (No: 29797). The revised SWQR that aims to reach good status in all surface (rivers and lakes) and other surface waters (transitional, coastal and territorial) included a list of 250 river basin-specific pollutants and their EQSs were in its annexes. The SWQR requires the implementation of the EQSs set for these substances and the use of water quality based discharge limits for the control of point sources [8], [9].

This thesis study was performed under TÜBİTAK 1003 Project entitled "Management of Point and Non-Point Pollution Sources in the Yeşilırmak River Basin (115Y013)". The Yeşilırmak Basin which is one of the largest basins of Turkey is located on the northern side of Turkey. The area of the Basin is 37,823 km^2 with a river length of 519 km, and Amasya, Çorum, Samsun, and Tokat are the major cities in the Basin [10]. A physical map of the Yeşilırmak River Basin can be seen in Figure 1. “The Management of Point and Non-Point Pollution Sources in Yeşilırmak River Basin Project” mainly aimed to develop a holistic management strategy for the point and non-point water pollution sources and to assure the surface water in the Yeşilırmak Basin to reach the good status target according to the SWQR. The Project which was started in March 2016 and was completed in October 2019 was carried out under the leadership of METU with the cooperation of the Environment and Cleaner Production Institute of TÜBİTAK MAM and Fırat University.

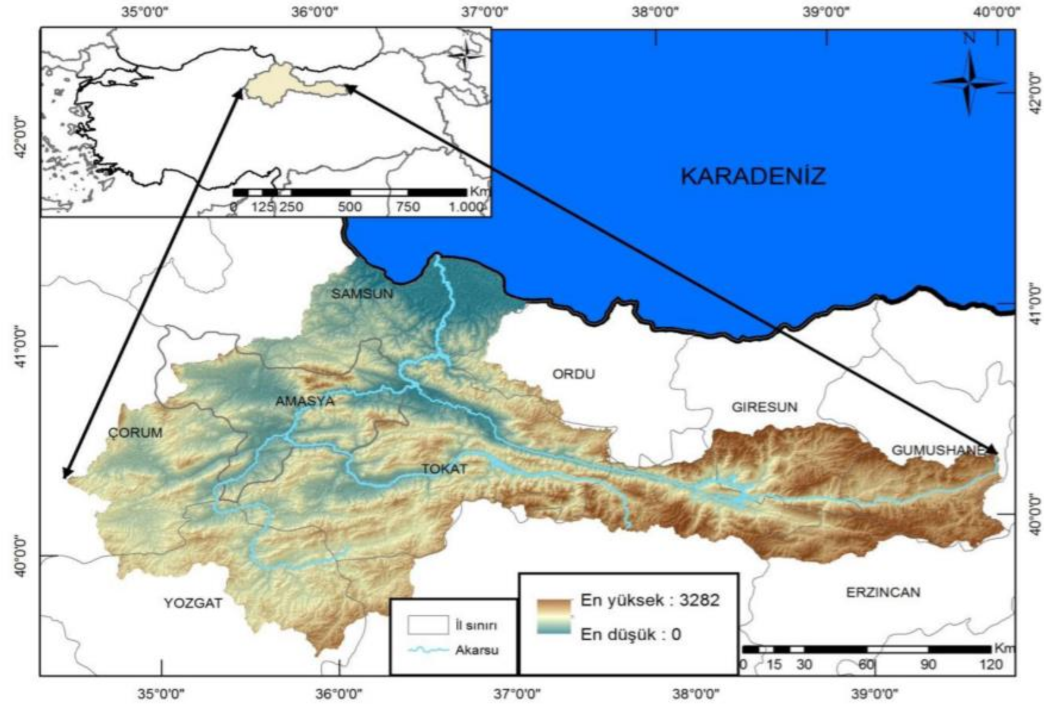

Figure 1. A physical map of the Yeşilırmak River Basin [11]

The major outputs of the Project are listed below:

- The identification of point and non-point pollution sources and specific pollutants for the Yeşilırmak Basin
- A pollutant inventory for the Yeşilırmak Basin
- Risk assessments of the priority and specific substances

- Studies of advanced treatment techniques for removal of priority and specific substances which are exceeding EQS
- A natural background concentration study
- A pollution control strategy for the provision of EQS for all sources
- Performance analysis of the existing WWTPs in the Basin
- Analysis of the WWTP effects on the Yeşilırmak water quality concerning the priority and specific substances

To reach these outputs, a 2-year monitoring study has been conducted within the scope of the Project. The seasonal samples collected from different locations in the Yeşilırmak River and different point sources in the Yeşilırmak River Basin were analyzed at the TUBITAK Marmara Research Center (MRC) laboratories for the micropollutants listed as priority substances in the EU WFD (45 substances) and the micropollutants given in the SWQR of Turkey as national river basin specific substances (250 substances). Based on the results received from these comprehensive monitoring studies, detailed data analysis and other further studies were carried out. In a part of these detailed data analysis studies; in line with the goal of developing pollution control strategies for the basin, pollutants detected in river waters have been tried to be linked with diffuse and point sources of pollution in the basin as rivers are major pathways by which pollutants are carried out.

1.2 Aim and Scope of the Study

The aim of this thesis study, carried out within the framework of the above-mentioned project, is to assess the contribution of point sources to the pollution in the Yeşilırmak River and to search for a link between point sources in the basin and the pollutants existing in the river water.

To this end, the occurrence of micropollutants in the urban WWTPs (UWWTPs) and industrial WWTPs (IWWTPs) of the Yeşilırmak River Basin was evaluated and the receptor levels of these pollutants were assessed to identify the micropollutants which must be paid attention in the receiving body, and to evaluate the impacts of these pollutants on the receiving body.

To achieve these aims, the scope of the study can be defined as follows:

- UWWTPs and IWWTPs to be evaluated were selected with respect to the processes and monitoring data obtained from the previously mentioned TÜBİTAK project. Process information of the selected WWTPs was obtained from a literature search or by contacting the competent authorities of the plants.
- To determine the upstream and downstream stations of the selected WWTPs, Strahler Method was applied in ArcGIS to distinguish orders of the Yeşilırmak River. Then upstream and downstream stations were determined.
- The micropollutants exceeding the annual average EQS (AA-EQS) were identified for all the selected WWTPs and their upstream and downstream stations.
- According to the Tiered approach, significant micropollutants for each WWTP were determined by calculating process contribution (PC).
- The pollution loads of the identified micropollutants were calculated and the load comparison according to upstream and downstream of the WWTPs were done to see the impacts of the plants on the receiving body.
- For the WWTPs whose influent data is available, removal rates of micropollutants exceeding AA-EQS were calculated.
- Key point sources that threaten the water quality in the Yeşilırmak water were identified.

In this thesis, Chapter 2 presents the literature review conducted for the micropollutant legislation, micropollutants occurrence in the WWTPs, and removal efficiencies. Chapter 3 gives information about the study area and the WWTPs studied within the scope of this thesis. Chapter 4 deals with the methodology used and data analysis. The results are given in Chapter 5 with the discussions of the results. Finally, the thesis is concluded in Chapter 6.

CHAPTER 2

LITERATURE REVIEW

2.1 Micropollutants

Micropollutants are unwanted and hazardous compounds that exist in the environment with low concentrations ranging from ng/L to a few µg/L. They are considered hazardous compounds because of their persistence, toxicity, and bioaccumulation in living organisms. Although most of the micropollutants are anthropogenic, they also contain heavy metals. Both inorganic and organic micropollutants can be found in the environment [12]. Inorganic micropollutants can be named as heavy metals (Cd, Hg, Pb, Ni), trace metals (Fe, Mn, Al, etc.), and metalloids (As, V, etc.) and can be found in the environment naturally. However, the problem is anthropogenic sources. Some anthropogenic sources of the inorganic micropollutants are listed as follows [13]:

- Pulp, paper mills, paperboard, building paper, board mills
- Fertilizers
- Petroleum refining
- Motor vehicles
- Flat glass, cement
- Textile mill products
- Leather tanning
- Power plants

On the other hand, organic micropollutants are almost completely human-made compounds. The major organic micropollutant groups are PPCPs, endocrine disruptive chemicals (EDCs), disinfectants, surfactants and detergents, biocides, additives, flame retardants, and plasticizers [14]. Organic micropollutants groups and class, their major sources and fates in the environment are summarized in Table 1.

Table 1. Summary of major organic micropollutants, their sources, and fates in the environment [14]

Organic Micropollutants		Sources	Fate
Group	**Class**		
Pharmaceuticals	Antibiotics, analgesics, antidiabetics, cardiovascular drugs, psychiatric drugs, veterinary drugs	Hospitals, veterinary clinics, excretion (domestic wastewaters)	WWTPs, surface waters, and groundwater (by leaching)
EDC	Steroids and hormones		Soil and groundwater
Personal care products	Antiseptics, fragrances, UV filters, insect repellents, cosmetics	Washing and shower waters (grey wastewater)	WWTPs, terrestrial runoff, surface waters, sediment
Biocides	Herbicides, pesticides, insecticides, wood preservatives, fungicides	Agriculture	Water and soil
Surfactants and detergents	Perfluorooctanoic acid, perfluoro octane sulfonate	Laundries, households, industries	WWTPs, surface water, and groundwater (by leaching)
Disinfections		Swimming pools, chlorination of materials	WWTPs, surface water, and groundwater (by leaching)
Flame retardants		Household items and industries	Deposition of soil and water
Plasticizers	Phthalates, nonylphenol	Industry, cosmetics, glues	WWTPs, surface water, and groundwater (by leaching)

As can also be seen from Table 1, micropollutants are spreading from so many different sources and eventually they end up in the environment, especially in the aquatic environment. Surface waters are being contaminated with micropollutants directly or indirectly through several pathways. Discharge of wastewaters (industrial or municipal), agricultural runoff, disposal, and washing of pesticide containers can be examples of direct discharges. Besides, treated wastewater discharge from

WWTPs, wet or dry deposition, irrigation, and leaching from soils and landfills to groundwater can be considered as indirect contamination [2]. Schematic illustration for pathways of micropollutants can be seen in Figure 2.

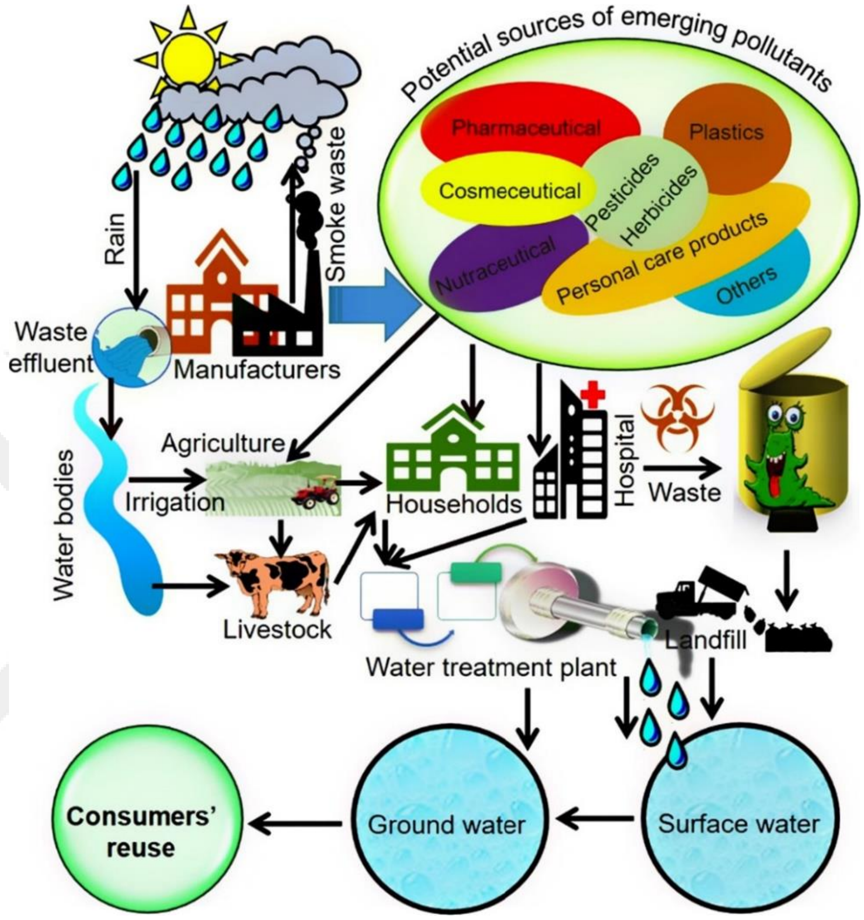

Figure 2. Schematic illustration for the pathway of micropollutant from sources to the environment [2]

Ultimately, contaminated waters are being used by humans and all other living organisms. In this way, micropollutants enter the food chain and accumulate in the body tissues. Hence, adverse side effects can be observed not only in humans but also in other organisms. Some examples of effects of the micropollutants on the living bodies are [13]:

- Endocrine disruption
- Carcinogen

- Mutagen
- Teratogen
- Developmental problems in juveniles and eggs and of fishes and birds
- Immune responses
- Neurotoxicity
- Inhibition of growth etc.

WWTPs as point sources are one of the main micropollutant sources to the aquatic environment. In the world, population and industrial activities are increasing so the volume of wastewater generated is increasing. That causes discharges of higher wastewater to the surface waters. Additionally, with the increased human activities, the concentration of the micropollutants is increasing in the wastewaters. The increased micropollutant concentration and wastewater volume cause higher micropollutant mass release to the water and higher risks for the environment and humans depending on the characterization of the micropollutant (Figure 3) [12].

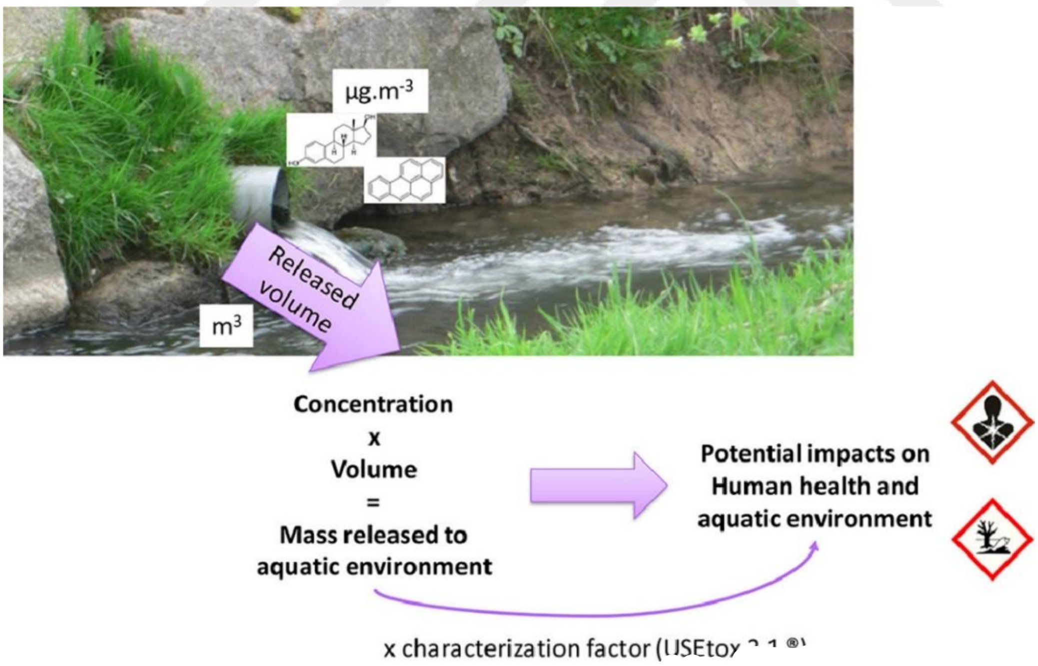

Figure 3. Illustration for the relation of released micropollutant mass and potential impact on the environment [12]

Detection of micropollutants

Due to very low concentrations of micropollutants in the water samples, detection and quantification are complex processes and required sensitive instruments [15]. There are different instruments used for micropollutant measurement and still, studies to increase the sensitivity in the measurement are being conducted. Frequently used instruments are chromatography (gas chromatography (GC) and high-performance liquid chromatography (HPLC)) and mass spectrometry (MS). However, none of these instruments can detect or measure the micropollutant concentration precisely. Therefore, analytical performance must be characterized to understand the limitations and capability. Limit of detection (LOD) and limit of quantification (LOQ) are the terms used for this purpose [16]. LOD can be defined as the lowest concentration that can be detected with a given analytical method [17]. Whereas LOQ is usually defined as the lowest concentration of the micropollutant that can be reliably quantified [18]. These parameters should be determined before analysis according to standard method alternatives.

2.2 EU Water Framework Directive and Relative Regulation of Turkey

The European continent, which is enclosed with nine sea basins, composes of a few million kilometers of streams and more than one million lakes [19]. Due to the pressure of urbanization, climate change, agriculture, and tourism, all these water basins have their own pollution problems, and the EC has been trying to protect water quality all over Europe with a range of environmental legislations since the 1970s [19].

The current EU water legislation is already in its third generation. The earliest water legislation dated 1975 was about rivers and lakes used for drinking water abstraction. In parallel, a series of directives related to different water bodies like groundwater, surface waters, discharges to surface water, and bathing water were started to be implemented in 1975. These directives included quality objectives for fish waters, shellfish waters, bathing waters, and groundwaters. The main piece of legislation was the Dangerous Substances Directive dated 1976. In 1991, some of these first directives were revised and new ones were adopted. Then, the WFD (2000/60/EC), which was based on a more integrated approach, was introduced by combining homogeneous directives [20].

The WFD, as the name implies, is a framework legal act to restructure the EU water legislation by combining some of the existing legislations under an umbrella for a water policy. It brought new concepts about water production like river basin management, ecological status, economic applications (Figure 4). It has strict rules for the assessment of the biological, quantitative, and hydrological status of all water bodies in Europe by analyses and further monitoring. Member States are obligated to adopt and implement river basin management plans, to make measurements, and to control point and non-point pollution sources based on a combined approach. The ultimate objective of the WFD is to reach a good status for all water bodies within Europe [21].

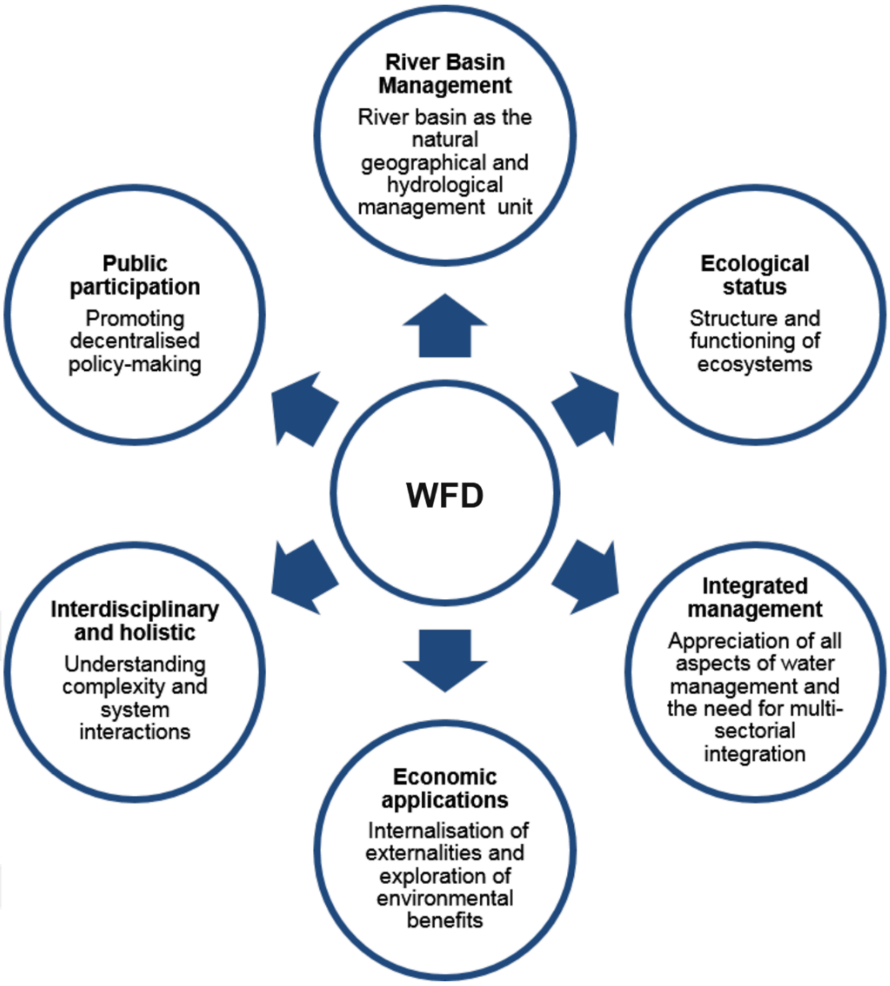

Figure 4. Some new concepts introduced by the WFD and brief information [22]

Good status means low chemical pollution and a functioning aquatic ecosystem in the water bodies. According to the WFD, good surface water status can be reached when both the chemical and ecological status of the surface water are at least good. The chemical and ecological status are classified according to the relevant provision, such as biological, hydromorphological, chemical, and physico-chemical elements and specific pollutants, in Annex V of the WFD [23]. For specific pollutants, the Directive gives two different groups, which are priority substances and other substances with significant quantities in the water bodies. Priority substances are explained as pollutants that present a significant risk to or via the aquatic environment. The Directive gives the list of priority substances. The other substances with significant quantities in the water bodies can also be named as river basin-specific pollutants, which are determined by each EU member state for its own river basins.

In addition to the determination of priority substances, the Directive requires the limitation of discharges of these substances. In this respect, the Environmental Quality Standards Directive (EQSD) (2008/105/EC) was published as a daughter directive of the WFD. The EQSD, firstly, established concentration limits for 33 priority substances in the surface waters. Then, the Directive was revised in 2013 (2013/39/EU) and 12 more priority substances were added with determined EQS values. In total, 45 priority substances and their stricter EQS values were established in the EQSD (2013/39/EU) [24], [25]. According to the WFD, EQS is defined as a maximum allowable concentration of a pollutant in water, sediment, or biota to protect the environment and human health [23]. Like determining the river basin-specific pollutants, each EU member state is obligated to establish EQS values for their river basin-specific pollutants. For the determination of specific pollutants and EQS values, and for other implementations, WFD Guidance Documents, which give overall methodological approaches, were published by EC.

Water pollution is also an important issue for Turkey and as a candidate country, Turkey had studied for implementation of the WFD. As a result of these studies, regulation about surface water quality, named SWQR, was published by the former MoFWM in 2012 and revised in 2016. The objective of the regulation is to determine the quality and quantity of surface, transitional and coastal waters and to determine the principles for the measures to be taken to reach the good status in these waters. In the revised version of SWQR, national specific pollutants were identified and their EQS values were established. In addition to 45 priority substances, there are 250 different specific pollutants and their EQS values in the SWQR. The priority substances and specific pollutants listed in the SWQR and their EQSs are given in Appendix A.

2.3 The Occurrence of Micropollutants in WWTPs and Effects on Water Bodies

The major point source of the micropollutants is the discharge of treated water from WWTPs [26], [27]. However, the occurrence of the micropollutants in the WWTPs shows significant variations in terms of type and concentration because of the rate of production and consumption in the area, population, water consumption per day and person, metabolism, and size of WWTPs [28]. For example, caffeine was detected at high levels in China's three different WWTPs with an average concentration of 50 µg/L due to the high consumption of tea or coffee [29]. Another reason for the variation in the micropollutant occurrence in the WWTPs is weather conditions. Wang et al. (2011) stated that pharmaceuticals in winter water samples showed higher occurrence ratios than those in summer. Higher biodegradability in warmer temperatures and increased dilution ratio in wetter summer can be the cause of this difference [30].

Another occurrence difference can be caused by wastewater treatment processes due to the transformation of the compounds by reacting with other pollutants or treatment chemicals. This may lead to increased concentration and higher toxicity problems in the environment [31]. A result of the study of Clara et al. (2005) can be given as an example. In the study, influent and effluent samples were taken from a conventional WWTP, and iopromide (IPM), which is a PPCP, was detected with a high mean concentration in the influent sample, which is 3840 ng/L. While the mean concentration of IPM of effluent was measured as 5060 ng/L. They could not identify any reasonable justification for this increase [32].

In many countries, so many different micropollutant types and their occurrences in the WWTPs have been investigated. The results of some of these studies can be found in the following part. For example, in South China, 14 different androgens, which are a type of steroids, have been investigated in 10 different WWTPs by Zhang et al. (2018). Ten androgens out of 14 were detected with concentrations up to 4650 ng/L in all of the investigated WWTPs' influents, while three and six of them were found in the effluent and sludge, respectively [33].

Another study from China was performed for 943 semi-volatile organic micropollutants in seven full-scale municipal WWTPs. As a result, the study showed total detection of 196 and 145 micropollutants in the secondary and advanced treatment effluents, respectively [34].

In Spain, micropollutant occurrence in WTTPs effluent and coastal water was investigated. Researchers have analyzed 71 micropollutants from 28 WTTP effluents. The result showed that the most frequent 13 micropollutants, which include volatile organic compounds (VOCs), organochlorinated pesticides, phthalates, and tributyltin compounds (TBT), were detected in coastal water were also detected in the WWTP effluents [35].

According to D'Alessio et al. (2018), the first investigation of the occurrence and removal of pharmaceuticals in Hawaiian Island WWTPs has been studied by them in 2018. 23 different pharmaceuticals have been investigated in influent and effluent waters. Seven of them could not be detected in any sample, while one pharmaceutical (acetaminophen) could be measured only in influent wastewater and four compounds (naproxen, sulfamethoxazole, gemfibrozil, and 1,7-dimethylxanthine) were detected in all samples of influent and effluent. The remaining pharmaceuticals could be detected in at least one sample. Among the detected micropollutants, caffeine and ibuprofen had the highest in influent wastewater samples, respectively 64 µg/L and 96.5 µg/L. On the other hand, diphenhydramine had the highest concentration in effluent samples with 0.9 µg/L [36].

The occurrence investigation in WWTPs has been used to back-calculate the illicit drug use of the population with consideration of target drug residue in the WWTP influents because they eventually arrive WWTPs by excreting. Generally, illicit drugs are non-prescribed so quantification of the discharged amount of these drugs into the environment is difficult. In Italy, the illicit drugs have been monitored in two WWTPs and average usage was calculated from occurrence concentrations in

WWTPs. As a result, cocaine, tetrahydrocannabinol (cannabis metabolite), benzoylecgonine (cocaine's metabolite), and codeine had the highest average concentration in both WWTPs. Then, consumption amounts of cocaine and cannabis were calculated as 1.6 doses/1000 inhabitants/day and 23.4 doses/1000 inhabitants/day [37].

Another study from Italy has shown pharmaceuticals occurrence in two WWTPs of Po Valley (Northern Italy). 27 pharmaceuticals have been selected and 24 of them were detected at least once while 10 pharmaceuticals were always detected in each sample of the monitored WWTPs. Diclofenac, hydrochlorothiazide, atenolol, and sotalol were the compounds that had the highest average concentration with 520 ng/L, 502 ng/L, 265 ng/L, and 262 ng/L, respectively. The maximum concentration detected was for diclofenac with 800 ng/L. In the study, surface water analysis has also been done and as a result of the collected data, average concentrations of selected pharmaceuticals were higher in WWTP effluents than in the surface waters. Additionally, some micropollutants detected in the surface waters could not be detected in the effluents of WWTPs. This is an indicator of at least one other pollutants source in the area [38].

A very recent study was done in France by Aemig et al. (2021) about the effect of 286 different micropollutants released by WWTPs. The measured concentration of the micropollutants ranges from 0.1 ng/L to 5 µg/L. According to the authors, some pesticides, and polycyclic aromatic hydrocarbons (PAHs) as well as Zn and As showed the highest potential effect on human health. While PCB 101, some pesticides, Al, Fe, and Cu showed the highest potential effect on the environment [12].

2.4 Removal Efficiencies of Micropollutants in WWTPs

Most of the WWTPs are not designed to remove micropollutants, therefore they are not effective for micropollutant removal [39]. Especially, in WWTPs that receive wastewater from both urban and industrial areas, micropollutant removal is more challenging due to complex mixtures of a wide variety of micropollutants in the wastewater [40].

The removal of micropollutants depends on the two main aspects, which are the physico-chemical properties of the micropollutants and the process type of the WWTPs. The most important parameters that affect the removal efficiencies in the WWTP are molecular weight and size, sorption coefficient, hydrophobicity, biodegradability, and volatility. Besides, process conditions in WWTP, such as sludge age, hydraulic retention time (HRT), pH, and temperature also determine the removal efficiency [4]. Therefore, a general removal solution for micropollutants cannot be devised and decisions should be made by analyzing each case specifically. For example, according to Luo et al. (2014), micropollutant removal efficiencies vary in the range of 12.5-100% in WWTPs [26].

For micropollutant removal, secondary or advanced treatment technologies are preferred. However, conventional secondary treatment techniques do not provide sufficient removal of micropollutants [41]. On the other hand, it is known that advanced treatment technologies like ozonation, activated carbon adsorption, nanofiltration, reverse osmosis (RO), etc. generally achieve better removal ratios [26]. Therefore, a considerable number of micropollutants in the secondary treatment effluents require suitable further treatment alternatives [34]. A lot of different studies have been conducted about the removal of micropollutants until now and still different techniques and removal efficiencies are being studied.

Ben et al. (2018) has conducted a study about the removal efficiencies of 42 micropollutants in 14 different WWTPs of China by comparing the processes. Among the different secondary treatment processes, the anaerobic/anoxic/aerobic (A2O) process combined with the moving-bed biofilm reactor provided higher removal of micropollutants. For tertiary treatment alternatives, a combination of ultrafiltration, ozonation, and ClO_2 disinfection processes achieved the highest removal rate [42].

Another process comparison study has been conducted in France in a WWTP with conventional biological treatment and a pilot system of activated carbon adsorption. In total, 48 organic micropollutants have been analyzed. Removal efficiencies of micropollutants in primary treatment were under 20%, whereas the secondary (biological) treatment removed easily adsorbable micropollutants with a rate of 60%. Then, additional treatment was provided with activated carbon adsorption. The removal rate of micropollutants that have been already removed in secondary treatment was not significant, under 10%. However, other persistent micropollutants have been removed with a ratio higher than 30%. The combination of biological treatment and activated carbon adsorption has removed 60% of organic micropollutants in total [43].

In Switzerland, two different advanced treatment techniques were tested at a WWTP as a large-scale pilot system. One of the techniques was ozonation followed by sand filtration and the other was adsorption with powdered activated carbon followed by ultrafiltration. In the treatment plant, more than 70 micropollutants were monitored and the removal of micropollutants has improved with both advanced techniques by comparing the secondary treatment. According to the result of the study, either ozonation or adsorption performed better depending on the properties of the micropollutants. Ozonation was more effective for removing a large scale of micropollutants, whereas adsorption was better for a broad spectrum of components. But in general, 80% removal of micropollutants from raw wastewater was obtained with an average ozone dose of 5.7 mg/L O_3 or powdered activated carbon dose of 13 mg/L [44].

Nanofiltration is one of the promising technologies for the removal of micropollutants from wastewater. The big disadvantage of this process is the retentate or concentrate. The concentrate of nanofiltration is highly saline and the high salinity makes further disposal of the concentrate very challenging [41]. Besides, several studies indicate that the removal of micropollutants with RO is highly effective. Most of the micropollutants' removal rates were greater than 90% [45].

In South Korea, 57 PPCPs' concentrations were investigated in the different treatment processes including A2O and membrane bioreactor (MBR) systems. Removal efficiencies of the A2O process of a WWTP and lab-scale MBR were compared. A2O process showed high removal efficiency for most of the PPCPs. However, the MBR process was better for the removal of more persistent PPCPs. In the removal of poorly or moderately eliminated compounds, the biodegradation mechanism had an important role than sorption, except for highly absorbable compounds [46].

While studying micropollutant removal efficiencies of WWTPs, for some cases negative removal can be seen because of several reasons. One of these reasons is conjugate and metabolite formations during microbial degradation of multimolecular micropollutants. The other one is due to the sampling process. While taking samples, HRT and/or solids retention time (SRT) may not be considered so that effluent does not correspond to the same plug of influent. However, when average concentrations are compared, removal efficiencies can be assumed as accurate [36], [47].

CHAPTER 3

STUDY AREA

3.1 Yeşilırmak Basin

Turkey is divided into 25 major basins. The Yeşilırmak Basin is one of them and its boundary coordination is 39° 30′ and 41° 21′ N, and 34° 40′ and 39° 48′ E, northern side of Turkey [48]. The Basin covers 5% of Turkey's surface area, with 37,823 km^2 area [10]. The Yeşilırmak River, which originates from Mountain Köse of Sivas, has a length of 519 km until flowing into the Black Sea in Samsun. The Yeşilırmak River forms a large delta in Çarşamba, where it meets the sea. The Yeşilırmak River has three main tributaries, which are Çekerek River, Kelkit, and Tersakan Creek [49]. Figure 5 shows the location of the Yeşilırmak Basin in Anatolia and its digital terrain map.

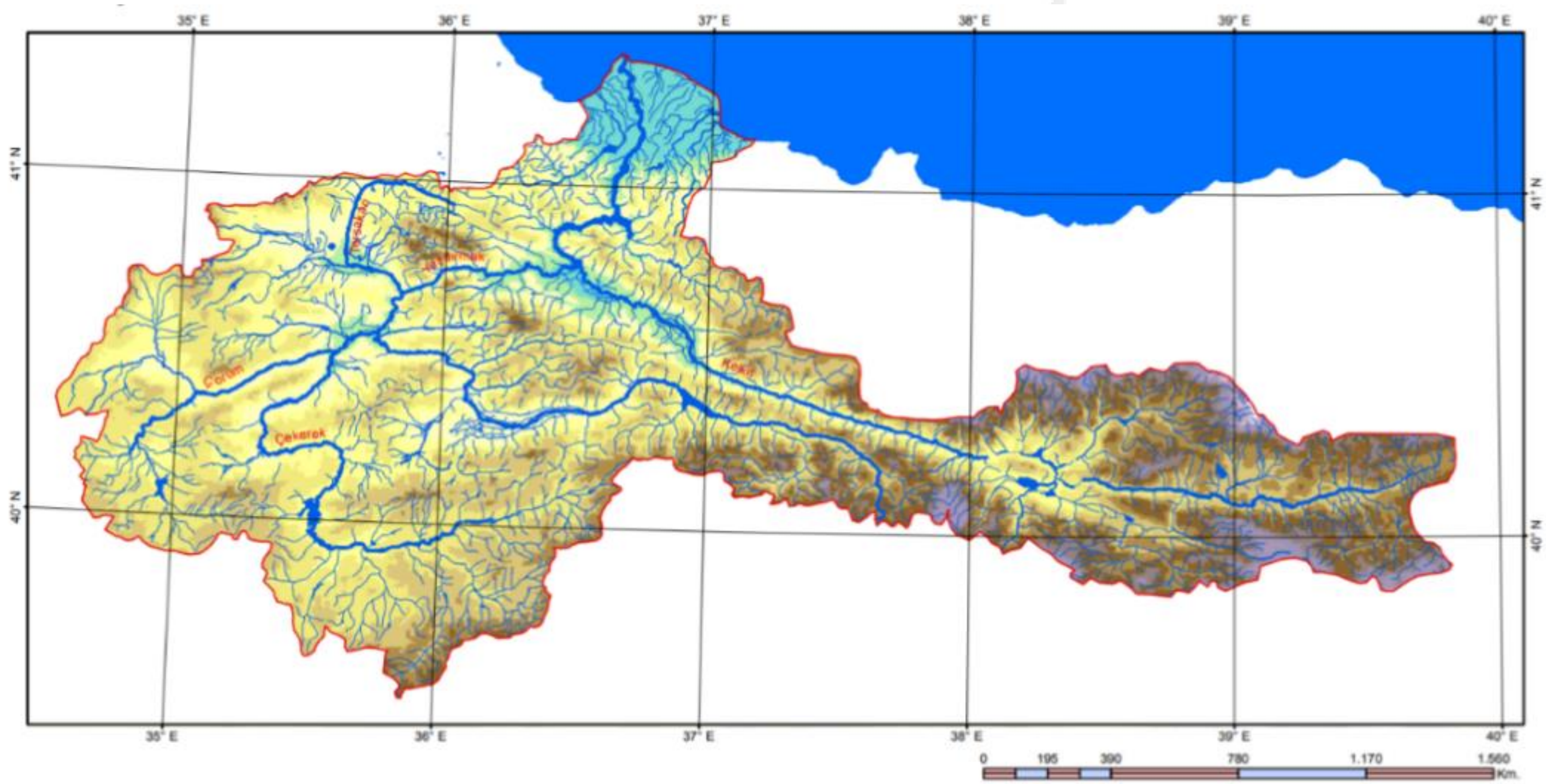

Figure 5. The Yeşilırmak River Basin main tributaries and the digital terrain map [50]

Eleven provinces of Turkey are within the boundaries of the Basin, which are Tokat, Samsun, Amasya, Çorum, Sivas, Yozgat, Gümüşhane, Giresun, Erzincan, Ordu, and Bayburt. However, the major provinces that remain in the Basin are Amasya, Çorum, Samsun, and Tokat [49]. The total population of all residential areas within the Basin is 2,752,803 people [10]. Figure 6 gives areal percentages of the provinces of the basin.

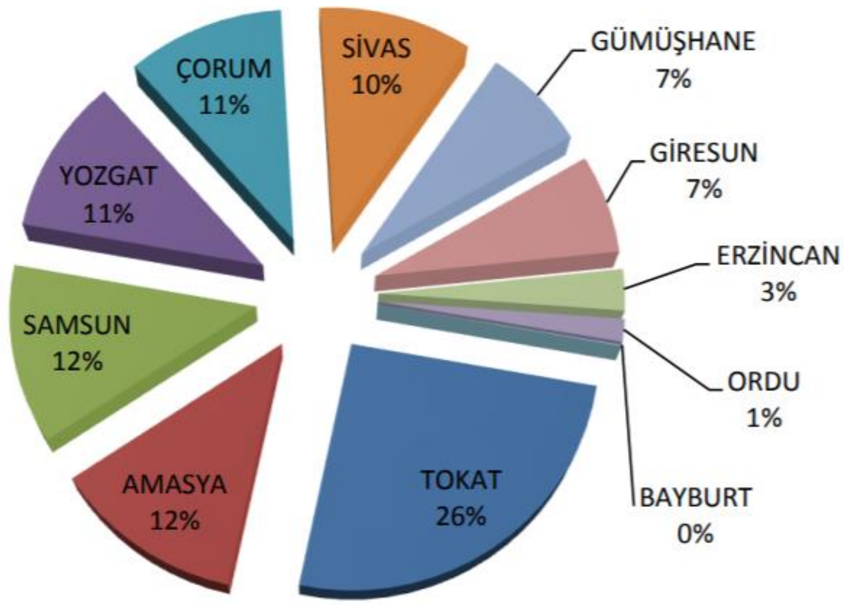

Figure 6. The areal ratio of the provinces in the basin [49]

The terrain of the basin is highly rough, and the geology of the basin consists of claystone, sandstone, volcanic brassica, andesite, and tuff. As a result of high altitude differences and the transition of humid air from the Black Sea, the basin has a subtropical and semi-arid climate. Temperature and precipitation in the basin show heterogeneity spatially and temporally [48]. According to statistical data from the Directorate General for State Hydraulic Works (DSİ), the precipitation area of the basin in 2018 is 39,595 km^2 and the average flow is 7.1 km^3 [51].

Dominant land use in the basin is forest and semi-natural areas with 21,647 km^2. Then, agricultural areas and artificial areas have the highest land area with 17,185 km^2 and 455 km^2 [52]. The land use distribution can be seen in Figure 7.

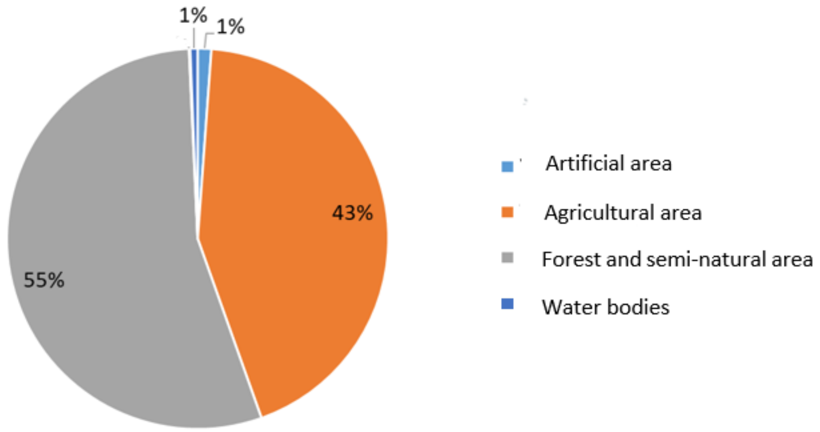

Figure 7. Land use of the Yeşilırmak River Basin [52]

As can be seen from land use percentages, agriculture and livestock are the major living sources in the basin. Hence, fertilizers, pesticides, and animal medicines are some of the major pollution sources. Besides, industrial activities can be counted as significant in terms of pollution sources. Food, beverage, mining, cement, forest products, paper and paper products, sugar and feed industries are common in the basin [49]. WWTPs of industries discharge the treated wastewater to the Yeşilırmak River or its tributaries likewise UWWTPs discharges. These non-point and point pollution sources have an important pressure on the aquatic environment. Other main environmental pressures of the basin are mining activities, dumping sites, erosions, and hydroelectric power plants [53].

3.2 WWTPs in the Basin and Monitoring

The monitoring study in the Yeşilırmak Basin was started in August 2016 and ended in January 2018 to determine the specific pollutants of the basin within the scope of the TÜBİTAK 1003 Project numbered 115Y013. In total, eight periods of monitoring studies were conducted by the project team. The monitoring periods were in August 2016, October 2016, February 2017, April 2017, June 2017, August 2017, November 2017, and January 2018. Seasonal variations due to weather conditions could be observed thanks to the long monitoring period. For this study, water samples were taken from different points of surface water of the basin, industrial discharges, and urban WWTPs. In the first two periods, receiving body stations were monitored then UWWTP and IWWTP stations were added. Additionally, if there were not any stations for the upstream or downstream of WWTPs, new surface water stations were also located in the upstream and downstream points. In this way, significant pollutants in the basin and major sources of these pollutants were determined and matched.

Throughout the monitoring study, some sampling stations were canceled, or new ones were added according to the condition of the river flow and requirements of the Project. Also, for some of the receiving body stations, samples could not be taken, or flowrates could not be measured due to the seasonal variations in flowrates. For some of the IWWTPs sampling points, this situation was observed due to the operating seasons of the facilities. Therefore, the number of monitored periods of each sampling station (receiving body or WWTP) differs from eight to two.

As stated before, the analysis was done for 45 parameters listed as priority substances in the WFD and 250 parameters listed as specific pollutants in the SWQR of Turkey. Some parameters from the SWQR list were excluded because of the technological conditions of the laboratory. Some other parameters whose LOD values could not be lowered under their AA-EQS values were also excluded. Because even they could not be detected by the laboratory instrument, they seemed to exceed their AA-EQS values. More detailed information for parameter selection is given in Section 4.4.

3.2.1 Urban WWTPs

UWWTP monitoring studies were started with the third period and in total, 17 different UWWTP stations were included in the monitoring study (listed in Appendix 0). However, 11 of them were excluded from the scope of this thesis study. Those excluded from the scope were applying natural treatment or did not have enough flow to be measured. Six UWWTPs out of 17 were selected to be studied in this thesis and for three of them, data of influent wastewater analysis were available. The list of them is given in Table 2 with their station codes, coordination, number of monitored periods, and upstream/ downstream/ influent data availability.

Table 2. Studied UWWTP definition, codes, coordination, number of monitored periods, and data availability for upstream/downstream/influent

Station Code (_UW)	Definition	Coordination	# of monitored periods	Data availability for;
YESIL-45	Tokat WWTP	N 40° 20' 23" E 36° 28' 26"	6	✓Upstream ✓Downstream ✓Influent
YESIL-47	Erbaa WWTP	N 40° 42' 24" E 36° 33' 18"	6	✓Upstream ✓Downstream ✕Influent
YESIL-48	Çorum WWTP	N 40° 29' 02" E 34° 54' 46"	6	✓Upstream ✓Downstream ✓Influent
YESIL-75	Mecitözü WWTP	N 40° 31' 42" E 35° 18' 14"	4	✕Upstream ✕Downstream ✕Influent
YESIL-107	Amasya WWTP	N 40° 40' 48" E 35° 52' 46"	3	✓Upstream ✓Downstream ✓Influent
YESIL-108	Havza WWTP	N 40° 56' 49" E 35° 39' 22"	3	✓Upstream ✓Downstream ✕Influent

3.2.2 Industrial WWTPs

The IWWTP monitoring studies were also started with the third period and in total, 38 different IWWTP stations were added to the monitoring study (listed in Appendix 0). The industries were selected from different types of the sector as much as possible to observe the differences in micropollutant content. However, 24 of them were excluded from the scope of this thesis study. Those excluded from the scope did not have enough flow to be measured. Fourteen IWWTPs out of 38 were selected to be studied in this thesis and for two of them, data of influent wastewater data were available. The list of them is given in Table 3 with their station codes, coordination, number of monitored periods, and upstream/ downstream/ influent data availability.

Table 3. Studied IWWTP definition, codes, coordination, number of monitored periods, and data availability for upstream/downstream/influent

Station Code (_IW)	Definition	Coordination	# of monitored periods	Data availability for;
YESIL-58	Merzifon OIZ* WWTP	N 40° 50' 49" E 35° 28' 39"	6	✓Upstream ✓Downstream ✓Influent
YESIL-59	Samsun OIZ WWTP	N 41° 14' 39" E 36° 25' 49"	4	✕Upstream ✕Downstream ✕Influent
YESIL-60	Dimes Food WWTP	N 40° 19' 52" E 36° 27' 24"	6	✓Upstream ✓Downstream ✕Influent
YESIL-61	Turhal Sugar Factory WWTP	N 40° 23' 46" E 36° 04' 51"	2	✓Upstream ✓Downstream ✕Influent
YESIL-62	Özdemir Antimony Mine WWTP	N 40° 25' 31" E 36° 06' 43"	6	✓Upstream ✓Downstream ✕Influent
YESIL-65	Meray Oil WWTP	N 40° 51' 44" E 35° 25' 58"	4	✕Upstream ✓Downstream ✓Influent
YESIL-69	Olmuksan International Paper WWTP	N 40° 31' 32" E 34° 54' 44"	5	✓Upstream ✓Downstream ✕Influent

Table 3. (cont'd)

Station Code (_IW)	**Definition**	**Coordination**	**# of monitored periods**	**Data availability for;**
YESIL-70	Özmaya (Lesaffre) WWTP	N 40° 41' 19" E 35° 54' 24"	5	✓Upstream ✓Downstream ✕Influent
YESIL-71	Eti Copper Inc. WWTP	N 41° 14' 24" E 36° 27' 42"	2	✕Upstream ✕Downstream ✕Influent
YESIL-73	Yemsel Poultry Livestock WWTP	N 41° 03' 29" E 36° 05' 41"	4	✕Upstream ✕Downstream ✕Influent
YESIL-76	Yuva Viol and Package WWTP	N 40° 35' 58" E 34° 54' 46"	3	✕Upstream ✕Downstream ✕Influent
YESIL-77	Et-Bir Suluova Slaughterhouse WWTP	N 40° 49' 24" E 35° 37' 19"	4	✓Upstream ✓Downstream ✕Influent
YESIL-78	Kozlu Food (Feed) WWTP	N 40° 48' 20" E 35° 39' 45"	4	✓Upstream ✓Downstream ✕Influent
YESIL-79	Bakraç Dairies WWTP	N 40° 44' 00" E 35° 46' 11"	4	✓Upstream ✓Downstream ✕Influent

*OIZ: Organized Industrial Zone

CHAPTER 4

METHODOLOGY AND DATA ANALYSIS

4.1 Stream Network and Strahler Method

To quantify the topological organization of a stream within a basin, drainage network analysis is performed by using geographical information systems (GIS). The digital stream data used as input in GIS for characterization is generally cell-based digital elevation models (DEMs). A DEM can be explained as a raster representation of a continuous surface. From the DEM data, the river network is extracted to define surface drainage direction. The drainage network is related to the runoff properties of a basin. River networks include stream links and nodes, which are channel head, confluences (joining), diffluences, and outlet, in an acyclic graph. Each link and node show upstream and downstream directionality for the overall flow through the basin [54] [55].

To determine the upstream and downstream in a river network, the stream ordering method is used. Stream order describes the hierarchy of the stream tributaries by assigning a numeric order from the top to the bottom of the basin. There are different methods for stream ordering and one of the most common methods is the Strahler method. In this method, the links that do not have any tributaries are assigned an order of 1 and these are the upstream segments. When two streams with the same order intersect, the stream order increases. However, if two streams with different orders intersect, the order will not increase, and the resulting stream will have the same order as the stream with the highest stream order. In other words, if first and second order streams intersect, the combined stream will be second order. The link with the highest order is the biggest and main stream in the basin. Figure 8 illustrates the visual description of the Strahler stream ordering method [56] [57].

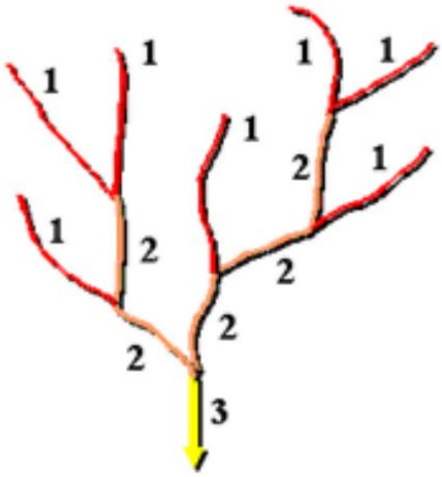

Figure 8. Strahler stream ordering method [57]

In this thesis study, to extract the stream network and to define the flow direction of the Yeşilırmak River, network analysis was performed in ArcGIS and for stream ordering, the Strahler method was preferred. DEM data for network analysis was obtained from an open source of the U.S. Geological Survey website[1].

4.2 Sampling Stations and Determination of Upstream and Downstream Stations

As stated previously, six UWWTPs and fourteen IWWTPs were included in this thesis study. After the preparation of the stream network in ArcGIS, the map was transferred to Google Earth to distinguish the exact location of each station and to determine the upstream and downstream stations.

During the monitoring study of the previously mentioned the TUBITAK Project, 52 sampling stations from the receiving body were designated in total. The receiving body stations were tried to be selected as upstream and downstream stations for all

[1] https://earthexplorer.usgs.gov/

monitored WWTPs as much as possible to be able to evaluate the effects of the WWTPs. Nevertheless, the upstream or downstream stations for some WWTPs do not exist due to dry riverbed or seasonal operating conditions of the WWTPs (no discharge or very low flowrate).

As mentioned before, upstream and downstream of each WWTP were determined after stream network analysis and location of the receiving body stations and WWTPs on the Google Earth, and approximate distances of determined upstream and downstream stations to the related WWTPs were measured. More detailed information about the locations and distances of the sampling points are given in Section 5.1.

More information (station description, coordination, and the number of monitored periods) of the receiving body stations determined as upstream or downstream for at least one WWTP is given in Appendix C.

4.3 Sample Analysis and Data

The water sample collection from the various points in the Yeşilırmak River Basin was performed in the scope of the previously mentioned Project (Project No:115Y013) by a group of researchers from the Department of Environmental Engineering of Munzur University (Tunceli) and Fırat University (Elazığ). During the monitoring period, sample collection was done in line with the planned methodology in order to get more accurate results. The collected samples were put in plastic or amber glass bottles with different volumes and preservation methods depending on the target micropollutant and analysis procedure. Transportation of the collected samples to the laboratory was done with mobile refrigerated vehicles with a temperature of 4^{o}C. Besides of the sample collection, flowrate measurement at each sampling point was also performed by muliner type flowmeters.

The water samples taken from the urban and industrial WWTPs discharges and the surface water stations throughout the 2-year monitoring period were analyzed for 45 priority substances defined in the WFD and 250 national river basin specific pollutants listed in SWQR at the accredited laboratories of TUBITAK MRC Environment and Cleaner Production Institute. While analyzing the samples, several methods and instruments were used according to the target micropollutant. The instruments used were LC-MS/MS, GC-MS/MS, P&T GC-MS, Twister GC-MS/MS, HRGC-HRMS, and ICP-MS.

The same procedure was carried out after each monitoring period and the analysis results of each period were received from the TÜBİTAK MRC laboratories with LOD values of each micropollutant. In total, analysis results of 42 wastewater discharge and receiving body sampling stations for 8 monitoring periods were evaluated for 295 micropollutants in this study. Among this tremendous data, the micropollutants that could not be detected (i.e., that could not exceed the LOD value) at any of the wastewater discharge sampling stations during any monitoring periods were eliminated since they are out of concern. 137 micropollutants out of 295 were detected in the effluents of IWWTP at least one monitoring period while the number of detected micropollutants in UWWTP at least one monitoring period was 99 out of 295. The detected micropollutants varied by season and type of the WWTP. Some of the micropollutants were detected only once whereas some of them were detected in all WWTPs throughout all monitoring periods. The frequency of occurrence of the micropollutants in WWTPs was calculated according to Eqn 1.

$$\text{frequency of occurrence (\%)} = \frac{\text{\# of x micropollutant was detected}}{\text{total \# of samples were analyzed}} \times 100 \qquad \text{Eqn 1}$$

The detected micropollutants in UWWTPs and IWWTPs are given in Appendix A with their occurrence frequencies.

4.4 Selection of Significant Micropollutants

It has been known that WWTP effluents carry various micropollutants with different concentrations to the receiving bodies and affect the conditions of the surface waters.

However, the concentration of the discharge micropollutant and flowrates of the effluent water and receiving body are the parameters that decide the significance of the effect. Hence, in this thesis study, concentrations of 295 micropollutants were evaluated with the flowrates of the WWTPs and their relative receiving bodies.

The analysis results received from the laboratories were assessed by calculating the average of the available measurements. The values that could not be recorded due to lower concentrations than LOD values were taken as halved LOD values in the calculation of averages. The method of taking half of LOD values for the undetected micropollutant concentrations was used because it is recommended in Article 5, which is about the calculation of mean values, of the European Commission Directive dated 31 July 2009 (2009/90/EC) [58]. After calculation of the average concentration values of all micropollutants detected at any sampling station during any measurement period, the average values were compared with their AA-EQS values given in the WFD [24] and SWQR [8] for priority substances and national river basin specific pollutants, respectively. However, there were exceptions for three metals, which are Al, Cu, and Fe due to their high natural background concentrations.

The natural background concentration (NBC) is the amount of the naturally occurring elements in the environment due to natural processes and conditions, which exclude the anthropogenic activities [59]. Geological properties of a river basin cause the high NBC of an element by transferring the element to water bodies from the soil, rocks, etc. Sometimes, the NBC of an element may exceed its EQS value and in this case, a new basin-specific environmental quality objective (EQO) must be determined as defined in SWQR. The calculation method defined in the SWQR is shown in Eqn 2.

$$\text{If NBC} < \text{EQS} \rightarrow \text{Basin specific EQO} = \text{EQS}$$

$$\text{If NBC} \geq \text{EQS} \rightarrow \text{Basin specific EQO} = \text{EQS} + \text{NBC} \qquad \text{Eqn 2[8]}$$

In this regard, the determination of the NBC of metals for the Yeşilırmak River Basin study was conducted in the scope of the previously mentioned TÜBİTAK Project (Project No:115Y013). The result of the study showed that basin-specific EQO for Al, Cu, and Fe must be determined [60]. The NBCs and the determined basin-specific EQO values of Al, Cu, and Fe are given in Table 4.

Table 4. Metals whose NBCs were determined and river basin EQO values [60]

Metals	**NBC (μg/L)**	**Existing AA-EQS (μg/L)**	**Calculated EQO (μg/L)**
Al	45.6	2.2	47.8
Cu	11.6	1.6	13.2
Fe	62.6	36	98.6

As a result, all calculations and analysis were done by taking determined EQOs as discharge standards for Al, Cu, and Fe, which are 47.8, 13.2, and 98.6 µg/L, respectively.

The other acceptances for EQS values while evaluating the analysis results were for Cd and the micropollutants that do not have AA-EQS values. In the WFD, five different AA-EQS values are defined for Cd and its compounds according to the water quality classes, which are given in Table 5. Therefore, the AA-EQS values that were compared with the average concentrations were selected according to the water quality class of receiving bodies where surface water stations were located or WWTPs discharged. Like the NBC study, water quality classes of each surface water where stations located were determined within the scope of the TUBITAK Project with No of 115Y013 and these results were used in this thesis study. On the other hand, for the micropollutants that do not have AA-EQS values, maximum allowable concentration values (MAC-EQS) were used. The micropollutants whose AA-EQS values are not available are hexachlorobenzene, hexachlorobutadiene, Hg and its compounds, benzo(b)fluoranthene, benzo(k)fluoranthene, and benzo(g,h,i)-perylene. Besides, for indeno(1,2,3-cd)-pyrene, and dioxins and dioxin-like compounds, only occurrence analysis was performed because they do not have EQS values.

Table 5. AA-EQS values defined in the WFD for Cd [61]

Name of the substance	AA-EQS (μg/L)
Cadmium and its compounds	≤0.08 for Class 1 0.08 for Class 2 0.09 for Class 3 0.15 for Class 4 0.25 for Class 5

After comparison, the average concentrations of the detected micropollutants with AA-EQS values, EQS exceeding percentages of each micropollutant in each WWTP were calculated according to Eqn 3.

$$\%\ \text{EQS Exceedance} = \frac{C_{average} - \text{EQS}}{\text{EQS}} \times 100 \qquad \text{Eqn 3}$$

where $C_{average}$ = Pollutant average concentration of monitored samples in the effluent (μg/L)

The main methodology followed in the present thesis study to determine the significant pollutants discharged from the UWWTP and IWWTP was the tiered approach, which is suggested by the Technical Background Document on Identification of Mixing Zones prepared by the EC. The reason for the proposed tiered approach, which comprises five tiers, is explained as to simplify the calculations and focus on the possible significant discharges to the water bodies because numerous specific data and complex calculations are needed for the extent of a mixing zone [62]. A summary of the defined tiers is given in Figure 9.

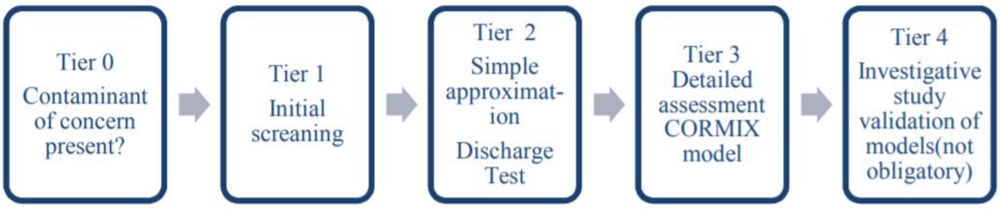

Figure 9. The summary diagram of the Tiered Approach [63]

At tier 0, it is first checked if the concerned micropollutant exists in the effluent water or not. If so, the concentration of that micropollutant is checked to determine if it exceeds the AA-EQS value. The discharges where any micropollutant does not exceed the AA-EQS values are canceled out since they will not affect the water bodies significantly. On the other hand, the discharges where any micropollutant exceeds the relevant AA-EQS are checked at tier 1 to detect the significant ones. The criterion to determine the significant discharges is the proposed allowable increase in concentration after complete mixing, expressed as a percentage of AA-EQS. To check if the proposed allowable increase is met or not, Process Contribution (PC) must be calculated, whose equation is given in Eqn 4. After calculation of PC, relative increase, which is the AA-EQS percentage of the PC (Eqn 5), is calculated and compared with the proposed allowable increase. If the relative increase is greater than the proposed allowable increase, which is suggested in the abovementioned document, this discharge is considered to have a significant impact on the water body. The allowable increase for a small water body is proposed as 2% in the document [62]. According to the median net flow (percentile 50) of the surface waters in the Yeşilırmak River Basin, a 2% increase was used as the proposed allowable increase in the present study.

$$PC = \frac{(C_{effluent} \times Q_{effluent})}{(Q_{effluent} + Q_{upstream})} \qquad \text{Eqn 4}$$

where, $C_{effluent}$ = Concentration of pollutant in the effluent

$Q_{effluent}$ = Flowrate of the effluent

$Q_{upstream}$ = Upstream flowrate of the discharge

$$\text{Relative Increase (\%)} = \frac{PC}{AA_{EQS}} \times 100 \qquad \text{Eqn 5}$$

The complexity of the tiered approach starts with tier 2. At tier 2, for the significant discharges, size of mixing zone and pollution concentration at the checkpoint to see whether the discharge is acceptable. The pollutants that exceed the AA-EQS values at the checkpoint are targeted and used in a complex 3D model, which needs enormous input data for reliable assessment results. Finally, at tier 4, detailed investigations and validations are carried out for possible contributions to Tiers 0-3 [62] [64].

In this thesis study, the tiered approach was used to determine the significant discharges by limiting the approach to Tiers 0 and 1, and their impacts on the relevant receiving bodies by comparing upstream and downstream water qualities in terms of pollution loads. Since the high differences in the flowrates, pollution loads were compared to eliminate the dilution effect and obtain more accurate results. The average pollution loads of the receiving bodies and effluent discharges of the WWTPs were calculated based on Eqn 6.

$$\text{Avg. Pollution Load (g / day)} = \mathrm{Q}_{\substack{effluent \\ or\ stream}} \times \mathrm{C}_{average} \times \left(\frac{24}{1000}\right) \qquad \text{Eqn 6}$$

where, $Q_{effluent}$ = Average flowrate of the effluent (m^3/h)

Q_{stream} = Average flowrate of the stream (m^3/h)

$C_{average}$ = Average concentration of the pollutant (µg/L)

(24/1000) = for unit conversion

Additionally, for three UWWTPs and two IWWTPs (in total 5 WWTPs), removal efficiencies of micropollutants that exceed the AA-EQS values were examined according to the 2-year sampling results. The removal efficiency of a WWTP was calculated according to Eqn 7.

$$\text{Removal Efficiency (\%)} = \frac{(\mathrm{C}_{influent} - \mathrm{C}_{effluent})}{\mathrm{C}_{influent}} \times 100 \qquad \text{Eqn 7}$$

where, $C_{influent}$ = Pollutant concentration in the influent (µg/L)

$C_{effluent}$ = Pollutant concentration in the effluent (µg/L)

A summary diagram of the used methodology in the present thesis study is illustrated in Figure 10.

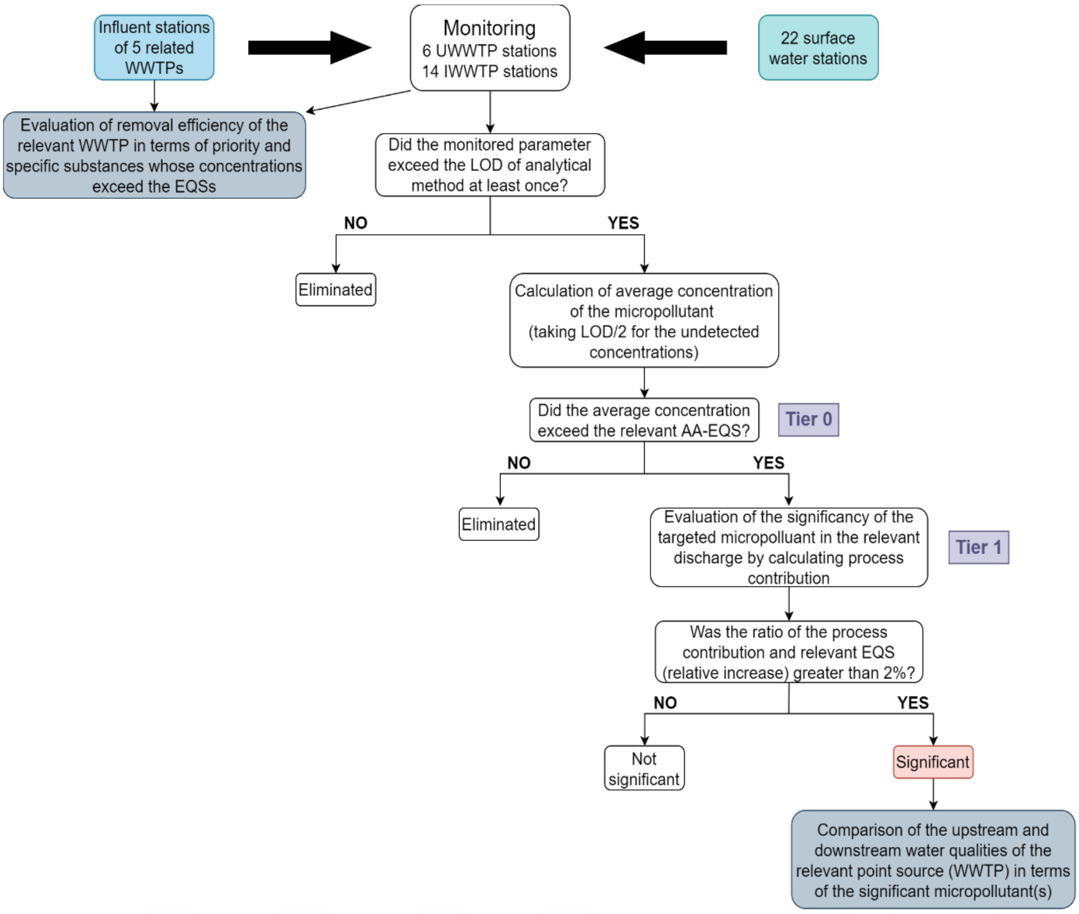

Figure 10. Summary diagram of the used methodology in the present thesis study

The flow and characterization of a receiving body or a point source are not consistent and differ according to the seasons. Therefore, while evaluating the impacts of the point sources on the receiving body, the average concentrations were taken into consideration for more accurate results. The long-term monitoring (in various seasons) also contributed to the accuracy of the result positively. Sampling analysis results of the receiving body stations, UWWTPs, and IWWTPs for all monitoring periods with the LOD and AA-EQS values of the relative micropollutants are given in Appendices A, F, and G, respectively.

CHAPTER 5

RESULTS AND DISCUSSION

5.1 Stream Network Analysis

Stream network analysis was performed according to the methodology given in Chapter 4.1. In order to define the stream network and flow direction, the Strahler method was performed in ArcGIS. Based on this study, upstream and downstream stations of the monitored WWTPs were determined. The stream network and stream orders of the Yeşilırmak River can be seen in Figure 11.

After the preparation of the stream network in ArcGIS, the map was transferred to Google Earth to distinguish the exact location of each station and to determine the upstream and downstream stations. Information about these WWTPs is given in Section 3.2. Yet, in Table 6, matching of surface water stations (as upstream and downstream) with WWTP stations are listed. In this table, "influent code" refers to code names of the influent stations, "upstream station code" and "downstream station code" refers to code names of the receiving body stations which were located in the upstream or downstream of the studied WWTPs.

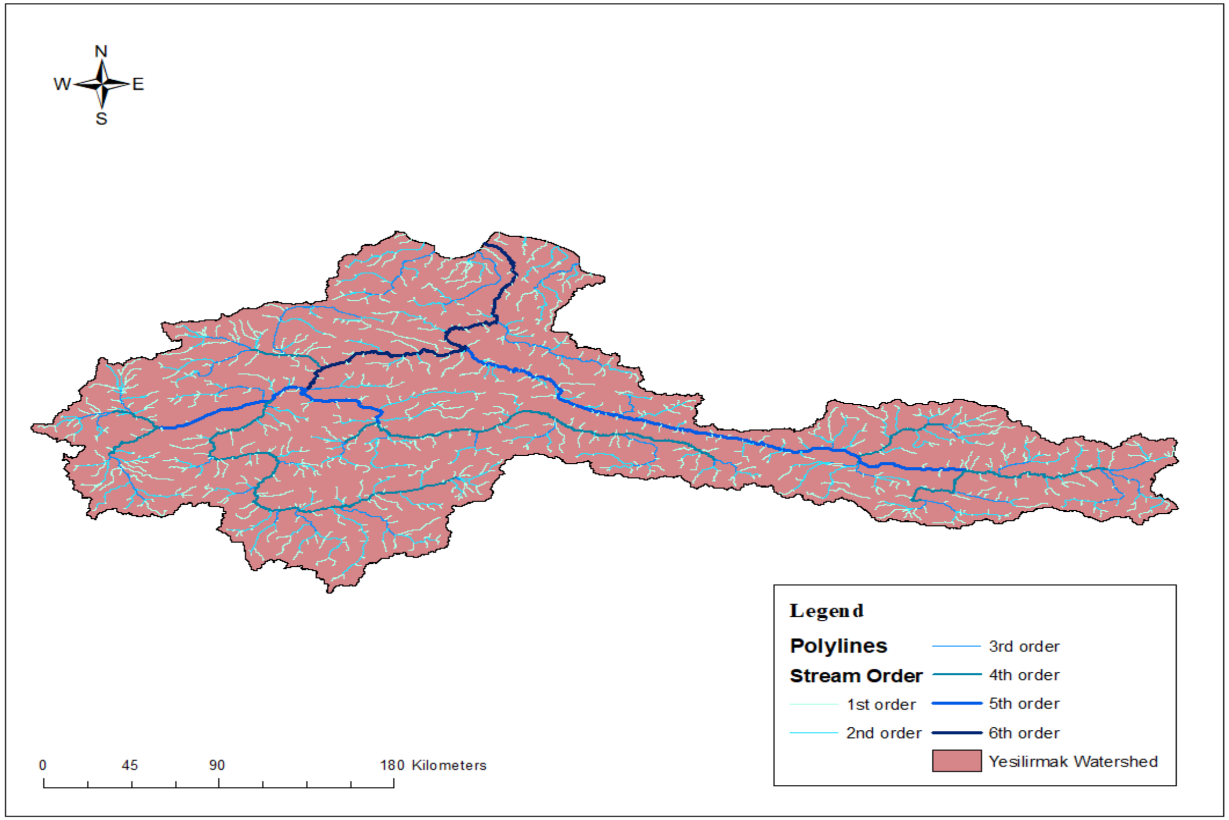

Figure 11. The Yeşilırmak River stream network and stream order

Table 6. Examined WWTPs and related upstream-downstream stations codes

WWTP Code	Influent Code	Upstream Station Code	Downstream Station Code
UWWTP			
YESIL 45_UW (Tokat UWWTP)	YESIL 104_INF	YESIL 11	YESIL 95
YESIL 47_UW (Erbaa UWWTP)	-	YESIL 37	YESIL 36
YESIL 48_UW (Çorum UWWTP)	YESIL 105_INF	YESIL 124	YESIL 25
YESIL 75_UW (Mecitözü UWWTP)	-	-	-
YESIL 107_UW (Amasya UWWTP)	YESIL 106_INF	YESIL 19	YESIL 33
YESIL 108_UW (Havza UWWTP)	-	YESIL 109	YESIL 123
IWWTP			
YESIL 58_IW (Merzifon OIZ IWWTP)	YESIL 103_INF	YESIL 97	YESIL 31
YESIL 59_IW (Samsun OIZ IWWTP)	-	-	-
YESIL 60_IW (Dimes Food IWWTP)	-	YESIL 95	YESIL 120
YESIL 61_IW (Turhal Sugar IWWTP)	-	YESIL 126	YESIL 18
YESIL 62_IW (Özdemir Antimony IWWTP)	-	YESIL 18	YESIL 99
YESIL 65_IW (Meray Oil IWWTP)	YESIL 102_INF	YESIL 96*	YESIL 97
YESIL 69_IW (Olmuksan Paper IWWTP)	-	YESIL 124	YESIL 25
YESIL 70_IW (Özmaya IWWTP)	-	YESIL 19	YESIL 33
YESIL 71_IW (Eti Copper IWWTP)	-	-	-
YESIL 73_IW (Yemsel Poultry-Livestock IWWTP)	-	-	-
YESIL 76_IW (Yuva Viol IWWTP)	-	-	-
YESIL 77_IW (Et-Bir Slaughterhouse IWWTP)	-	YESIL 123	YESIL 32
YESIL 78_IW (Kozlu Food IWWTP)	-	YESIL 122	YESIL 125
YESIL 79_IW (Bakraç Dairy IWWTP)	-	YESIL 125	YESIL 20

* No data available due to dry riverbed

The number of the receiving body sampling stations determined as upstream or downstream of a WWTPs is 22, which are shown in Table 6. Besides, additional water samples were taken from the influent waters of some WWTPs to analyze the removal efficiencies. Influent wastewater of three UWWTPs and two IWWTPs was analyzed and removal efficiencies of the WWTPs were evaluated (Section 5.3). Locations of the studied WWTPs and receiving body sampling stations, which correspond to upstream and downstream stations, are shown in Figure 12. The total number of the UWWTP, IWWTP, and receiving body stations evaluated in this thesis study is 6, 14, and 22, respectively.

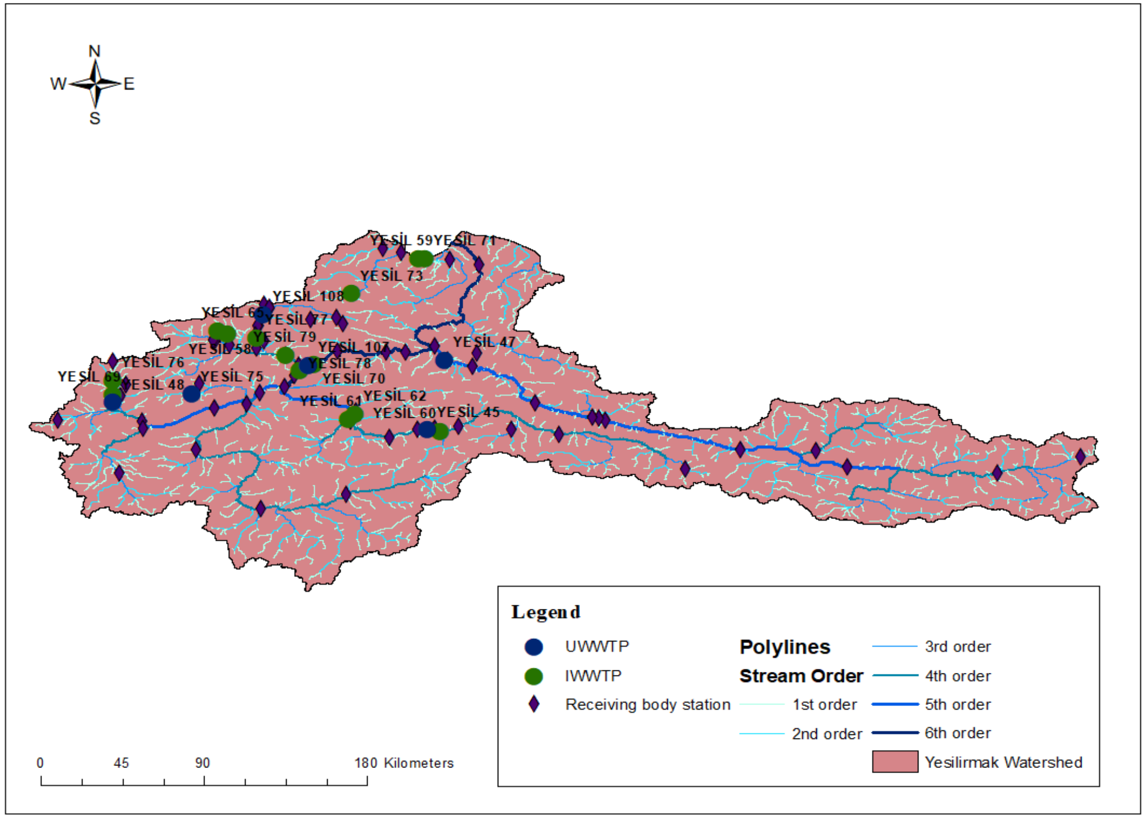

Figure 12. Location of the WWTPs and receiving body sampling stations

5.2 Micropollutant Occurrence in WWTPs and the Effects on the Receiving Body

As mentioned previously, in the Yeşilırmak River Basin, a 2-year seasonal monitoring study was conducted between the years of 2016 and 2018 for the UWWTPs and IWWTPs to examine the micropollutant occurrence in the different WWTPs. For this study, six UWWTPs and fourteen IWWTPs were monitored, and the samples taken from their effluents were analyzed in terms of 45 priority substances and 250 specific pollutants. Also, 22 surface water stations were examined to be able to evaluate the impact of the WWTPs discharges on the receiving bodies. In this section, the results of the sample analysis, the detected micropollutants in the effluents of WWTPs and, significant micropollutants for the receiving environment and their effects were presented and discussed.

5.2.1 Urban WWTP Sources

The biggest six UWWTPs located in the Yeşilırmak Basin were evaluated and 99 micropollutants out of 295 were detected in the effluent samples at least once, i.e., concentrations of 99 micropollutants exceed the LOD values in at least one sampling period. Therefore, further evaluation was done for 99 micropollutants and average concentrations of 22 micropollutants out of 99 over the sampling periods exceed the AA-EQS values. Hence, these micropollutants were selected in the scope of tier 0 of the above-mentioned Tiered Approach. The micropollutant whose average concentrations exceeded the AA-EQS values are listed in Table 7.

Table 7. Micropollutants whose concentrations exceeded the AA-EQS values in the effluent discharges of UWWTPs

Cd	Bromide	Nicosulfuron
Dichlorvos	Co	Petroleum hydrocarbons
Ni	Cr	Si
Nonylphenols (4-Nonylphenol)	Cu	Tridecane

Table 7. (cont'd)

Octylphenols ((4-(1,1′,3,3′-tetramethylbutyl)-phenol))	Ethalfluralin	V
Pb	Fe	Zn
Trichloromethane	Free CN	
Al	Imidacloprid	

Blue: Priority substances
Purple: River basin specific pollutants

To determine the significant discharges, Tier 1 was applied to 22 micropollutants discharged from the UWWTPs. Only, trichloromethane and nicosulfuron were eliminated and the others were determined as significant micropollutants discharged from UWWTPs for the receiving bodies in the Yeşilırmak River Basin. More detailed information based on each UWWTP is given in the following sections.

5.2.1.1 Tokat UWWTP

The Tokat UWWTP that serves Tokat Province begun operating in 2010. It has a treatment capacity of 43,440 m^3/day. The Tokat UWWTP also receives the wastewater coming from the Tokat OIZ and some other small industrial facilities. In total, this plant has a design capacity to serve approximately 233,000 population equivalents (PE). As the Tokat UWWTP serves both urban and industrial areas, it receives wastewater with a complex mixture of pollutants. After the wastewater is treated, the effluent is discharged into the Yeşilırmak River [65].

The Tokat UWWTP includes preliminary, primary, and secondary treatment processes. In secondary treatment, an activated sludge system with an SRT of 14 days is used. The activated sludge process applied is a biological nutrient removal (BNR) system that contains nitrification and denitrification processes. The detailed flow diagram of the plant is shown in Figure 13.

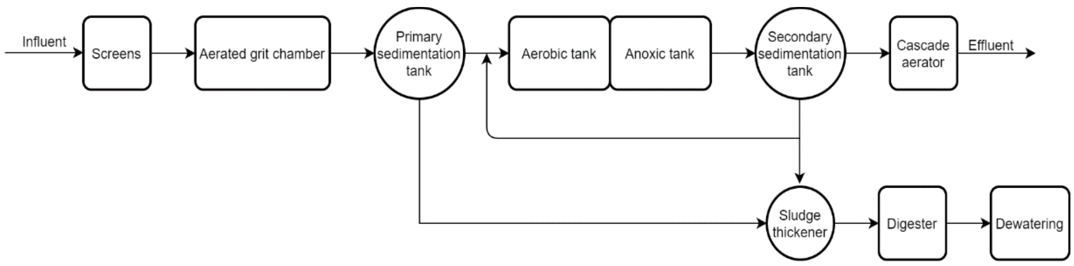

Figure 13. Process flow diagram of Tokat UWWTP

The samples from the discharge of the Tokat UWWTP, which was coded as YESIL 45_UW, were taken for six periods between February 2017 and January 2018. The upstream station of the plant is YESIL 11, which has a distance of 15 km to the plant, while the downstream station of the plant is YESIL 95, which is 2 km away from the plant. Figure 14 illustrates the locations of these stations in the streamline.

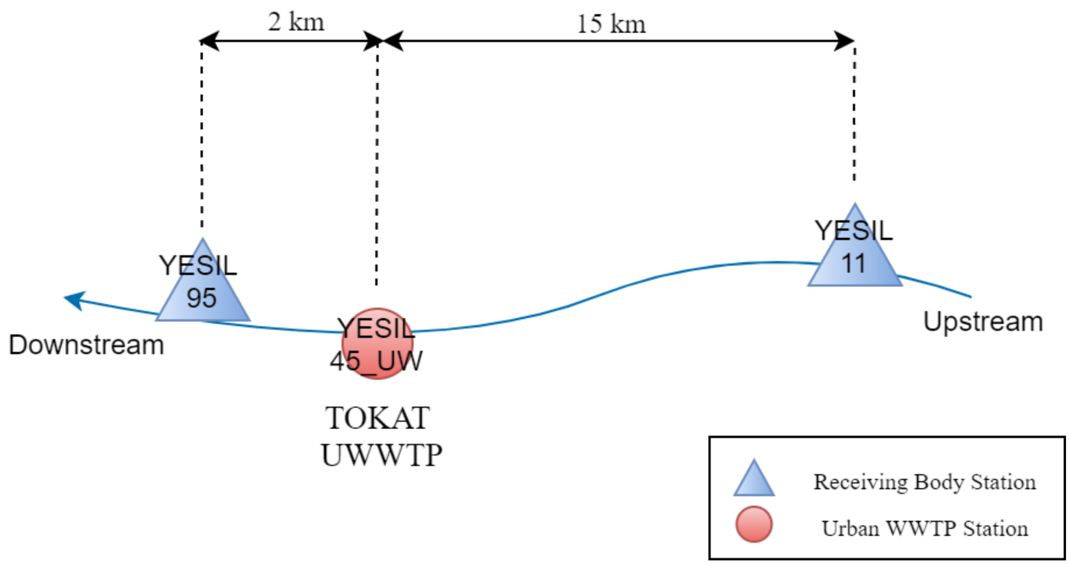

Figure 14. Illustration of the stations that locate in the same streamline, where the Tokat UWWTP is and distances between them

According to the analysis results, 15 priority substances and 53 basin-specific pollutants, in total 68 micropollutants, were detected in the effluent of the Tokat UWWTP. Some of the detected micropollutants were eliminated after applying tier 0 because their average concentrations were below the AA-EQS values. The number of the micropollutants whose average concentrations exceeded their AA-EQSs was

11 and only one of them was a priority substance, which was Pb. The others were seven metals or semi-metals (Al, Co, Cr, Cu, Fe, Si, and Zn), and petroleum hydrocarbons, tridecane, and imidacloprid. After micropollutants that exceeded AA-EQSs were determined, PC and relative increase for these chemicals were calculated (tier 1). The calculated data are given in Table 8 for each micropollutant exceeding its AA-EQS.

Table 8. Concentrations and loads of the micropollutants exceeded AA-EQSs in the effluent of the Tokat UWWTP (YESIL 45_UW) with related PC and relative increase

Micropollutants	**Avg. conc. (μg/L)**	**AA-EQS μg/L)**	**% EQS exceedance**	**Avg. pollution load (g/d)**	**PC**	**% Relative increase**
Pb	2.4	1.2	90.1	34	0.1	**10.2**
Al	149.2	47.8	212.2	22345	8.0	**16.8**
Co	0.3	0.3	12.8	5	0.02	**6.1**
Cr	3.1	1.6	93.6	46	0.2	**10.4**
Cu	27.9	13.2	111.0	417	1.5	**11.3**
Fe	146.1	98.6	48.2	2188	7.9	**8.0**
Petroleum hydrocarbons	246.0	96	156.3	3684	13.2	**13.8**
Si	8428.7	1830	360.6	126208	452.6	**24.7**
Tridecane	0.2	0.05	354	3	0.01	**24.4**
Zn	80.4	5.9	1262.4	1204	4.3	**73.2**
Imidacloprid	0.1	0.14	2.0	2	0.008	**5.5**
Avg. flowrate (m^3/h)			**623.9**			

The average upstream flowrate of the Tokat UWWTP was measured as 10,995.68 m^3/h while the average discharge flowrate of the UWWTP was 623.9 m^3/h. Due to the high average concentrations of the listed micropollutants and relatively high discharge flowrate, the calculated relative increases that discharge from the plant caused were greater than 2%, which means the Tokat UWWTP has a significant impact on the surface water. Most of the significant pollutants were metals and semi-metals. Besides of the metals or semi-metals, the significant pollutants caused by the Tokat UWWTP were petroleum hydrocarbons, tridecane, and imidacloprid. The average concentration of petroleum hydrocarbons exceeded its AA-EQS by 156.3%, which was one of the highest exceedances. Petroleum hydrocarbons, which comprise of a mixture of petrochemicals like benzene, toluene, hexane, naphthalene, xylenes, mineral oils, etc., hydrogen, and carbon, can be caused by pipelines and oil wells leakages, the wrong method of disposal of petroleum wastes, or accidental oil spills [66] [67]. Tridecane is used as a solvent and distillation chaser, mostly in the manufacture of paraffin products, paper industry, jet fuel research, and rubber industry [68]. The Tokat OIZ and other small individual industries can be the source of this micropollutant. Imidacloprid is another synthetic substance that exceeded AA-EQS in YESIL 45_UW. It is a neonicotinoid, which is a class of neuro-active insecticides [69]. Since the agricultural activities cause that micropollutant, detection of it changes by seasons and average concentration exceedance was low (2%).

To be able to see the effect of the significant discharges, upstream and downstream of the plant were compared in terms of pollution loads values. This comparison can be seen in Figure 15 and Table 9.

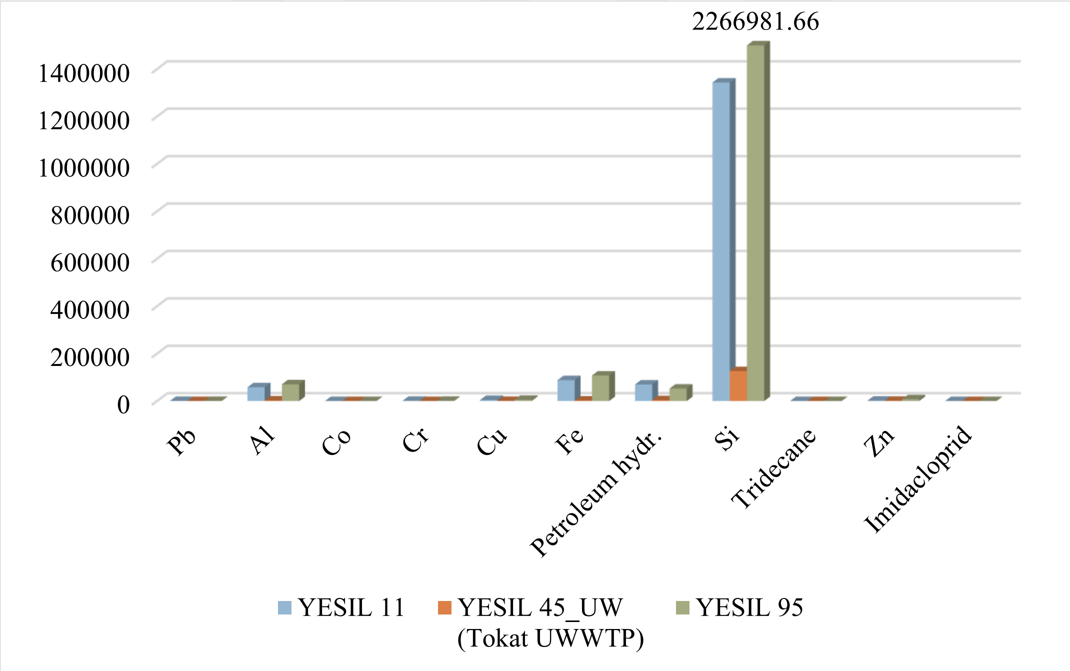

Figure 15. Pollution load comparison between upstream (YESIL 11) and downstream (YESIL 95) stations of the Tokat UWWTP (YESIL 45_UW)

Table 9. Comparison of the significant micropollutants from the discharge of the Tokat UWWTP with its upstream and downstream

Micropollutants	**AA-EQS (µg/L)**	**YESIL 11 (Upstream)**		**YESIL 45_UW (Tokat UWWTP)**		**YESIL 95 (Downstream)**		**% Change in load**
		Concentration (µg/L)	**Load (g/day)**	**Concentration (µg/L)**	**Load (g/day)**	**Concentration (µg/L)**	**Load (g/day)**	
Pb	1.2	1.8	479	2.3	34	1.8	660	27.4
Al	47.8	220.3	58126	149.2	2235	195.1	70389	17.4
Co	0.3	0.4	97	0.3	5	0.3	125	22.5
Cr	1.6	4.0	1066	3.1	46	3.0	1094	2.5
Cu	13.2	16.5	4344	27.9	471	14.3	5168	16.0
Fe	98.6	333.9	88127	146.1	2188	298.2	107572	18.1
Petroleum hydrocarbons	96	263.8	69616	246.0	3684	145.5	52490	**-32.6**
Si	1830	5090.6	1343397	8428.7	126207	6284.0	2266982	40.7
Tridecane	0.05	0.02	6	0.2	3	0.01 (<LOD)	4	**-58.2**
Zn	5.9	6.5	1720	80.4	1204	21.0	7584	77.3
Imidacloprid	0.14	0.01 (<LOD)	3	0.1	2	0.01 (<LOD)	4	26.8
Avg. flowrate (m^3/h)		10995.7		623.9		15031.4		

Both bar graphs in Figure 15 and data in Table 9 show how pollution load changed after the discharge of the Tokat UWWTP effluent into the river. Loads of all metals (Pb, Al, Co, Cr, Cu, Fe, and Zn) in the list increased in the downstream. Especially, the load difference of Zn in upstream and downstream was significantly high (77%), which shows that the Tokat UWWTP cannot be the only source for Zn pollution. This situation is also valid for Si. Si load coming from the plant was minor according to the loads in the receiving body. However, the case for imidacloprid is different. According to the high concentration of imidacloprid in the effluent and tiered approach calculations, the Tokat UWWTP is a point source for imidacloprid pollution. However, another reason of the load increase in the downstream was the higher flowrate of the downstream because imidacloprid concentration in both upstream and downstream did not exceed its LOD at any monitoring period.

The Tokat UWWTP is also estimated as a point source for petroleum hydrocarbons and tridecane. However, loads of these micropollutants were in the downstream lower than the ones in the upstream. The explanation of this situation can be the fate of the micropollutants in the environment e.g., evaporation, dilution, oxidation, biodegradation, biofouling, adsorption, etc.) [64].

5.2.1.2 Erbaa UWWTP

Erbaa is a county of the Tokat Province. The Erbaa UWWTP was designed to treat the domestic wastewater of the Erbaa Municipality and industrial wastewater of the Erbaa OIZ. It has a treatment capacity of 35,808 m^3/day, which serves approximately 90,000 PE [49]. Since the Erbaa UWWTP serves both urban and industrial areas, it receives wastewater with a complex mixture of pollutants. After the wastewater is treated, the effluent is discharged to the Kelkit Creek.

Extended aeration activated sludge system is used in the plant as biological treatment. The activated sludge system is of the BNR type and is expected to remove both N and P. Before the biological treatment, physical treatment is provided by fine and coarse screens followed by a grit chamber. The average wastewater flow to the plant is approximately 10,000 m^3/day and the SRT of the biological unit is 21 days. The detailed flow diagram of the plant is shown in Figure 16.

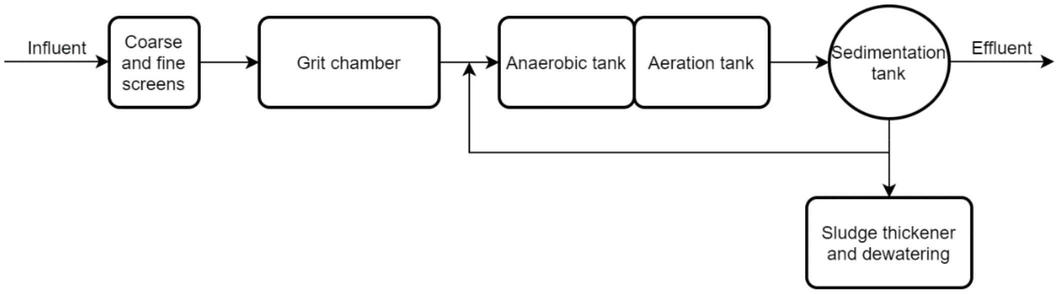

Figure 16. Process flow diagram of the Erbaa UWWTP

The samples from the discharge of the Erbaa UWWTP, which was coded as YESIL 47_UW, were taken for six periods between February 2017 and January 2018. The upstream station of the plant is YESIL 37, which has a distance of 1.7 km to the plant, while the downstream station of the plant is YESIL 26, which is 8 km away from the plant. Figure 17 illustrates the locations of these stations in the streamline.

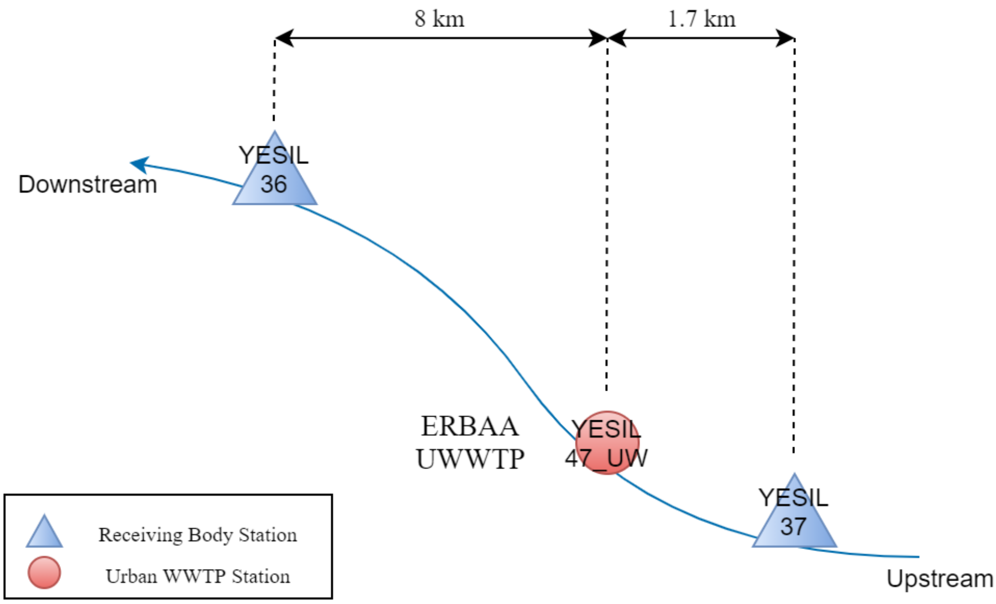

Figure 17. Illustration of the stations that locate in the same streamline, where the Erbaa UWWTP is and distances between them

According to the analysis results, 6 priority substances and 35 basin-specific pollutants, in total 41 micropollutants, were detected in the effluent of the Erbaa UWWTP. After applying tier 0, 29 micropollutants were screened out because their average concentrations were below the AA-EQS values. The number of the micropollutants whose average concentrations exceeded their AA-EQSs was 12 and one of them was Pb, which is the only AA-EQS exceeding priority substance. The others were eight metals or semi-metals (Al, Co, Cr, Cu, Fe, Si, V, and Zn), and petroleum hydrocarbons, imidacloprid, and nicosulfuron. After micropollutants that exceeded AA-EQSs were determined, PC and relative increase for these chemicals were calculated (tier 1). The calculated data are given in Table 10 for each micropollutant exceeding its AA-EQS.

Table 10. Concentrations and loads of the micropollutants exceeded AA-EQSs in the effluent of the Erbaa UWWTP (YESIL 47_UW) with related PC and relative increase

Micropollutants	**Avg. conc. (µg/L)**	**AA-EQS µg/L)**	**% EQS exceedance**	**Avg. pollution load (g/d)**	**PC**	**% Relative increase**
Pb	2.0	1.2	170.7	17	0.01	1.0
Al	131.0	47.8	274.1	1105	0.7	1.5
Co	0.4	0.3	125.6	3	0.002	0.7
Cr	2.1	1.6	133.4	18	0.01	0.7
Cu	15.6	13.2	118.1	131	0.09	0.7
Fe	227.3	98.6	230.5	1917	1.3	1.3
Petroleum hydrocarbons	265.3	96	276.0	2237	1.5	1.6
Si	9309.3	1830.0	508.7	78510	52.2	**2.9**
V	1.9	1.6	120.3	16	0.01	0.7
Zn	50.2	5.9	850.7	423	0.3	**4.8**
Imidacloprid	0.2	0.14	169.6	2	0.001	1.0
Nicosulfuron	0.2	0.05	340.4	1	0.001	1.9
Avg. flowrate (m^3/h)			**351.4**			

The average upstream flowrate of the Erbaa UWWTP was measured as 62,235.5 m^3/h while the average discharge flowrate of the UWWTP was 351.4 m^3/h. The EQS exceedances of all listed micropollutants are higher than 100%. However, only two micropollutants had relative increases higher than 2% because the difference between upstream flowrate and discharged flowrate was high. The discharge of the

Erbaa UWWTP had a significant impact on the receiving body in terms of Si and Zn. As can be seen from Table 10, Zn and Si had the highest EQS exceedance ratios. Although the third highest value of the EQS exceedance belonged to nicosulfuron, which is a herbicide, the calculated relative increase of nicosulfuron was slightly below 2%. Therefore, it can be said that the Erbaa UWWTP is a potential point source of nicosulfuron.

To be able to see the effect of the significant discharges, upstream and downstream of the plant were compared in terms of pollution loads values. This comparison can be seen in Figure 18 and Table 11.

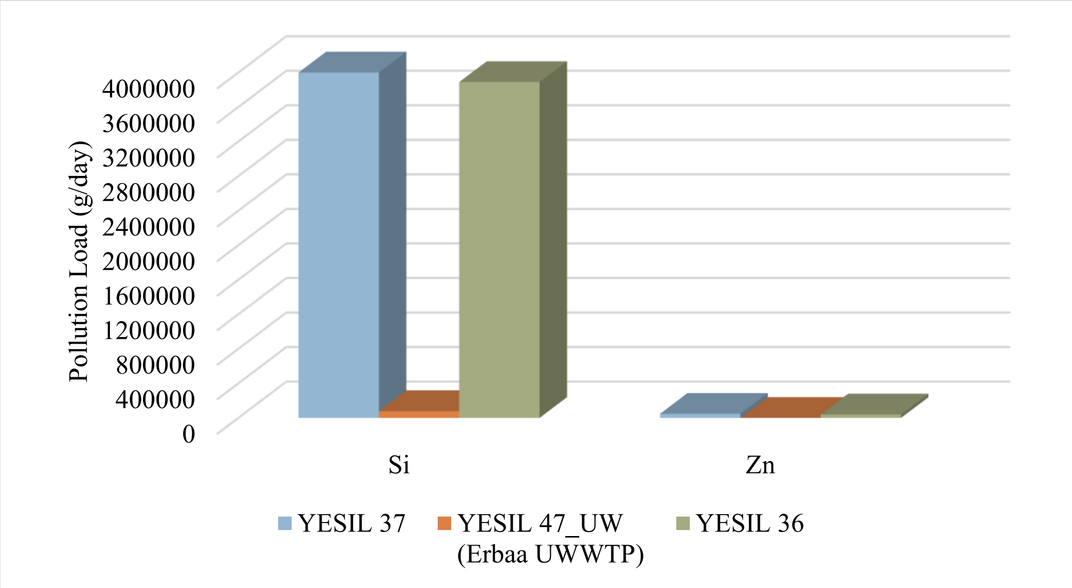

Figure 18. Pollution load comparison between upstream (YESIL 37) and downstream (YESIL 36) stations of the Erbaa UWWTP (YESIL 47_UW)

Table 11. Comparison of the significant micropollutants from the discharge of the Erbaa UWWTP with its upstream and downstream

Micropollutants	**AA-EQS (µg/L)**	**YESIL 37 (Upstream)**		**YESIL 47_UW (Erbaa UWWTP)**		**YESIL 36 (Downstream)**		**% Change in load**
		Concentration (µg/L)	**Load (g/day)**	**Concentration (µg/L)**	**Load (g/day)**	**Concentration (µg/L)**	**Load (g/day)**	
Si	1830	5006.1	7477435	9309.3	78510	5180.5	3889602	**-92.2**
Zn	5.9	32.0	47774	50.2	423	53.5	40145	**-19.0**
Avg. flowrate (m^3/h)		62235.5		351.4		31284		

Based on the tiered approach calculations, it was expected to see higher Si and Zn loads in downstream. However, loads of Si and Zn were observed higher in the upstream. The reason for this situation was that the downstream flowrate used in the calculations was half of the upstream flowrate because flowrates of the downstream could not be measured at most of the monitoring periods due to very high flowrates in the stream. Hence, it can be still assumed that the discharge of the Erbaa UWWTP has a significant impact on the receiving body mostly in terms of Si and Zn.

5.2.1.3 Çorum UWWTP

The Çorum UWWTP that serves Çorum Province begun operating in 2001. It has an average treatment capacity of 65,000 m^3/day. Çorum UWWTP also receives the wastewater coming from Çorum OIZ and some other small industrial facilities. In total, the PE of the plant is approximately 267,500 people according to the total organic load. Since the Çorum UWWTP serves both urban and industrial areas, it receives wastewater with a complex mixture of pollutants. The treated wastewater is discharged to Derinçay Creek [70].

The Çorum UWWTP has physical and biological treatment units. The biological treatment unit is a conventional activated sludge system. The detailed flow diagram of the plant is shown in Figure 19.

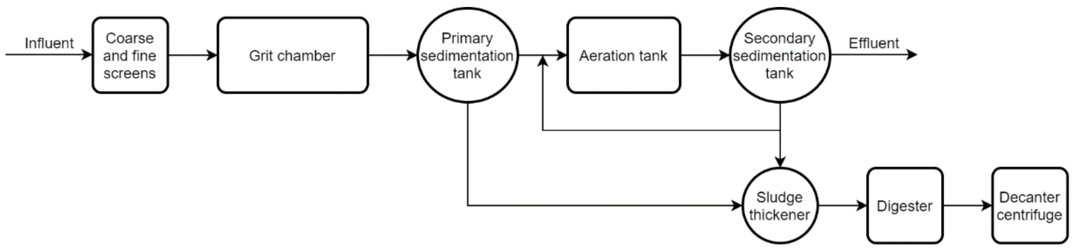

Figure 19. Process flow diagram of the Çorum UWWTP

The samples from the discharge of the Çorum UWWTP, which was coded as YESIL 48_UW, were taken for six periods between February 2017 and January 2018. The upstream station of the plant is YESIL 124, which has a distance of 7.5 km to the plant, while the downstream station of the plant is YESIL 25, which is 20 km away from the plant. Figure 20 illustrates the locations of these stations in the streamline. Additionally, there is a big paper and paper products factory, which is Olmuksan International Paper Inc, between the Çorum UWWTP and its upstream (YESIL 124). The WWTP of Olmuksan International Paper was also analyzed in this thesis study and detailed information is given in Section 5.2.2.7.

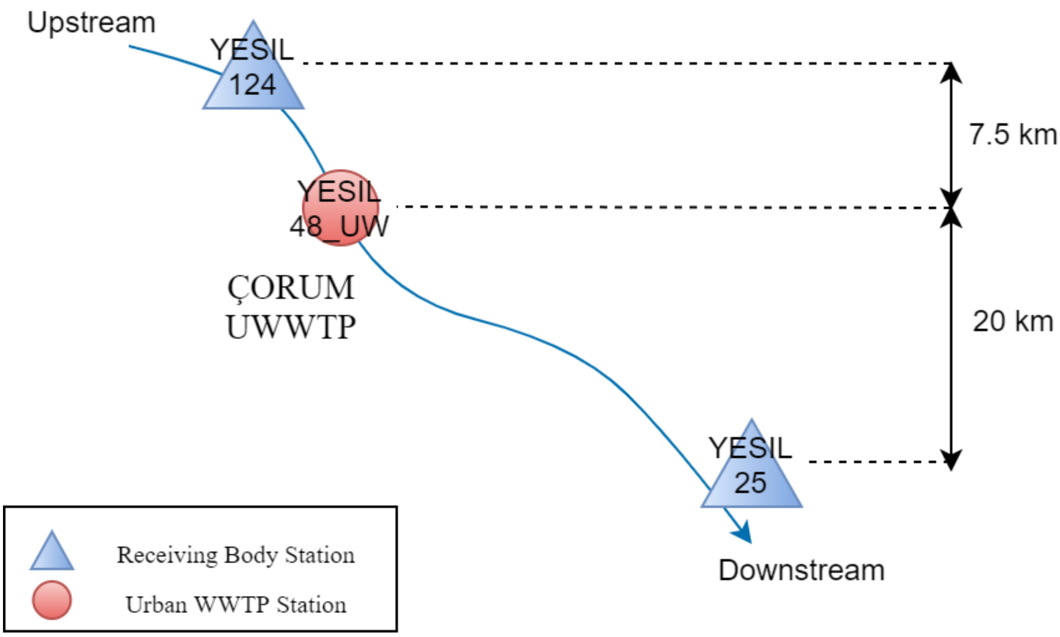

Figure 20. Illustration of the stations that locate in the same streamline, where the Çorum UWWTP is and distances between them

According to the analysis results, 17 priority substances and 58 basin-specific pollutants, in total 75 micropollutants, were detected in the effluent of the Çorum UWWTP. Some of the detected micropollutants were eliminated after applying tier 0 because their average concentrations were below the AA-EQS values. The number of the micropollutants whose average concentrations exceeded their AA-EQSs was 17 and six of them were priority substances, which were Cd, dichlorvos, Ni, nonylphenols, octylphenols, and Pb. The other included mostly metals or semi-metal and they were Al, bromide, Co, Cr, Cu, Fe, free CN, petroleum hydrocarbons, Si, Zn, and ethalflurin. After micropollutants that exceeded AA-EQSs were determined, PC and relative increase for these chemicals were calculated (tier 1). The calculated data are given in Table 12 for each micropollutant exceeding its AA-EQS.

Table 12. Concentrations and loads of the micropollutants exceeded AA-EQSs in the effluent of the Çorum UWWTP (YESIL 48_UW) with related PC and relative increase

Micropollutants	**Avg. conc. (µg/L)**	**AA-EQS µg/L)**	**% EQS exceedance**	**Avg. pollution load (g/d)**	**PC**	**% Relative increase**
Cd	1.2	0.15*	685.3	65	0.6	**421.0**
Dichlorvos	0.01	0.0006	1462.5	1	0.01	**837.5**
Ni	5.9	4	47.7	325	3.2	**79.2**
Nonylphenols (4-Nonylphenols)	0.4	0.3	49.4	25	0.2	**80.1**
Octylphenols ((4-(1,1′,3,3′-tetramethylbutyl)-phenol))	0.1	0.1	46.7	8	0.08	**78.6**
Pb	3.8	1.2	217.4	209	2.0	**170.1**
Al	171.4	47.8	258.7	9429	91.9	**192.3**
Bromide	259.6	31	737.3	14276	139.1	**448.8**
Co	3.9	0.3	1196.1	214	2.1	**694.8**
Cr	2.0	1.6	28.3	113	1.1	**68.8**
Cu	24.1	13.2	82.8	1327	12.9	**98.0**
Fe	498.3	98.6	405.3	27405	267.1	**270.9**
Free CN	1.4	1.2	19.9	79	0.8	**64.2**
Petroleum hydrocarbons	133.3	96	38.8	7329	71.4	**74.4**
Si	6213.0	1830	239.5	341715	3330.3	**182.0**
Zn	115.2	5.9	1852.3	6335	61.7	**1046.5**
Ethalfluralin	0.7	0.3	124.0	37	0.4	**120.1**
Avg. flowrate (m^3/h)			**2291.7**			

*MAC-EQS

The average upstream flowrate of the Çorum UWWTP was measured as 1983.6 m^3/h while the average discharge flowrate of the UWWTP was 2291.67 m^3/h. According to the measurements, the effluent flowrate was higher than the upstream flowrate. Hence, any discharge from the plant would affect the downstream significantly. Moreover, the average concentrations of micropollutants in the discharged water were high. Consequently, all micropollutants whose average concentrations exceeded their AA-EQS values caused major relative increases. As can be seen from Table 12, all calculated relative increases were much greater than 2%. Among the evaluated UWWTPs, the Çorum UWWTP had the highest significance in terms of priority substances. Six priority substances, Cd, dichlorvos, Ni, nonylphenols, octylphenols, and Pb, were determined as important ones for the Çorum UWWTP. It is known that Cd, Ni, and Pb are very toxic metals and their occurrence in the environment can cause serious health effects. Other than metals, organic priority substances had also important negative effects and the important ones for the Çorum UWWTP were dichlorvos, nonylphenols, and octylphenols. Dichlorvos is an organophosphate insecticide using in agricultural activities. It leads to serious acute and chronic toxicity in the environment and human health [71]. Therefore, its usage in agricultural activities had been banned in Turkey in 2011 [72]. Despite this fact, dichlorvos was detected and exceeded its AA-EQS value in both WWTPs and surface waters, which demonstrates its persistency or illegal usage in the basin. Nonylphenols and octylphenols are endocrine disrupters that are very persistent anthropogenic organic substances. They are mostly used in industrial activities such as chemical production, pulp and paper, steel manufacturing, etc. [73]. Besides, effluents from the Çorum UWWTP also contained various river basin-specific substances, which were mostly metals. However, similar to the situation of dichlorvos, ethalfluralin, which is a herbicide, was detected and exceed its AA-EQS value due to its persistency despite its usage has been also banned in Turkey [66].

To be able to see the effect of the significant discharges, upstream and downstream of the plant were compared in terms of pollution loads values. This comparison can be seen in Figure 21 and Table 13.

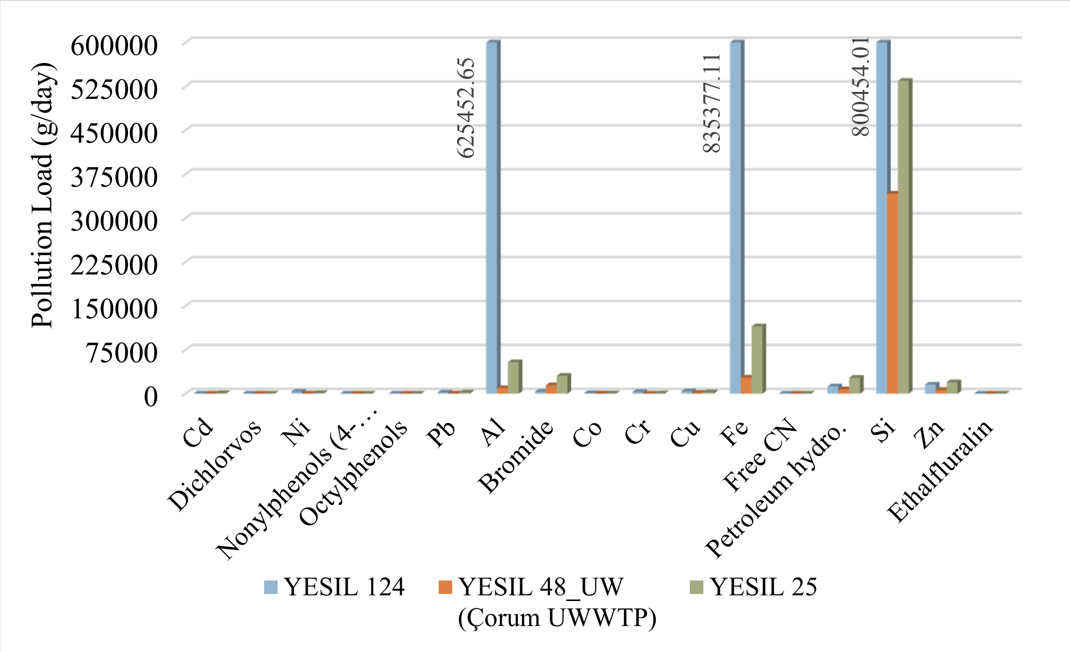

Figure 21. Pollution load comparison between upstream (YESIL 124) and downstream (YESIL 25) stations of the Çorum UWWTP (YESIL 48_UW)

Both bar graphs in Figure 21 and data in Table 13 show how pollution load changed after the discharge of the Çorum UWWTP effluent into the river. Especially, the increases in loads of dichlorvos, nonylphenol, octylphenol, and free CN were spotted easily since they could not be even detected in the upstream. The other load increases in the downstream for Cd, bromide, petroleum hydrocarbons, Zn, and ethalfluralin, the Çorum UWWTP had a significant impact although any other point or non-point source may also be the additional reason. However, for eight micropollutants (Ni, Pb, Al, Co, Cr, Cu, Fe, and Si), downstream concentrations were measured lower despite the high discharged loads. This result might be due to the IWWTP (Olmuksan Int. Paper - YESIL 69_IW) before the Çorum UWWTP and the fate of micropollutants in the environment.

Nevertheless, discharges from the Çorum UWWTP have the most significant impact on the environment according to the Tiered Approach and monitoring results among all of the UWWTP evaluated.

Table 13. Comparison of the significant micropollutants from the discharge of the Çorum UWWTP with its upstream and downstream

Micropollutants	AA-EQS (µg/L)	YESIL 124 (Upstream)		YESIL 48_UW (Çorum UWWTP)		YESIL 25 (Downstream)		% Change in load
		Concentration (µg/L)	Load (g/day)	Concentration (µg/L)	Load (g/day)	Concentration (µg/L)	Load (g/day)	
Cd	0.15*	1.0	47	1.2	65	8.9	755	93.8
Dichlorvos	0.0006	0.00025 (<LOD)	0.01	0.01	0.5	0.04	4	99.7
Ni	4	70.7	3365	5.9	325	10.0	842	**-299.4**
Nonylphenols (4-Nonylphenols)	0.3	0.0005 (<LOD)	0.02	0.4	25	0.004	0.34	93.0
Octylphenols ((4-(1,1′,3,3′-tetramethylbutyl)-phenol))	0.1	0.0025 (<LOD)	0.1	0.1	8	0.004	0.37	68.2
Pb	1.2	41.0	1954	3.8	209	23.0	1944	**-0.5**
Al	47.8	13138.0	625453	171.4	9429	636.2	53705	**-1064.6**
Bromide	31	68.7	3271	259.6	14276	361.6	30521	89.3
Co	0.3	14.2	675	3.9	214	5.7	485	**-39.1**
Cr	1.6	59.5	2832	2.1	113	4.0	338	**-737.4**
Cu	13.2	82.5	3928	24.1	1327	28.0	2366	**-66.1**
Fe	98.6	17547.6	835377	498.3	27405	1362.6	115025	**-626.3**
Free CN	1.2	0.5 (<LOD)	24	1.4	79	0.6	54	56.0
Petroleum hydrocarbons	96	263.0	12520	133.3	7329	320.4	27047	53.7
Si	1830	16814.0	800454	6213.0	341715	6331.4	534470	**-49.8**
Zn	5.9	324.3	15439	115.2	6335	231.8	19571	21.1
Ethalfluralin	0.3	0.0025 (<LOD)	0.1	0.7	37	0.0025 (<LOD)	0.21	43.6
Avg. flowrate (m^3/h)		**1983.6**		**2291.7**		**3517.3**		

*MAC-EQS

5.2.1.4 Mecitözü UWWTP

Mecitözü is a county of the Çorum Province. Mecitözü UWWTP was designed to treat the domestic wastewater of Mecitözü Municipality. There is not any industrial activity in the region so industrial wastewater influent to the plant does not exist. The UWWTP has an average treatment capacity of 700 m^3/day. The treated effluent is discharged to Efendik Creek [70].

Mecitözü UWWTP consists of simple physical and biological treatment units. For the biological treatment system, an oxidation ditch with an SRT of 19 days is used. The detailed flow diagram of the plant is shown in Figure 22.

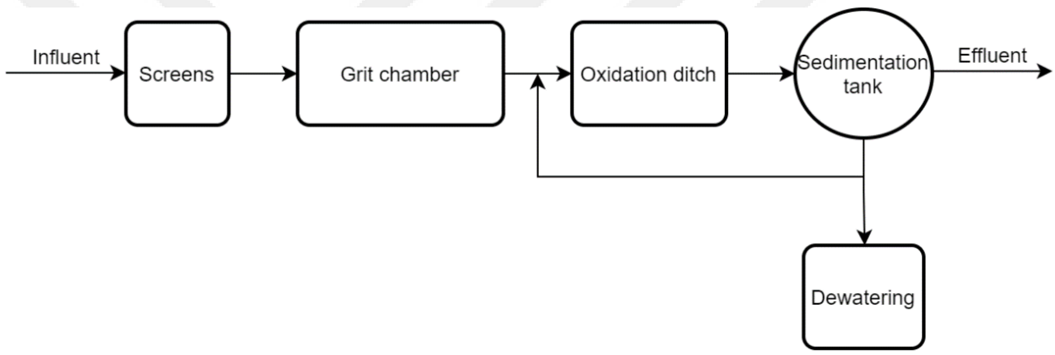

Figure 22. Process flow diagram of Mecitözü UWWTP

The samples from the discharge of Mecitözü UWWTP, which was coded as YESIL 75_UW, were taken for four periods between June 2017 and January 2018. There were no upstream and downstream stations of Mecitözü UWWTP. Hence, only tier 0 was applied to the analysis results of the UWWTP. According to the analysis results, 5 priority substances and 22 basin-specific pollutants, in total 27 micropollutants, were detected in the effluent of Mecitözü UWWTP. After applying tier 0, 17 micropollutants were eliminated because their average concentrations were below the AA-EQS values. The number of the micropollutants whose average concentrations exceeded their AA-EQSs was 10 and two of them were priority substances (Pb and trichloromethane). Except for bromide and Si, the others were metals from the river basin-specific pollutants lists, which were Al, Co, Cu, Fe, V, and Zn. Since there were no upstream flowrate knowledge, PC and the relative increase could not be calculated for the effluent of Mecitözü UWWTP. The calculated average concentrations, EQS exceedances, and discharged average loads are given in Table 14 for each micropollutant exceeding its AA-EQS.

Table 14. Concentrations and loads of the micropollutants exceeded AA-EQSs in the effluent of Mecitözü UWWTP (YESIL 75_UW)

Micropollutants	**Avg. conc. (µg/L)**	**AA-EQS µg/L)**	**% EQS exceedance**	**Avg. pollution load (g/d)**
Pb	2.3	1.2	191.0	0.4
Trichloromethane	4.4	2.5	176.4	0.7
Al	94.7	47.8	198.2	15
Bromide	46.7	31	150.7	7
Co	0.4	0.3	141.7	0.07
Cu	16.2	13.2	122.8	3
Fe	113.5	98.6	115.1	18
Si	6595.0	1830	360.4	1041
V	2.9	1.6	178.3	0.5
Zn	51.1	5.9	866.6	8
Avg. flowrate (m^3/h)			**6.6**	

The average discharge flowrate of the UWWTP was measured as 6.575 m^3/h (approximately 160 m^3/day). Since the effluent flowrate is very low, pollution loads in the effluent were relatively insignificant for the water body although the average concentrations of the micropollutants highly exceeded the relative AA-EQS values. Even though the impact of the plant could not be estimated by comparing pollution loads in the upstream and downstream, it can be said that Mecitözü UWWTP might be a potential point source of Pb, trichloromethane, Al, bromide, Co, Cu, Fe, Si, V, and Zn.

5.2.1.5 Amasya UWWTP

The Amasya UWWTP that serves Amasya Province begun operating in 2015. It has an average treatment capacity of 17,748 m^3/day and 147,900 PE. The treated wastewater in the Amasya UWWTP is discharged to the Yeşilırmak River [74].

Amasya UWWTP has physical and biological treatment units. The biological treatment unit consists of anaerobic and aeration tanks, where nitrogen and phosphorus removals occur with carbon removal. The detailed flow diagram of the plant is shown in Figure 23.

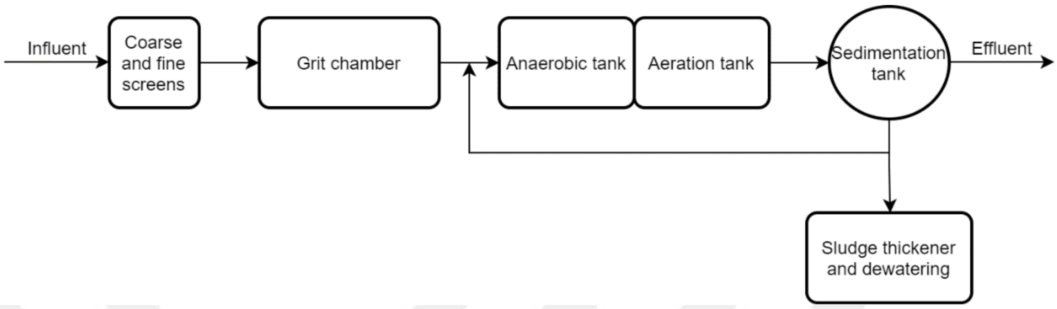

Figure 23. Process flow diagram of Amasya UWWTP

The samples from the discharge of Amasya UWWTP, which was coded as YESIL 107_UW, were taken for three periods between August 2017 and January 2018. The upstream station of the plant is YESIL 19, which has a distance of 12 km to the plant, while the downstream station of the plant is YESIL 33, which is 17 km away from the plant. Figure 24 illustrates the locations of these stations in the streamline. Additionally, there is a big yeast production factory between Amasya UWWTP and its downstream station. That factory is called Özmaya (Lesaffre) (coded as YESIL 70_IW in this study) and it is one of the biggest yeast factories in Turkey. It was also evaluated in Section 5.2.2.8.

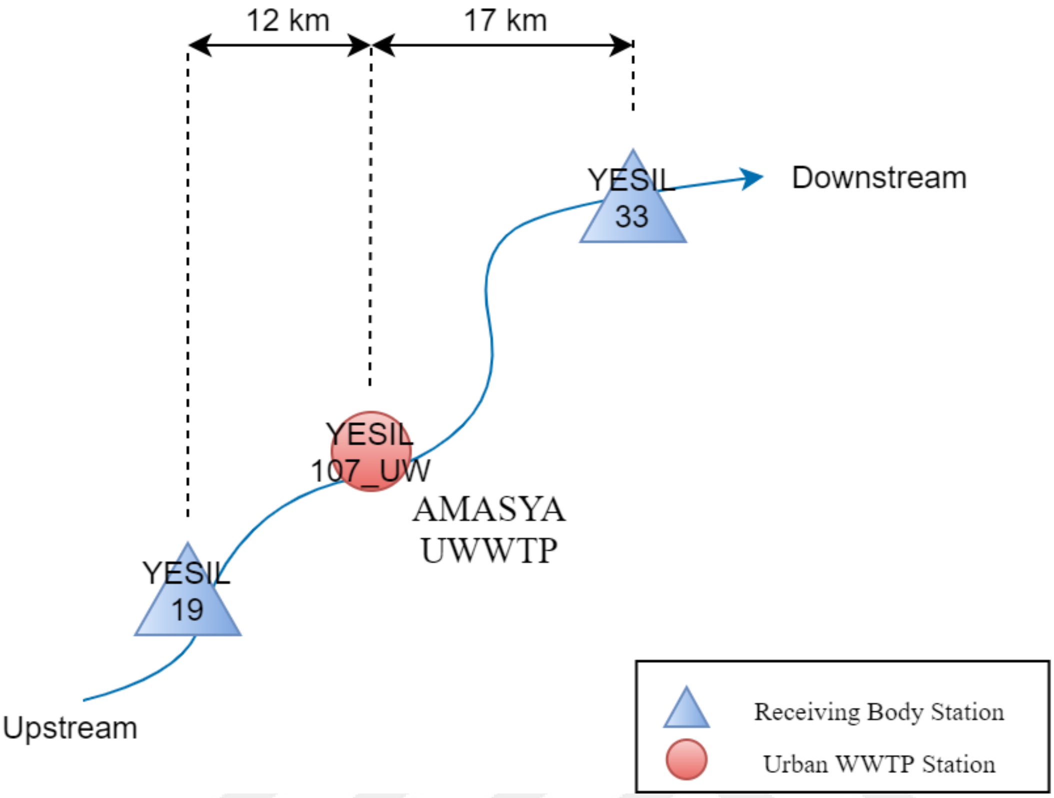

Figure 24. Illustration of the stations that locate in the same streamline, where Amasya UWWTP is and distances between them

According to the analysis results, 4 priority substances and 22 basin-specific pollutants, in total 26 micropollutants, were detected in the effluent of Amasya UWWTP. After applying tier 0, 14 micropollutants were screened out because their average concentrations were below the AA-EQS values. The number of the micropollutants whose average concentrations exceeded their AA-EQSs was 12 and only one of them was a priority substance, which is Pb. The others were Al, bromide, Co, Cr, Cu, Fe, free CN, petroleum hydrocarbons, Si, V, and Zn (mostly metals). After micropollutants that exceeded AA-EQSs were determined, PC and relative increase for these chemicals were calculated (tier 1). The calculated data are given in Table 15 for each micropollutant exceeding its AA-EQS.

Table 15. Concentrations and loads of the micropollutants exceeded AA-EQSs in the effluent of Amasya UWWTP (YESIL 107_UW) with related PC and relative increase

Micropollutants	Avg. conc. (µg/L)	AA-EQS µg/L)	% EQS exceedance	Avg. pollution load (g/d)	PC	% Relative increase
Pb	2.1	1.2	72.8	32	0.04	**3.3**
Al	50.0	47.8	4.5	773	0.9	1.9
Bromide	60.9	31	96.6	942	1.2	**3.7**
Co	0.4	0.3	28.9	6	0.01	**2.4**
Cr	1.9	1.6	15.6	29	0.04	**2.2**
Cu	17.6	13.2	33.6	273	0.3	**2.5**
Fe	349.2	98.6	254.2	5400	6.6	**6.7**
Free CN	1.2	1.2	3.3	19	0.02	1.9
Petroleum hydrocarbons	128.0	96	33.3	1979	2.4	**2.5**
Si	8238.7	1830	350.2	127392	155.5	**8.5**
V	1.9	1.6	17.1	29	0.03	**2.2**
Zn	110.8	5.9	1777.3	1713	2.1	**35.4**
Avg. flowrate (m^3/h)			**644.3**			

The average upstream flowrate of Amasya UWWTP was measured as 33,485.05 m^3/h while the average discharge flowrate of the UWWTP was 644.28 m^3/h. The EQS exceedances of most of the listed micropollutants were relatively low due to low discharged concentrations and flowrate. Among the listed micropollutants, Fe, Si, and Zn had the highest EQS exceedances and relative impacts despite the low effluent flowrate. Additionally, Zn became pointed with the highest relative increase of 35.4%. On the other hand, Al and free CN were not included in the significant micropollutants list of Amasya UWWTP because their relative increases were lower than 2%. The upstream and downstream load comparisons were not done for these micropollutants.

To be able to see the effect of the significant discharges, upstream and downstream of the plant were compared in terms of pollution loads values. This comparison can be seen in Figure 25 and Table 16.

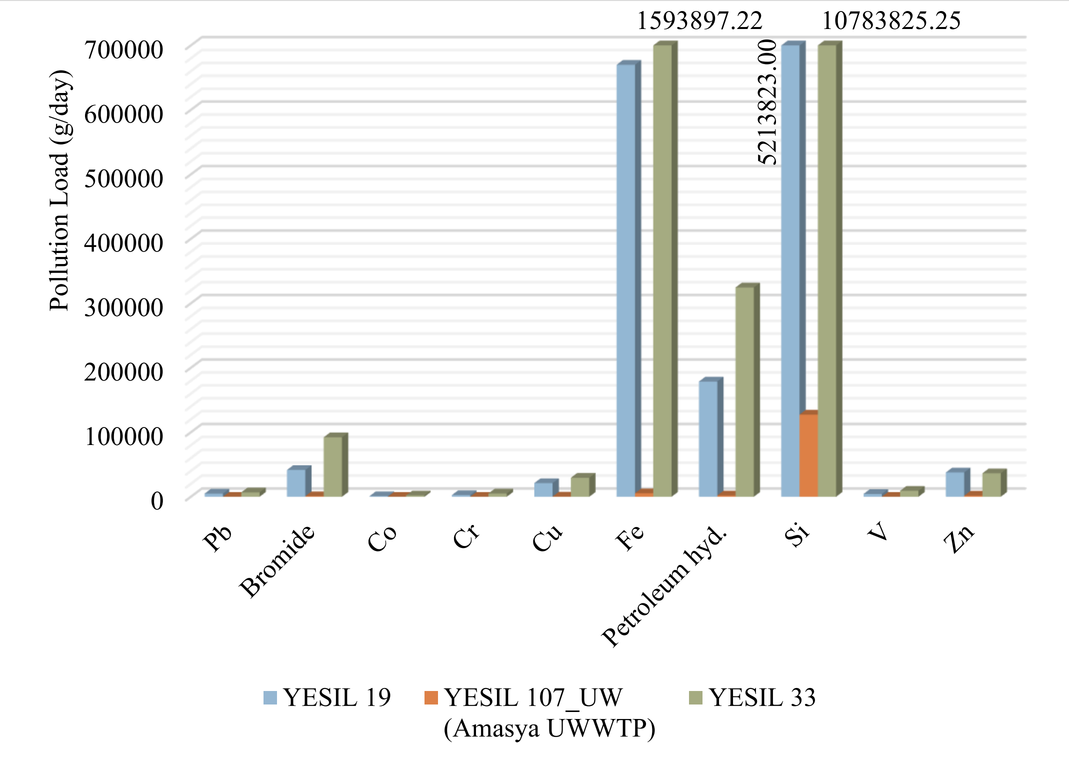

Figure 25. Pollution load comparison between upstream (YESIL 19) and downstream (YESIL 33) stations of the Amasya UWWTP (YESIL 107_UW)

Both bar graphs in Figure 25 and data in Table 16 show how pollution load changed after the discharge of the Amasya UWWTP effluent into the river. Loads of all micropollutants exceeding AA-EQSs and determined as significant discharges elevated in the downstream, except Zn. The increases in the micropollutant loads were also due to Özmaya Factory (YESIL 70_IW), which is between the Amasya UWWTP and its downstream station. In spite of the very high concentration and relative increase of Zn, and effluent of the other industrial WWTP source (YESIL 70_IW), Zn load in the downstream was lower than the load in the upstream since the concentration of Zn in the downstream was relatively low. Dilution may be the reason of this situation because the flowrate highly increased in the downstream.

The Amasya UWWTP has an important point source especially for Si, V, and Zn. However, due to its low discharge flowrate, its impact on the receiving body seems less by comparison with the other UWWTPs.

Table 16. Comparison of the significant micropollutants from the discharge of Amasya UWWTP with its upstream and downstream

Micropollutants	**AA-EQS (µg/L)**	**YESIL 19 (Upstream)**		**YESIL 107_UW (Amasya UWWTP)**		**YESIL 33 (Downstream)**		**% Change in load**
		Concentration (µg/L)	**Load (g/day)**	**Concentration (µg/L)**	**Load (g/day)**	**Concentration (µg/L)**	**Load (g/day)**	
Pb	1.2	6.2	4945	2.0	32	4.4	6754	26.8
Bromide	31	51.8	41629	60.9	942	60.3	92270	54.9
Co	0.3	1.1	884	0.4	6	1.3	2023	56.3
Cr	1.6	3.2	2611	1.9	29	3.3	5119	49.0
Cu	13.2	26.3	21166	17.6	273	19.3	29467	28.2
Fe	98.6	833.6	669935	349.2	5400	1041.9	1593897	58.0
Petroleum hydrocarbons	96	222.4	178730	128.0	1979	212.2	324637	44.9
Si	1830	6488.0	5213823	8238.7	127392	7048.9	10783825	51.7
V	1.6	5.4	4349	1.9	29	6.0	9246	53.0
Zn	5.9	47.0	37756	110.8	1713	23.8	36421	**-3.7**
Avg. flowrate (m^3/h)		33485.1		644.3		63744.4		

5.2.1.6 Havza UWWTP

Havza is a county of Samsun Province. Havza UWWTP was designed to treat the domestic wastewater of Havza Municipality. The current treatment capacity of the plant is 3,555 m^3/day, which corresponds to 33,195 PE. After the wastewater is treated, the effluent is discharged to the Tersakan Creek [75].

The Havza UWWTP has physical and biological treatment units similar to the other UWWTPs. However, it also has a chlorination unit. The Havza UWWTP is the only WWTP that contains a disinfection unit among studied UWWTP in this thesis study. The biological treatment unit is an extended aeration activated sludge system. The detailed flow diagram of the plant is shown in Figure 26.

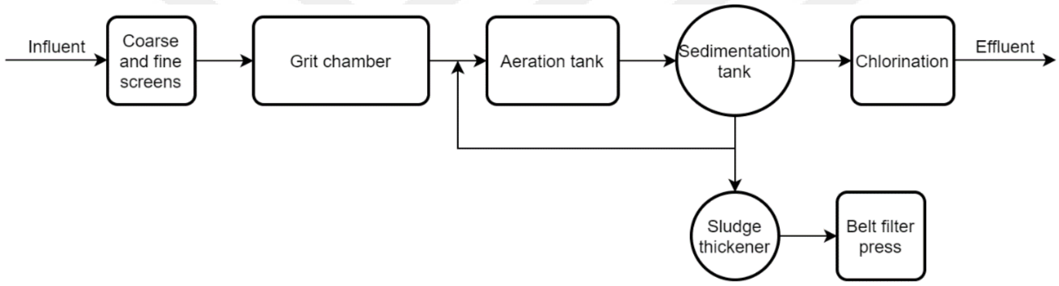

Figure 26. Process flow diagram of Havza UWWTP

The samples from the discharge of Havza UWWTP, which was coded as YESIL 108_UW, were taken for three periods between August 2017 and January 2018. The upstream station of the plant is YESIL 109, which has a distance of 0.4 km to the plant, while the downstream station of the plant is YESIL 123, which is 16 km away from the plant. Figure 27 illustrates the locations of these stations in the streamline.

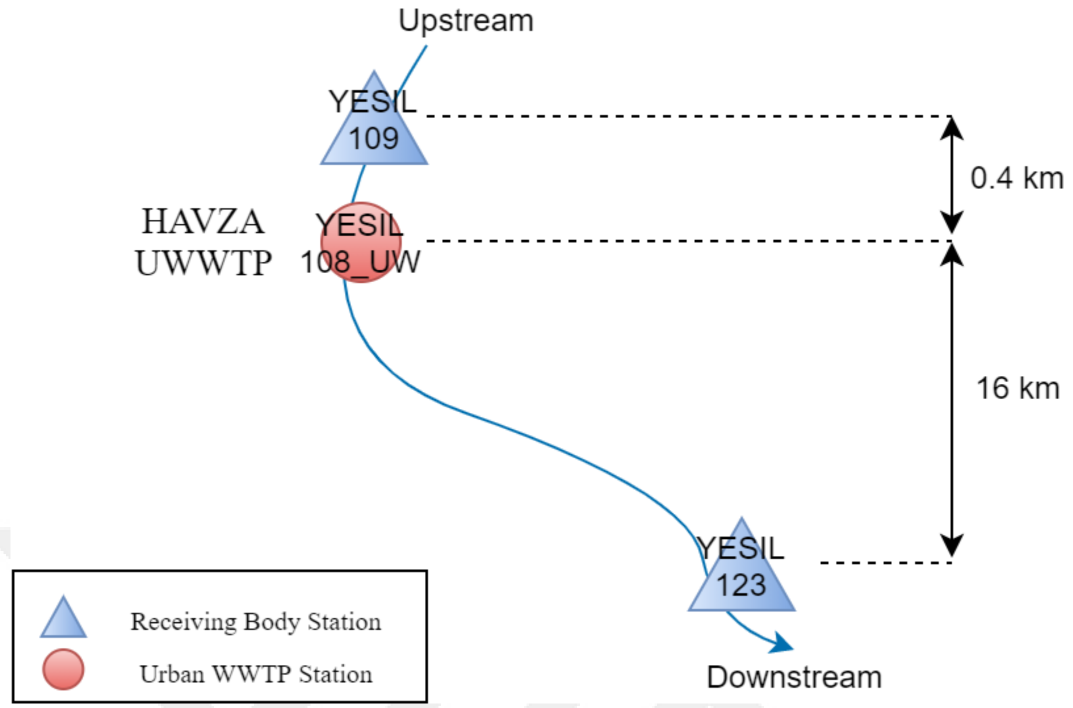

Figure 27. Illustration of the stations that locate in the same streamline, where Havza UWWTP is and distances between them

According to the analysis results, 3 priority substances and 23 basin-specific pollutants, in total 26 micropollutants, were detected in the effluent of Havza UWWTP. After applying tier 0, 20 micropollutants were eliminated because their average concentrations were below the AA-EQS values. The number of the micropollutants whose average concentrations exceeded their AA-EQSs was 6 and none of them was a priority substance. The micropollutants exceeding AA-EQSs were Al, bromide, Cu, Fe, Si, and Zn. After micropollutants that exceeded AA-EQSs were determined, PC and relative increase for these chemicals were calculated (tier 1) and all micropollutants mentioned before passed tier 1, i.e., their relative increases were greater than 2%. The calculated data are given in Table 17 for each micropollutant exceeding its AA-EQS.

Table 17. Concentrations and loads of the micropollutants exceeded AA-EQSs in the effluent of Havza UWWTP (YESIL 108_UW) with related PC and relative increase

Micropollutants	**Avg. conc. (µg/L)**	**AA-EQS µg/L)**	**% EQS exceedance**	**Avg. pollution load (g/d)**	**PC**	**% Relative increase**
Al	82.7	47.8	172.9	192	1.7	**3.6**
Bromide	32.9	31	106.2	77	0.7	**2.2**
Cu	16.2	13.2	122.5	38	0.3	**2.6**
Fe	130.2	98.6	132.0	303	2.7	**2.8**
Si	7288.0	1830	398.3	16966	152.2	**8.3**
Zn	18.2	5.9	307.9	42	0.4	**6.4**
Avg. flowrate (m^3/h)			**97**			

The average upstream flowrate of the Havza UWWTP was measured as 4,548.6 m^3/h while the average discharge flowrate of the UWWTP was 97 m^3/h. Havza UWWTP had the second lowest effluent flowrate. Therefore, the impact of the plant on the water body became less significant although EQS exceedances of the listed micropollutants were greater than 100%. The high difference between upstream and effluent flowrates made the impact of the effluent smaller. The most significant pollutants caused by Havza UWWTP were Si and Zn.

To be able to see the effect of the significant discharges, upstream and downstream of the plant were compared in terms of pollution loads values. This comparison can be seen in Figure 28 and Table 18.

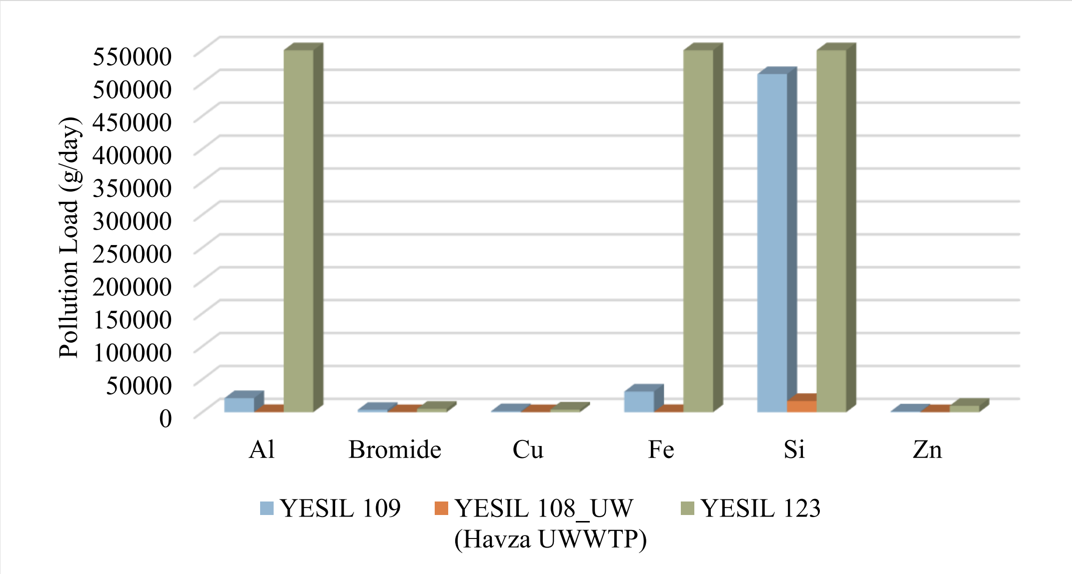

Figure 28. Pollution load comparison between upstream (YESIL 109) and downstream (YESIL 123) stations of Havza UWWTP (YESIL 108_UW)

Both bar graphs in Figure 28 and data in Table 18 show how pollution load changed after the discharge of Havza UWWTP effluent into the river. Loads of all micropollutants exceeding AA-EQSs and determined as significant discharges elevated in the downstream although the average flowrate of the downstream was lower than the average flowrate of the upstream. This shows that the Havza UWWTP cannot be the only point or non-point source in that region because pollution load differences were greater than the loads contributed by the Havza UWWTP.

On the other hand, although the impact of Havza UWWTP on the receiving body is less than the other UWWTPs because of the low effluent flowrate, it still has a significant impact in terms of Al, Si, and Zn, especially.

Table 18. Comparison of the significant micropollutants from the discharge of Havza UWWTP with its upstream and downstream

Micropollutants	AA-EQS (µg/L)	YESIL 109 (Upstream)		YESIL 108_UW (Havza UWWTP)		YESIL 123 (Downstream)		% Change in load
		Concentration (µg/L)	Load (g/day)	Concentration (µg/L)	Load (g/day)	Concentration (µg/L)	Load (g/day)	
Al	47.8	196.0	21394	82.7	192	23681.2	773000	97.2
Bromide	31	33.0	3602	32.9	77	157.0	5126	29.7
Cu	13.2	13.2	1437	16.2	38	126.1	4117	65.1
Fe	98.6	287.4	31379	130.2	303	34806.9	1136165	97.2
Si	1830	4706.5	513792	7288.0	16966	31986.7	1044106	50.8
Zn	5.9	9.7	1060	18.2	42	298.0	9726	89.1
Avg. flowrate (m^3/h)		4548.6		97		1360.1		

5.2.2 Industrial WWTP Sources

The major industrial activities performed in the Yeşilırmak River Basin are sugar production, paper manufacturing, food processing, mining, feed manufacturing, and various small industrial activities located in OIZs [66]. For this study, representative IWWTPs from each sector were tried to be selected for a better evaluation. Fourteen IWWTPs located in the Yeşilırmak Basin were evaluated and 137 micropollutants out of 295 were detected in the effluent samples at least once, i.e., concentrations of 137 micropollutants exceed the LOD values in at least one sampling period. Therefore, like in the evaluation of UWWTPs, further evaluation was done for 137 micropollutants and average concentrations of 38 micropollutants out of 137 over the sampling periods exceed the AA-EQS values. Hence, these micropollutants were selected in the scope of tier 0 of the abovementioned Tiered Approach. The micropollutant whose average concentrations exceeded the AA-EQS values are listed in Table 19.

Table 19. Micropollutants whose concentrations exceeded the AA-EQS values in the effluent discharges of IWWTPs

Benzo(a)pyrene	B	Fenpropimorph
Cd	Ba	Free CN
Dichlorvos	Be	PCB 153
Fluoranthene	Bis(2-ethylhexyl) terephthalate	Petroleum hydrocarbons
Hg	Bromide	Pyrene
Ni	Chlorfenapyr	Sb
Nonylphenols (4-Nonylphenol)	Co	Si
Pb	Cr	Sn
4-Chloroaniline	Cu	Ti
Ag	Diphenyl ether; Diphenyl oxide	Tridecane
Al	Endrin	V
As	Ethalfluralin	Zn
Azinphos methyl	Fe	

Blue: Priority substances
Purple: River basin specific pollutants

To determine the significant discharges, Tier 1 was applied to 38 micropollutants discharged from the UWWTPs. 9 of them (benzo(a)pyrene, fluoranthene, Ag, Ba, Be, bis(2-ethylhexyl) terephthalate, PCB 153, pyrene, Sn) were eliminated and the others were determined as significant micropollutants discharged from IWWTPs for the receiving bodies in the Yeşilırmak River Basin. More detailed information based on each IWWTP is given in the following sections.

5.2.2.1 Merzifon OIZ IWWTP

Merzifon is a county of Amasya Province. Merzifon OIZ was established in an area of 155 ha, which is located on Samsun-Ankara Highway in Merzifon. Currently, 37 companies are actively operating in the OIZ and the main industrial activities in the OIZ are metal and metal processing and food sectors. WWTP of the OIZ was designed to treat the industrial wastewater coming from the various industrial facilities. The IWWTP of Merzifon OIZ has physical and biological treatment units with a capacity of 300 m^3/day [74], [76]. However, according to the information obtained from an authority of the IWWTP, the wastewater flow coming to the plant is much higher than 300 m^3/day, which causes an ineffective treatment. The biological treatment unit is an extended aeration activated sludge system with an SRT of 15 days. The treated wastewater is discharged to Gümüşsuyu Brook. The detailed flow diagram of the plant is shown in Figure 29.

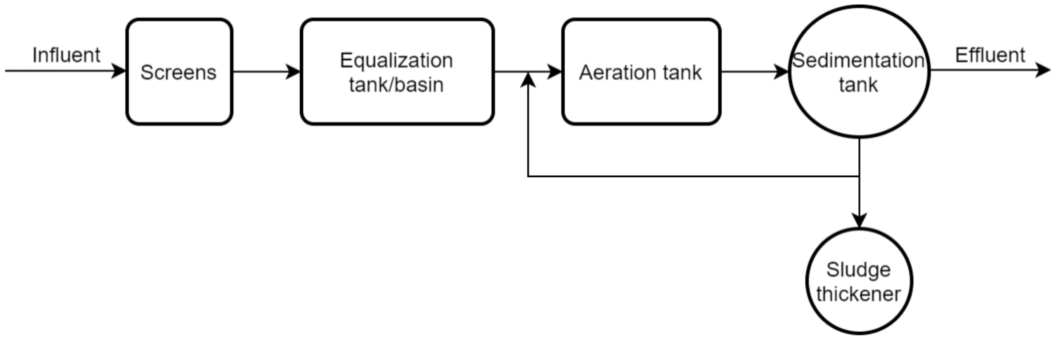

Figure 29. Process flow diagram of the Merzifon OIZ IWWTP

The samples from the discharge of Merzifon OIZ IWWTP, which was coded as YESIL 58_IW, were taken for six periods between February 2017 and January 2018. The upstream station of the plant is YESIL 97, which has a distance of 4.5 km to the plant, while the downstream station of the plant is YESIL 31, which is 8 km away from the plant. Figure 30 illustrates the locations of these stations in the streamline.

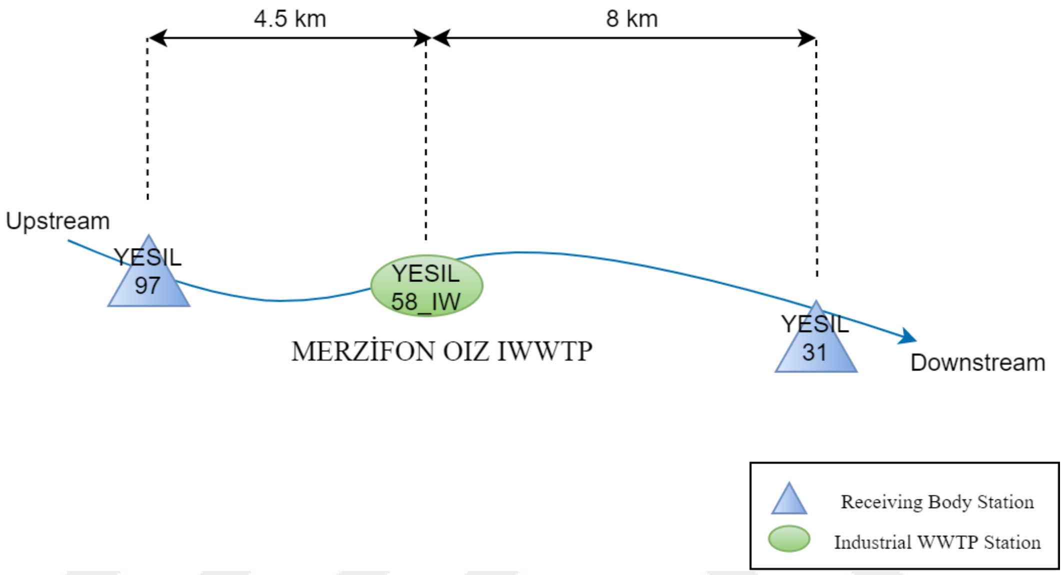

Figure 30. Illustration of the stations that locate in the same streamline, where Merzifon OIZ IWWTP is and distances between them

According to the analysis results, 13 priority substances and 62 basin-specific pollutants, in total 75 micropollutants, were detected in the effluent of Merzifon OIZ IWWTP. After applying tier 0, 52 micropollutants were eliminated because their average concentrations were below the AA-EQS values. The number of the micropollutants whose average concentrations exceeded their AA-EQSs was 23 and five of them were priority substances (Cd, Hg, Ni, nonylphenols, Pb). The other micropollutants exceeding AA-EQSs were 4-chloroaniline, Al, B, bromide, Co, Cr, Cu, diphenyl ether; diphenyl oxide, Fe, free CN, petroleum hydrocarbons, Si, Ti, tridecane, V, Zn, ethalfluralin, and fenpropimorph. After micropollutants that exceeded AA-EQSs were determined, PC and relative increase for these chemicals were calculated (tier 1) and all abovementioned micropollutants passed tier 1, i.e., their relative increases were greater than 2%. The calculated data are given in Table 20 for each micropollutant exceeding its AA-EQS.

Table 20. Concentrations and loads of the micropollutants exceeded AA-EQSs in the effluent of Merzifon OIZ IWWTP (YESIL 58_IW) with related PC and relative increase

Micropollutants	**Avg. conc. (μg/L)**	**AA-EQS μg/L)**	**% EQS exceedance**	**Avg. pollution load (g/d)**	**PC**	**% Relative increase**
Cd	0.2	0.09*	89.1	0.06	0.01	**14.6**
Hg	0.1	0.07**	41.1	0.03	0.01	**10.9**
Ni	93.7	4	2242.2	31	7.3	**181.4**
Nonylphenols (4-Nonylphenol)	0.8	0.3	153.5	0.3	0.06	**19.6**
Pb	7.1	1.2	492.4	2	0.6	**45.9**
4-Chloroaniline	0.01	0.005	25.0	0.002	0.001	**9.7**
Al	1980.1	47.8	4042.5	653	153.3	**320.8**
B	1257.8	707	77.9	415	97.4	**13.8**
Bromide	134.1	31	332.4	44	10.4	**33.5**
Co	7.2	0.3	2296.1	2	0.6	**185.5**
Cr	19.5	1.6	1117.4	6	1.5	**94.3**
Cu	98.5	13.2	646.5	32	7.6	**57.8**
Diphenyl ether; Diphenyl oxide	7.8	6	30.6	3	0.6	**10.1**
Fe	2644.1	98.6	2581.7	872	204.7	**207.7**
Free CN	8.0	1.2	569.2	3	0.6	**51.8**
Petroleum hydrocarbons	359.8	96	274.7	119	27.9	**29.0**
Si	10079.8	1830	450.8	3322	780.5	**42.7**
Ti	41.4	26	59.1	14	3.2	**12.3**
Tridecane	1.5	0.05	2860.0	0.5	0.1	**229.2**
V	3.4	1.6	111.8	1	0.3	**16.4**
Zn	2158.3	5.9	36481.8	711	167.1	**2832.7**
Ethalfluralin	1.1	0.3	265.1	0.4	0.1	**28.3**
Fenpropimorph	0.1	0.1	45.0	0.04	0.01	**11.2**
Avg. flowrate (m^3/h)			**13.73**			

*AA-EQS of Class 3 **MAC-EQS

The average upstream flowrate of Merzifon OIZ IWWTP was measured as 163.62 m^3/h while the average discharge flowrate of the IWWTP was 13.73 m^3/h. Although the effluent flowrate of the plant was very low, its impact on the receiving water was highly significant since the flowrate of the upstream water was also very low. Some of the micropollutants such as Ni, Al, Co, Fe, tridecane, and Zn had relative increases even greater than 100% (especially Zn with 2832.7%). According to these results, it can be easily estimated that Merzifon OIZ IWWTP has certainly a significant pollution impact on the environment even though its low flowrate. Additionally, the IWWTP is the source of a wide variety of micropollutants. 4-chloroaniline, which is a toxic organic compound, can be produced due to the biodegradation of some herbicides and the production of polymers, dyes, rubber additives, and pharmaceuticals as intermediates. It has very high persistency and low biodegradability [77]. Diphenyl ether (or diphenyl oxide) is an organic compound that has low solubility in water. It is mostly used in electrical insulation as a heat transfer agent, production of other chemicals or perfumes, or soaps as a fragrance. Its effect on humans is not well-known although it is an irritant compound and toxic to aquatic life [78]. Fenpropimorph is a fungicide which is especially used for cereals and like all other biocides, its toxic effect on human health and the environment is significant [79]. The other micropollutants exceeding AA-EQSs were mostly metals.

To be able to see the effect of the significant discharges, upstream and downstream of the plant were compared in terms of pollution loads values. This comparison can be seen in Figure 31 and Table 21.

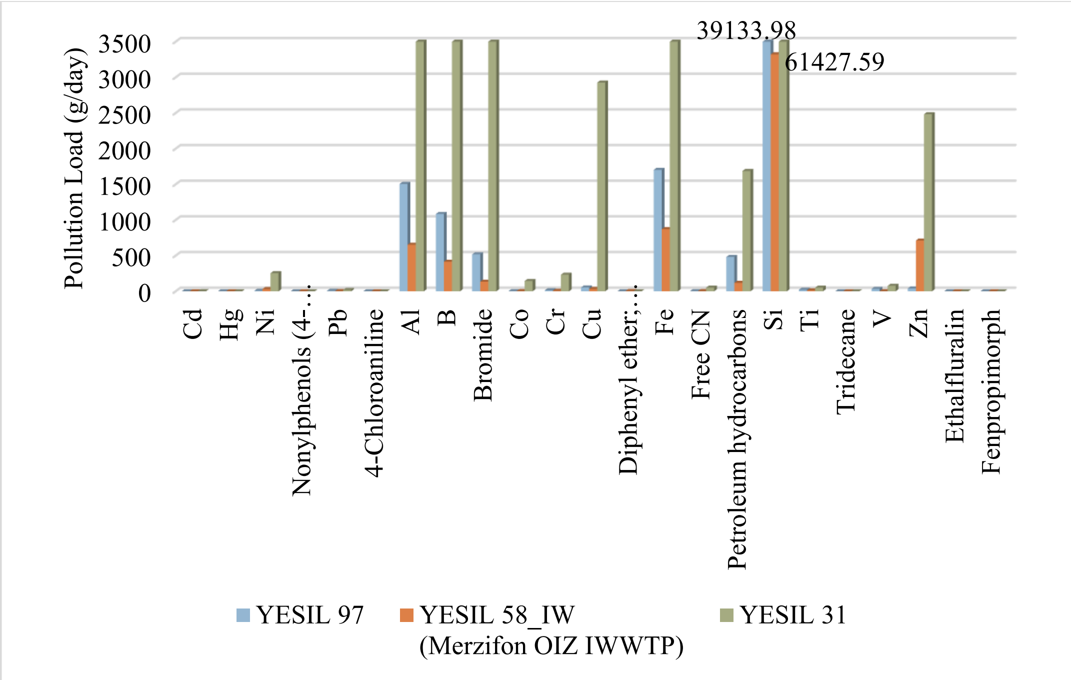

Figure 31. Pollution load comparison between upstream (YESIL 97) and downstream (YESIL 31) stations of Merzifon OIZ IWWTP (YESIL 58_IW)

Both bar graphs in Figure 31 and data in Table 21 show how pollution load changed after the discharge of Merzifon OIZ IWWTP effluent into the river. Loads of all micropollutants exceeding AA-EQSs and determined as significant discharges increased in the downstream, considerably. Since the receiving body of the effluent of Merzifon OIZ IWWTP is a small brook and has a very low flowrate. Additionally, concentrations of the micropollutants discharged from the IWWTP were noticeably high. Consequently, Merzifon OIZ IWWTP has the highest significant discharge in terms of impact on the water bodies among the evaluated IWWTPs in this study.

Table 21. Comparison of the significant micropollutants from the discharge of Merzifon OIZ IWWTP with its upstream and downstream

Micropollutants	**AA-EQS (µg/L)**	**YESIL 97 (Upstream)**		**YESIL 58_IW (Merzifon OIZ IWWTP)**		**YESIL 31 (Downstream)**		**% Change in load**
		Concentration (µg/L)	**Load (g/day)**	**Concentration (µg/L)**	**Load (g/day)**	**Concentration (µg/L)**	**Load (g/day)**	
Cd	0.09*	0.0295(<LOD)	0.1	0.2	0.06	0.2	1	89.4
Hg	0.07**	0.065(<LOD)	0.3	0.1	0.03	0.065(<LOD)	0.5	43.9
Ni	4	1.7	7	93.7	31	36.4	254	97.4
Nonylphenols (4-Nonylphenol)	0.3	0.0005(<LOD)	0.002	0.8	0.3	0.04	0.3	99.3
Pb	1.2	1.4	6	7.1	2	2.6	18	69.2
4-Chloroaniline	0.005	0.0025(<LOD)	0.01	0.01	0.002	0.0025(<LOD)	0.02	43.9
Al	47.8	383.3	1505	1980.1	653	688.7	4816	68.7
B	707	276.1	1084	1257.8	415	628.3	4394	75.3
Bromide	31	131.9	518	134.1	134	575.0	4022	87.1
Co	0.3	0.4	2	7.2	2	20.6	144	98.9
Cr	1.6	3.6	14	19.5	6	33.4	233	94.0
Cu	13.2	13.7	54	98.5	32	418.4	2926	98.2
Diphenyl ether; Diphenyl oxide	6	0.0005(<LOD)	0.002	7.8	3	0.0005(<LOD)	0.003	43.9
Fe	98.6	433.4	1702	2644.1	872	1054.7	7376	76.9
Free CN	1.2	0.5(<LOD)	2	8.0	3	7.3	51	96.2
Petroleum hydrocarbons	96	122.5	481	359.8	119	241.2	1687	71.5
Si	1830	9965.7	39134	10079.8	3322	8783.3	61428	36.3
Ti	26	5.3	21	41.4	14	7.3	51	59.0
Tridecane	0.05	0.01(<LOD)	0.04	1.5	0.5	0.01(<LOD)	0.07	43.9
V	1.6	8.6	34	3.4	1	11.1	77	56.3

Table 21. (cont'd)

Micropollutants	AA-EQS (µg/L)	YESIL 97 (Upstream)		YESIL 58_IW (Merzifon OIZ IWWTP)		YESIL 31 (Downstream)		% Change in load
		Concentration (µg/L)	Load (g/day)	Concentration (µg/L)	Load (g/day)	Concentration (µg/L)	Load (g/day)	
Zn	5.9	10.1	40	2158.3	711	354.9	2482	98.4
Ethalfluralin	0.3	0.0025(<LOD)	0.01	1.1	0.4	0.0025(<LOD)	0.02	43.9
Fenpropimorph	0.1	0.05(<LOD)	0.2	0.1	0.05	0.05(<LOD)	0.4	43.9
Avg. flowrate (m^3/h)		163.62		13.73		291.41		

* AA-EQS for Class 3
** MAC-EQS

5.2.2.2 Samsun OIZ IWWTP

Samsun OIZ was established on an area of 160 ha, which is located on the Samsun-Ordu Highway within the border of Tekkeköy County. Currently, 76 companies are actively operating in the OIZ and the main industrial activities in the OIZ are metal and metal processing, food sectors, and plastic manufacturing [49]. The WWTP of the OIZ was started to operate in 2012 and it was designed to treat the industrial wastewater coming from the various industrial facilities. The treatment capacity of the Samsun OIZ IWWTP is 2,000 m^3/day and there are physical, chemical, and biological treatment units in the plant [80]. The treated wastewater is discharged to the canal of DSİ, then to the Black Sea [75]. The detailed flow diagram of the plant is shown in Figure 32.

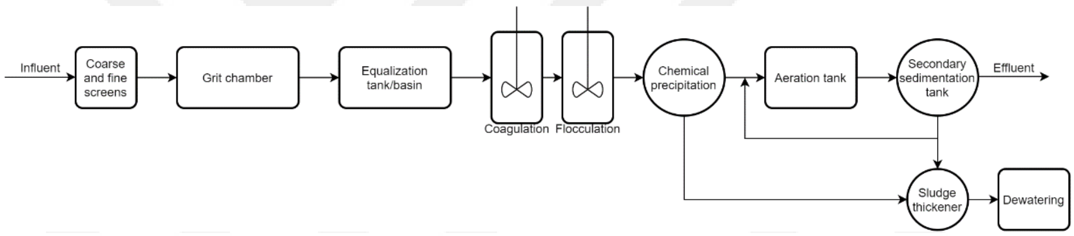

Figure 32. Process flow diagram of Samsun OIZ IWWTP

The samples from the discharge of the Samsun OIZ IWWTP, which was coded as YESIL 59_IW, were taken for four periods between February 2017 and August 2017. There were no upstream and downstream stations of the Samsun OIZ IWWTP. Hence, only tier 0 was applied to the analysis results of the IWWTP. According to the analysis results, 15 priority substances and 55 basin-specific pollutants, in total 70 micropollutants, were detected in the effluent of the Samsun OIZ IWWTP. After applying tier 0, 50 micropollutants were eliminated because their average concentrations were below the AA-EQS values. The number of the micropollutants whose average concentrations exceeded their AA-EQSs was 20 and five of them were priority substances (Cd, fluoranthene, Ni, nonylphenols, Pb). The others were river basin-specific pollutants, which were mostly metals. Since there were no upstream flowrate knowledge, PC and the relative increase could not be calculated for the effluent of Samsun OIZ IWWTP. The calculated average concentrations, EQS exceedances, and discharged average loads are given in Table 1Table 22 for each micropollutant exceeding its AA-EQS.

Table 22. Concentrations and loads of the micropollutants exceeded AA-EQSs in the effluent of Samsun OIZ IWWTP (YESIL 59_IW)

Micropollutants	Avg. conc. (µg/L)	AA-EQS µg/L)	% EQS exceedance	Avg. pollution load (g/d)
Cd	0.1	0.08*	38.6	0.2
Fluoranthene	0.03	0.0063	314.7	0.04
Ni	317.1	4	7828.6	490
Nonylphenols (4-Nonylphenol)	0.4	0.3	25	0.6
Pb	4.2	1.2	250	6
4-Chloroaniline	0.01	0.005	32.5	0.01
Al	688.7	47.8	1340.7	1064
B	783.7	707	10.8	1211
Bromide	1064.0	31	3332.2	1644
Co	224.3	0.3	74653.3	347
Cr	270.6	1.6	16809.8	418
Cu	23.8	13.2	80	37
Fe	2443.7	98.6	2378.4	3776
Petroleum hydrocarbons	153.0	96	59.4	236
Si	8756.8	1830	378.5	13529
Tridecane	0.2	0.05	234.5	0.3
V	4.3	1.6	168.9	7
Zn	4258.3	5.9	72073.9	6579
Chlorfenapyr	0.01	0.007	94.6	0.02
Ethalfluralin	1.9	0.3	542.7	3
Avg. flowrate (m^3/h)			**64.4**	

*AA-EQS for Class 1-2

The average discharge flowrate of the IWWTP was measured as 64.38 m^3/h (approximately 1,545 m^3/day). According to the calculated pollution loads, it can be estimated that Samsun OIZ IWWTP probably has a significant impact on the receiving environment. Also, the concentrations of the wide range of micropollutants discharged from Samsun OIZ IWWTP were high. Fluoranthene is a PAH which can be generated from the incomplete combustion of fossil fuels, such as coal. Also, it is known that PAHs are toxic and carcinogenic compounds and most of them are in the priority substances list [81]. Chlorfenapyr is a pro-insecticide, which is a type of pesticide, and it is a very toxic compound to aquatic life [82].

Consequently, according to the analysis results, Samsun OIZ IWWTP is one of the IWWTPs that must be paid attention due to its possible significant effect on the environment.

5.2.2.3 Dimes Food IWWTP

Dimes is one of the biggest fruit juice brands in Turkey. Besides of the juice, nectar, milk, and coffee production are being conducted in their factories. Dimes Food has several factories in different cities of Turkey and two of them are in Tokat Province. However, one of them does not have a WWTP within the facility and its wastewater is given to the sewage system. The other one, which has a WWTP, was studied under the scope of the present thesis. In that factory, vegetable and fruit juice, alcoholic beverage and soft drink are being produced. An activated sludge system is used in Dimes Food IWWTP whose has a capacity of 432,000 m^3/year and the treated water is discharged to the Yeşilırmak River [83]. A more detailed process flow diagram could not be figured due to lack of data.

The samples from the discharge of Dimes Food IWWTP, which was coded as YESIL 60_IW, were taken for six periods between February 2017 and January 2018. The upstream station of the plant is YESIL 95, which has a distance of 0.5 km to the plant, while the downstream station of the plant is YESIL 120, which is 3 km away from the plant. Figure 33 illustrates the locations of these stations in the streamline.

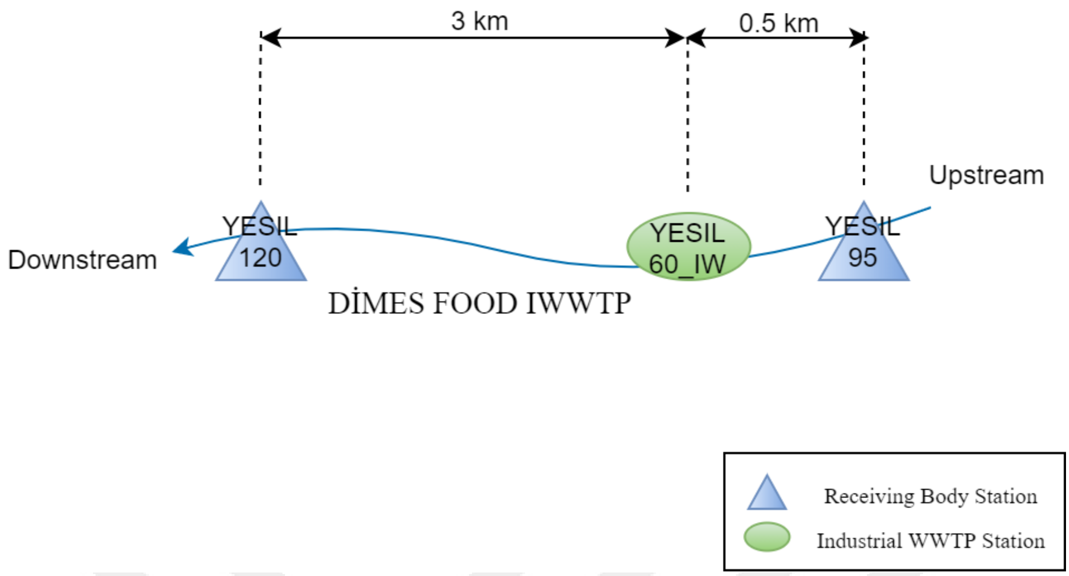

Figure 33. Illustration of the stations that locate in the same streamline, where Dimes Food IWWTP is and distances between them

According to the analysis results, 12 priority substances and 52 basin-specific pollutants, in total 64 micropollutants, were detected in the effluent of Dimes Food IWWTP. After applying tier 0, 38 micropollutants were eliminated because their average concentrations were below the AA-EQS values. The number of the micropollutants whose average concentrations exceeded their AA-EQSs was 14 and only two of them were priority substances (Cd and Pb). The other micropollutants exceeding AA-EQSs were metals and bromide, free CN, petroleum hydrocarbons, Si, fenpropimorph. After micropollutants that exceeded AA-EQSs were determined, PC and relative increase for these chemicals were calculated (tier 1) and relative increases of all abovementioned micropollutants were smaller than 2%. The calculated data are given in Table 23 for each micropollutant exceeding its AA-EQS.

Table 23. Concentrations and loads of the micropollutants exceeded AA-EQSs in the effluent of Dimes Food IWWTP (YESIL 60_IW) with related PC and relative increase

Micropollutants	Avg. conc. (µg/L)	AA-EQS µg/L)	% EQS exceedance	Avg. pollution load (g/d)	PC	% Relative increase
Cd	0.1	0.09*	103.1	0.03	8.9E-05	0.01

Table 23. (cont'd)

Micropollutants	Avg. conc. (µg/L)	AA-EQS µg/L)	% EQS exceedance	Avg. pollution load (g/d)	PC	% Relative increase
Pb	3.9	1.2	323.9	1	3.7E-03	0.3
Al	77.3	47.8	161.7	27	7.4E-02	0.2
Bromide	55.6	31	179.2	19	5.3E-02	0.2
Co	0.4	0.3	120	0.13	3.5E-04	0.1
Cr	2.5	1.6	156.7	0.9	2.4E-03	0.2
Cu	21.0	13.2	158.8	7	2.0E-02	0.2
Fe	173.5	98.6	176	60	1.7E-01	0.2
Free CN	1.3	1.2	107.8	0.4	1.2E-03	0.1
Petroleum hydrocarbons	357.3	96	372.1	124	3.4E-01	0.4
Si	8252.5	1830	451	2860	7.9E+00	0.4
V	2.6	1.6	164.1	0.9	2.5E-03	0.2
Zn	115.6	5.9	1959.2	40	1.1E-01	1.9
Fenpropimorph	0.2	0.1	237.3	0.1	2.3E-04	0.2
Avg. flowrate (m^3/h)			**14.44**			

*AA-EQS for Class 3

The average upstream flowrate of Dimes Food IWWTP was measured as 15,031.44 m^3/h while the average discharge flowrate of the IWWTP was 13.73 m^3/h. In the comparison of the flowrates, the effluent flowrate was negligibly small. As a result of this situation, relative increase ratios of all micropollutants exceeding AA-EQSs were calculated smaller than 2%. Therefore, a comparison of pollution loads in the upstream and downstream was not needed. In conclusion, the discharges of Dimes Food IWWTP does not have a significant impact on the receiving body.

5.2.2.4 Turhal Sugar IWWTP

Turhal is a county of Tokat Province. Turhal Sugar Factory is one of the first sugar factories in Turkey and had a production capacity of 8,400 tons/day [84]. The wastewater generated from the handling and washing processes is transferred to the WWTP of the factory. The IWWTP that consists of physical and biological treatment units has a treatment capacity of 180 m^3/hour. Nitrogen removal is also performed in the IWWTP. After treatment is completed, the effluent is discharged to the Yeşilırmak River. Since sugar manufacturing is a seasonal industry, Turhal Sugar

Factory operates three months in a year. Therefore, discharge from the IWWTP is not continuous [83]. The detailed flow diagram of the plant is shown in Figure 34.

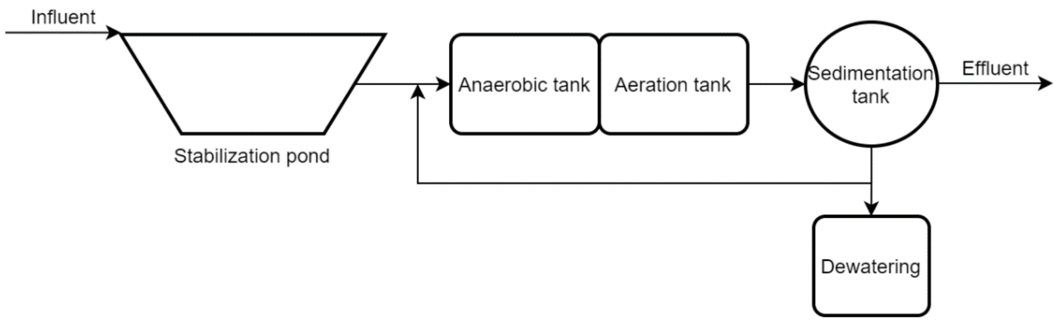

Figure 34. Process flow diagram of Turhal Sugar IWWTP

The samples from the discharge of Turhal Sugar IWWTP, which was coded as YESIL 61_IW, were taken only for two periods in November 2017 and January 2018. The upstream station of the plant is YESIL 126, which has a distance of 0.05 km to the plant, while the downstream station of the plant is YESIL 18, which is 2.5 km away from the plant. Figure 35 illustrates the locations of these stations in the streamline.

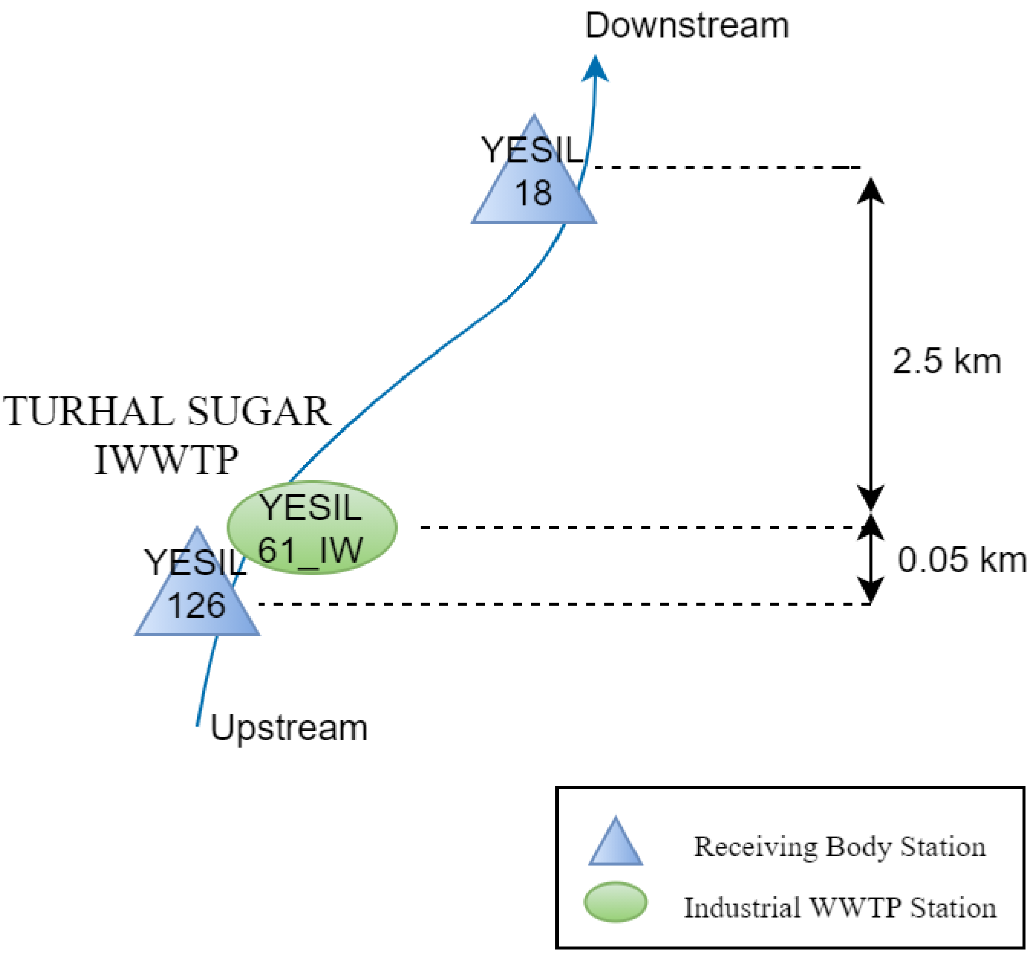

Figure 35. Illustration of the stations that locate in the same streamline, where Turhal Sugar IWWTP is and distances between them

According to the analysis results, 4 priority substances and 19 basin-specific pollutants, in total 23 micropollutants, were detected in the effluent of Turhal Sugar IWWTP. After applying tier 0, 9 micropollutants were eliminated because their average concentrations were below the AA-EQS values. The number of the micropollutants whose average concentrations exceeded their AA-EQSs was 14 and three of them were priority substances (Cd, Ni, and Pb). The other micropollutants exceeding AA-EQSs were mostly metals (Al, Co, Cr, Cu, Fe, V, Zn) and bromide, free CN, petroleum hydrocarbons, and Si. After micropollutants that exceeded AA-EQSs were determined, PC and relative increase for these chemicals were calculated (tier 1) and seven of the abovementioned micropollutants passed tier 1, i.e., their relative increases were greater than 2%. The calculated data are given in Table 24 for each micropollutant exceeding its AA-EQS.

Table 24. Concentrations and loads of the micropollutants exceeded AA-EQSs in the effluent of Turhal Sugar IWWTP (YESIL 61_IW) with related PC and relative increase

Micropollutants	**Avg. conc. (µg/L)**	**AA-EQS µg/L)**	**% EQS exceedance**	**Avg. pollution load (g/d)**	**PC**	**% Relative increase**
Cd	0.1	0.09*	111.9	0.3	0.001	1.0
Ni	26.6	4	665.9	83	0.2	**6.2**
Pb	4.0	1.2	329.2	12	0.04	**3.1**
Al	65.5	47.8	137.0	204	0.6	1.3
Bromide	41.4	31	133.5	129	0.4	1.3
Co	7.4	0.3	2463.3	23	0.07	**23.1**
Cr	3.9	1.6	245.3	12	0.04	**2.3**
Cu	16.1	13.2	121.8	50	0.2	1.1
Fe	419.1	98.6	425.1	1308	3.9	**4.0**
Free CN	1.8	1.2	153.3	6	0.02	1.4
Petroleum hydrocarbons	97.5	96	101.6	304	0.9	1.0
Si	9421.5	1830	514.8	29395	88.2	**4.8**
V	21.7	1.6	1355.9	68	0.2	**12.7**
Zn	8.5	5.9	144.2	27	0.08	1.3
Avg. flowrate (m^3/h)			**130**			

*AA-EQS for Class 3

The average upstream flowrate of Turhal Sugar IWWTP was measured as 13,671 m^3/h while the average discharge flowrate of the IWWTP was 130 m^3/h. All micropollutants that were estimated as significant in the discharge were metals except Si. Co and V had the highest relative increase ratios with 23% and 12.7%, respectively, because the EQS exceedances of these two micropollutants were extremely high. In fact, all other significant pollutants exceeded their AA-EQS values highly.

To be able to see the effect of the significant discharges, upstream and downstream of the plant were compared in terms of pollution loads values. This comparison can be seen in Figure 36 and Table 25.

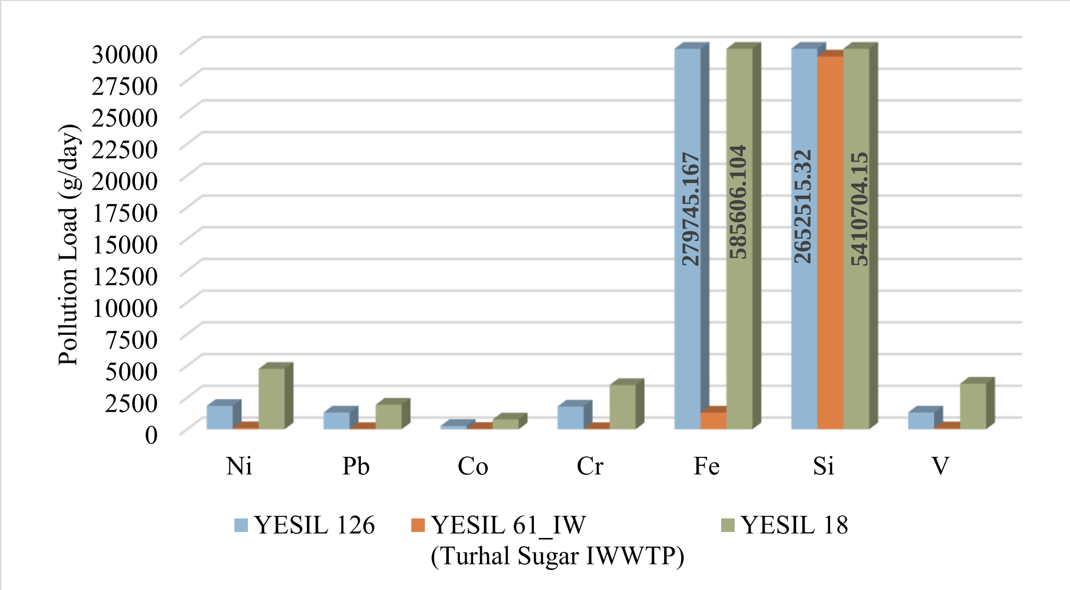

Figure 36. Pollution load comparison between upstream (YESIL 126) and downstream (YESIL 18) stations of Turhal Sugar IWWTP (YESIL 61_IW)

Both bar graphs in Figure 36 and data in Table 25 show how pollution load changed after the discharge of Turhal Sugar IWWTP effluent into the river. Loads of all micropollutants exceeding AA-EQSs and determined as significant discharges elevated in the downstream, considerably. However, by comparing the pollution load differences, it can be seen that Turhal Sugar could not be the only source that increased the load in the downstream since the pollution loads coming from the discharges of Turhal Sugar IWWTP were not that high. The high flowrate of the downstream had also an influence on the load differences. Nevertheless, Turhal Sugar IWWTP has significant discharge in terms of impact on the receiving body.

Table 25. Comparison of the significant micropollutants from the discharge of Turhal Sugar IWWTP with its upstream and downstream

Micropollutants	AA-EQS (µg/L)	YESIL 126 (Upstream)		YESIL 61_IW (Turhal Sugar IWWTP)		YESIL 18 (Downstream)		% Change in load
		Concentration (µg/L)	Load (g/day)	Concentration (µg/L)	Load (g/day)	Concentration (µg/L)	Load (g/day)	
Ni	4	5.6	1836	26.6	83	5.5	4759	61.4
Pb	1.2	4.0	1318	4.0	12	2.2	1930	31.7
Co	0.3	0.8	259	7.4	23	0.9	772	66.4
Cr	1.6	5.4	1793	3.9	12	4.0	3481	48.5
Fe	98.6	847.0	279745	419.1	1308	680.0	585606	52.2
Si	1830	8031.5	2652515	9421.5	29395	6283	5410704	51.0
V	1.6	4.0	1323	21.7	68	4.2	3595	63.2
Avg. flowrate (m^3/h)		13761		130		35884.1		

5.2.2.5 Özdemir Antimony Mine IWWTP

Özdemir Antimony Mine is another industrial plant located in Turhal (county of Tokat). The plant consists of an underground mine, where mine extraction takes place, and a mine processing/enrichment factory. Metal production in the plant is 600 tons per year. The wastewater is mostly generated from the flotation process and the generated wastewater is sent to a sedimentation pond, which has a capacity of 12,500 m^3/day. The supernatant from the pond is discharged to the Yeşilırmak River [83]. The detailed flow diagram of the plant is shown in Figure 37.

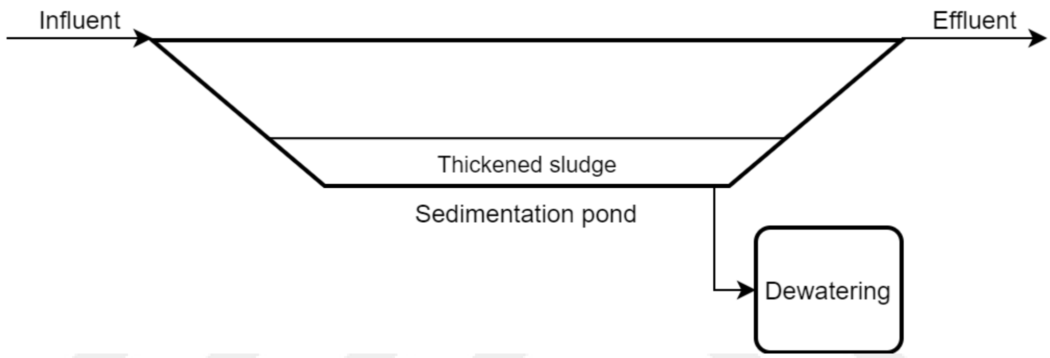

Figure 37. Process flow diagram of Özdemir Antimony IWWTP

The samples from the discharge of Özdemir Antimony IWWTP, which was coded as YESIL 62_IW, were taken for six periods between February 2017 and January 2018. The upstream station of the plant is YESIL 18, which has a distance of 2 km to the plant, while the downstream station of the plant is YESIL 99, which is 0.08 km away from the plant. Figure 38 illustrates the locations of these stations in the streamline.

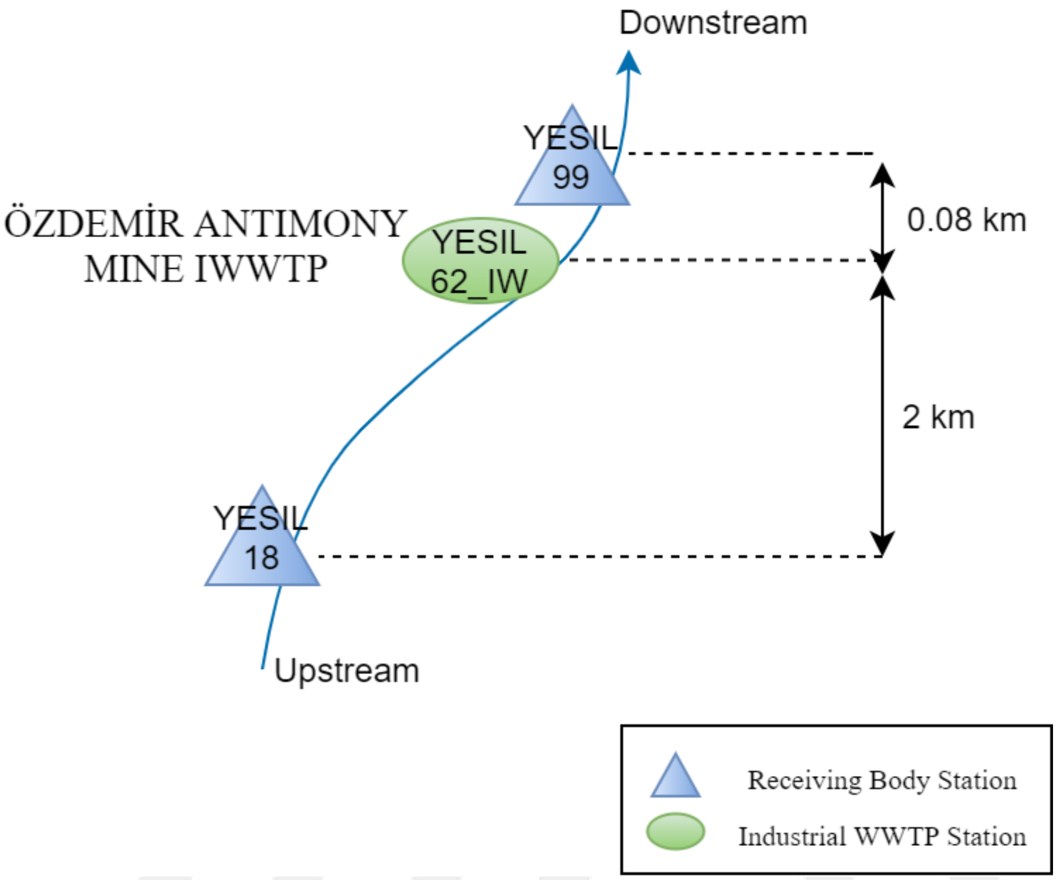

Figure 38. Illustration of the stations that locate in the same streamline, where Özdemir Antimony IWWTP is and distances between them

According to the analysis results, 11 priority substances and 48 basin-specific pollutants, in total 59 micropollutants, were detected in the effluent of Özdemir Antimony IWWTP. After applying tier 0, 36 micropollutants were eliminated because their average concentrations were below the AA-EQS values. The number of the micropollutants whose average concentrations exceeded their AA-EQSs was 23 and three of them were priority substances (Cd, Ni, and Pb). The other micropollutants exceeding AA-EQSs were mostly metals (or semi-metals) (Ag, Al, As, B, Ba, Be, Co, Cr, Cu, Fe, Sb, Si, Sn, Ti, V, Zn) and bromide, petroleum hydrocarbons, tridecane, and ethalfluralin. After micropollutants that exceeded AA-EQSs were determined, PC and relative increase for these chemicals were calculated (tier 1) and nine of the abovementioned micropollutants passed tier 1, i.e., their relative increases were greater than 2%. The calculated data are given in Table 26 for each micropollutant exceeding its AA-EQS.

Table 26. Concentrations and loads of the micropollutants exceeded AA-EQSs in the effluent of Özdemir Antimony IWWTP (YESIL 62_IW) with related PC and relative increase

Micropollutants	**Avg. conc. (µg/L)**	**AA-EQS µg/L)**	**% EQS exceedance**	**Avg. pollution load (g/d)**	**PC**	**% Relative increase**
Cd	1.1	0.09*	1225.5	0.2	0.0002	0.2
Ni	2297.1	4	57426.8	334	0.4	**9.7**
Pb	40.3	1.2	3355.4	6	0.01	0.6
Ag	3.6	1.5	240.7	0.5	0.001	0.04
Al	432622.1	47.8	905067.2	62869	73.0	**152.7**
As	80465.4	53	151821.5	11693	13.6	**25.6**
B	2419.4	707	342.2	352	0.4	0.06
Ba	3764.0	680	553.5	547	0.6	0.1
Be	13.0	2.5	520.4	2	0.002	0.1
Bromide	40.6	31	130.8	6	0.01	0.02
Co	532.3	0.3	177427.8	77	0.1	**30.0**
Cr	1242.0	1.6	77626.7	180	0.2	**13.1**
Cu	857.5	13.2	6496.1	125	0.1	1.1
Fe	962627.3	98.6	976295.4	139889	162.4	**164.7**
Petroleum hydrocarbons	231.8	96	241.4	34	0.04	0.04
Sb	102285.4	7.8	1311351.3	14864	17.3	**221.2**
Si	33933.8	1830	1854.3	4931	5.7	0.3
Sn	20.3	13	156.1	3	0.003	0.03
Ti	538.2	26	2069.9	78	0.1	0.3
Tridecane	0.2	0.05	456.7	0.03	0.00004	0.08
V	986.0	1.6	61627.2	143	0.2	**10.4**
Zn	1113.9	5.9	18879.8	162	0.2	**3.2**
Ethalfluralin	2.6	0.3	882.5	0.4	0.0004	0.1
Avg. flowrate (m^3/h)			**6.055**			

*AA-EQS for Class 3

The average upstream flowrate of Özdemir Antimony IWWTP was measured as 35,884.05 m^3/h while the average discharge flowrate of the IWWTP was 6.055 m^3/h. The micropollutants that were estimated as significant in the discharge were Ni, Al, As, Co, Cr, Fe, Sb, V, and Zn. According to the calculations, the discharges of Özdemir Antimony can be a good example of the importance of process contribution for the decision of significance. Since the relative increase ratio of Pb was smaller than 2% even though its EQS exceedance was 3,355%. The low average flowrate of the effluent was the cause of this result. Besides, Sb had the highest relative increase ratio with 221% as it was expected. Yet, all significant pollutants exceeded their AA-EQS values highly.

To be able to see the effect of the significant discharges, upstream and downstream of the plant were compared in terms of pollution loads values. This comparison can be seen in Figure 39 and Table 27.

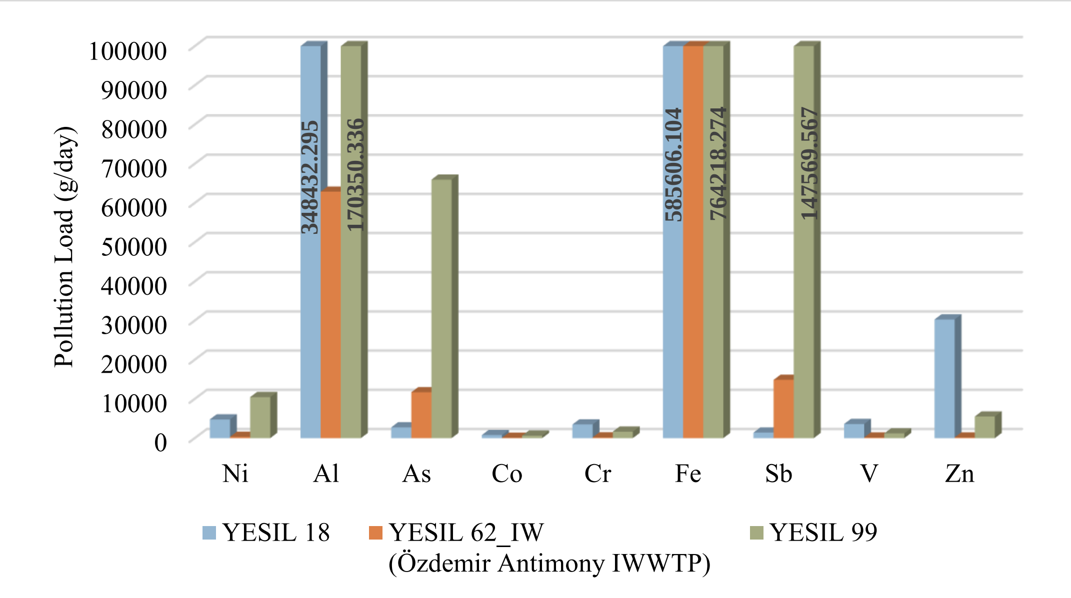

Figure 39. Pollution load comparison between upstream (YESIL 18) and downstream (YESIL 99) stations of Özdemir Antimony IWWTP (YESIL 62_IW)

Table 27. Comparison of the significant micropollutants from the discharge of Özdemir Antimony IWWTP with its upstream and downstream

Micropollutants	AA-EQS (µg/L)	YESIL 18 (Upstream)		YESIL 62_IW (Özdemir Antimony IWWTP)		YESIL 99 (Downstream)		% Change in load
		Concentration (µg/L)	Load (g/day)	Concentration (µg/L)	Load (g/day)	Concentration (µg/L)	Load (g/day)	
Ni	4	5.5	4759	2297.1	334	38.5	10455	54.5
Al	47.8	404.6	348432	432622.1	62869	626.9	170350	**-104.5**
As	53	3.2	2741	80465.4	11693	242.6	65933	95.8
Co	0.3	0.9	772	532.3	77	2.3	627	**-23.1**
Cr	1.6	4.0	3481	1242.0	180	6.1	1648	**-111.3**
Fe	98.6	680.0	585606	962627.3	139889	2812.3	764218	23.4
Sb	7.8	1.6	1406	102285.4	14864	543.1	147570	99.0
V	1.6	4.2	3595	986.0	143	4.4	1193	**-201.3**
Zn	5.9	35.1	30270	1113.9	162	20.3	5505	**-449.9**
Avg. flowrate (m^3/h)		35884.1		6.1		11322.5		

Both bar graphs in Figure 39 and data in Table 27 show how pollution load changed after the discharge of Özdemir Antimony IWWTP effluent into the river. Five of the nine micropollutants that were estimated as significant had lower loads in the downstream although concentrations of these micropollutants were higher in the downstream. Since the average flowrate of the downstream was lower. Yet, the loads of the others increased in the downstream, especially the loads of As and Sb were greater by 96% and 99%, respectively. The discharge from Özdemir Antimony has a significant impact on the receiving body for Sb as it is expected.

5.2.2.6 Meray Oil IWWTP

Meray Oil Inc. was established in 1970 in Merzifon, which is a county of Amasya Province. The factory consists of two main plants for the production of raw oil and refined oil. In the raw oil production units, oil seeds (sunflower, soybean, canola, etc.) are obtained and processed as raw oil. Then the produced raw oil is sent to the refined oil production units as input to produce various edible refined winterized oil [85]. The annual capacity of the facility for sunflower seed processing, pulp production, raw oil, and refined oil production is 60,000 tons, 24,000 tons, 24,000 tons, and 24,000 tons, respectively. The generated wastewater generated from the production process is treated in the WWTP of the facility. Meray Oil IWWTP has a capacity of 200 m^3/day, which includes physical, chemical, and biological treatment units. For biological treatment, a conventional activated sludge system with an SRT of 10 days. The treated wastewater is discharged to Kuruçay Creek after the disinfection process. The detailed flow diagram of the plant is shown in Figure 40.

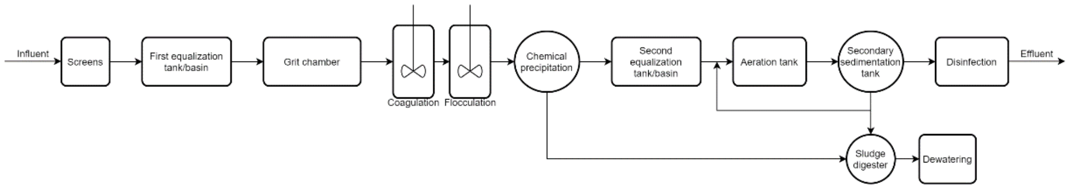

Figure 40. Process flow diagram of Meray Oil IWWTP

The samples from the discharge of Meray Oil IWWTP, which was coded as YESIL 65_IW, were taken for four periods in February 2017, June 2017, November 2017, and January 2018. The upstream station of the plant is YESIL 96, which has a distance of 2 km to the plant, while the downstream station of the plant is YESIL 97, which is 4 km away from the plant. Due to the dry river bed of the upstream of Meray Oil IWWTP, any sample could not be taken from the upstream station. Therefore, the flowrate of the upstream of the IWWTP was calculated by using the flowrate of the tributary of the related streamline. Figure 41 illustrates the locations of these stations in the streamline.

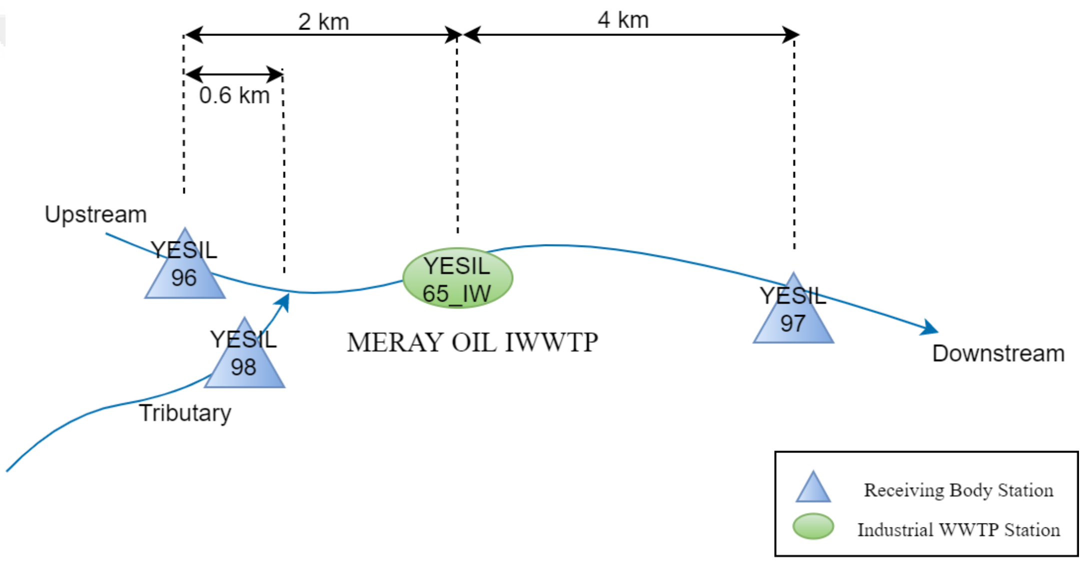

Figure 41. Illustration of the stations that locate in the same streamline, where Meray Oil IWWTP is and its tributary with distances between them

To be able to calculate the PC of Meray Oil IWWTP to the receiving body, the flowrate of the upstream was calculated by assuming that the flowrate of the downstream was of flowrates of upstream, tributary, and discharged effluent. For this calculation, the effects of the precipitation, evaporation, infiltration, etc. were assumed negligible. The calculation was done according to Eqn 8.

$$Q_{downstream} = Q_{upstream} + Q_{tributary} + Q_{effluent} \qquad \text{Eqn 8}$$

where, $Q_{downstream}$ = Average flowrate of the downstream of Meray Oil IWWTP (YESIL 97), m^3/hour

$Q_{upstream}$ = Average flowrate of the upstream of Meray Oil IWWTP (YESIL 96), m^3/hour

$Q_{tributary}$ = Average flowrate of the tributary of Meray Oil IWWTP (where YESIL 98 is located), m^3/hour

$Q_{effluent}$ = Average flowrate of the discharged effluent from Meray Oil IWWTP (YESIL 65_IW), m^3/hour

The average flowrate of the upstream of Meray Oil IWWT was calculated as 80.08 m^3/hour as a result of the calculation is shown below.

$$163.62 = Q_{upstream} + 74.16 + 9.38$$

$$Q_{upstream} = 80.08 \text{ m}^3\text{/hour}$$

According to the analysis results, 5 priority substances and 28 basin-specific pollutants, in total 33 micropollutants, were detected in the effluent of Meray Oil IWWTP. After applying tier 0, 20 micropollutants were eliminated because their average concentrations were below the AA-EQS values. The number of the micropollutants whose average concentrations exceeded their AA-EQSs was 13 and three of them were priority substances (dichlorvos, Ni, and Pb). The other micropollutants exceeding AA-EQSs were Al, bromide, Co, Cr, Cu, Fe, Sb, Si, V, and Zn. After micropollutants that exceeded AA-EQSs were determined, PC and relative increase for these chemicals were calculated (tier 1) according to the assumed upstream flowrate, and all the above-mentioned micropollutants passed the tier 1, i.e., their relative increases were greater than 2%. The calculated data are given in Table 28 for each micropollutant exceeding its AA-EQS.

Table 28. Concentrations and loads of the micropollutants exceeded AA-EQSs in the effluent of Meray Oil IWWTP (YESIL 65_IW) with related PC and relative increase

Micropollutants	**Avg. conc. (µg/L)**	**AA-EQS µg/L)**	**% EQS exceedance**	**Avg. pollution load (g/d)**	**PC**	**% Relative increase**
Dichlorvos	0.02	0.0006	3004.2	0.004	0.002	**325.5**
Ni	9.8	4	144.1	2	1.0	**25.6**
Pb	2.3	1.2	95.2	0.5	0.25	**20.5**
Al	131.3	47.8	174.6	30	13.8	**28.8**
Bromide	36.8	31	18.7	8	3.9	**12.4**
Co	0.5	0.3	73.3	0.11	0.06	**18.2**
Cr	3.6	1.6	122.8	0.8	0.4	**23.4**
Cu	16.8	13.2	27.2	4	1.8	**13.3**
Fe	244.3	98.6	147.7	55	25.6	**26.0**
Sb	9.9	7.8	28	2	1.0	**13.4**
Si	13078	1830	614.6	2945	1371.4	**74.9**
V	8.9	1.6	457	2	0.9	**58.4**
Zn	71.7	5.9	1114.4	16	7.5	**127.4**
Avg. flowrate (m^3/h)			**9.38**			

The average discharge flowrate of Meray Oil IWWTP was measured as 9.38 m^3/h and as stated before, the average upstream flowrate of the IWWTP was calculated as 80.08 m^3/h. The stream to which Meray Oil IWWTP is discharged is running dry. Therefore, the impact of the discharge could be seen drastically despite the low effluent flowrate. As mentioned previously, dichlorvos is a banned insecticide. Yet, its EQS exceedance and relative increase ratio were the highest. This shows that dichlorvos may still be used in the agricultural activities of plants such as sunflower, soybean, hazelnut, canola, etc. The impact of the discharges from Meray Oil IWWTP in terms of other listed micropollutants is also significant. However, the comparison study for pollution loads in the upstream and downstream of Meray Oil IWWTP could not be conducted because any water samples could not be taken from the upstream station due to the dry river bed. Nevertheless, it can be estimated that Meray Oil IWWTP causes significant discharges to the receiving body due to low stream flowrate and high concentrations in the effluent.

5.2.2.7 Olmuksan International Paper IWWTP

The paper production sector constitutes 2% of the Çorum industry [70]. Olmuksan International Paper is one of the paper and paper products factories in Çorum. The facility produces corrugated boards for various packaging products with a capacity of 60 million m^2 [86]. The wastewater generated from the production process is sent to the WWTP of the facility and the average treatment capacity of Olmuksan Int. Paper IWWTP is 30 m^2/day. The treated wastewater is sent to Derinçay Creek. The detailed flow diagram of the plant is shown in Figure 42.

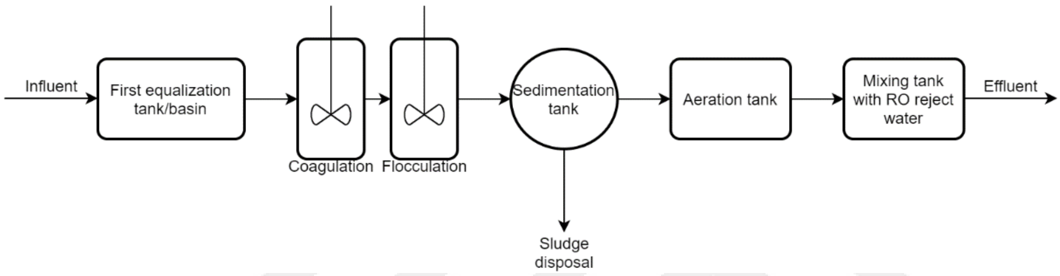

Figure 42. Process flow diagram of Olmuksan Int. Paper IWWTP

The samples from the discharge of Olmuksan Int. Paper IWWTP, which was coded as YESIL 69_IW, were taken for five periods between April 2017 and January 2018. The upstream station of the plant is YESIL 124, which has a distance of 0.1 km to the plant, while the downstream station of the plant is YESIL 25, which is 25 km away from the plant. Figure 43 illustrates the locations of these stations in the streamline.

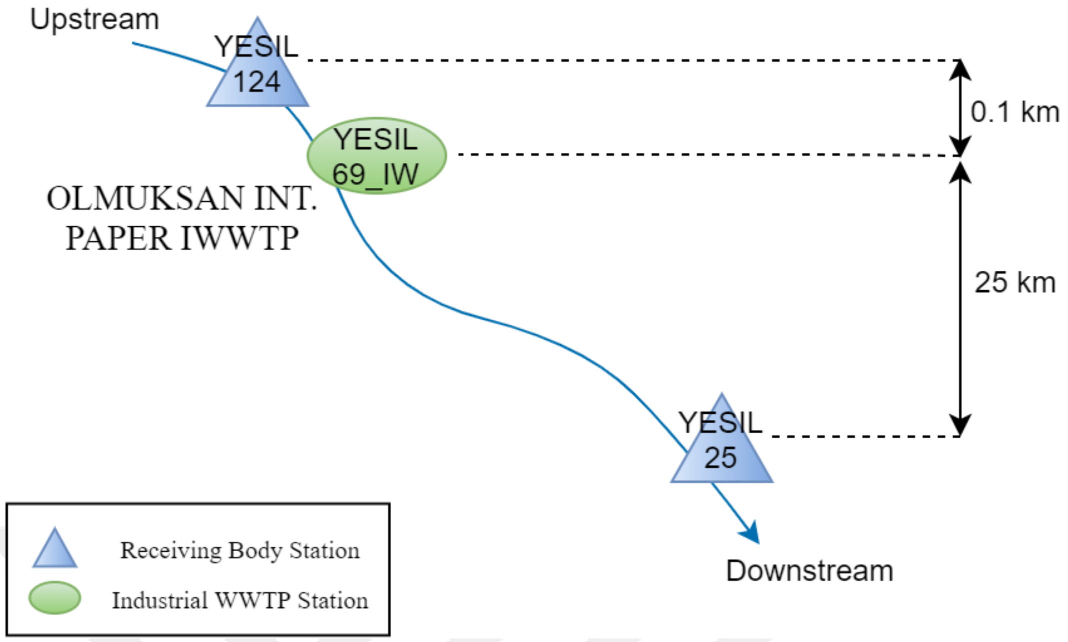

Figure 43. Illustration of the stations that locate in the same streamline, where Olmuksan Int. Paper IWWTP is and distances between them

According to the analysis results, 13 priority substances and 57 basin-specific pollutants, in total 70 micropollutants, were detected in the effluent of Olmuksan Int. Paper IWWTP. After applying tier 0, 50 micropollutants were eliminated because their average concentrations were below the AA-EQS values. The number of the micropollutants whose average concentrations exceeded their AA-EQSs was 20 and four of them were priority substances (Cd, dichlorvos Ni, and Pb). The other micropollutants exceeding AA-EQSs were 4-chloroaniline, Al, azinphos methyl, bromide, Co, Cu, endrin, Fe, free CN, petroleum hydrocarbons, Sb, Si, V, Zn, chlorfenapyr, and fenpropimorph. After micropollutants that exceeded AA-EQSs were determined, PC and relative increase for these chemicals were calculated (tier 1) and 14 of the abovementioned micropollutants passed the tier 1, i.e., their relative increases were greater than 2%. The calculated data are given in Table 29 for each micropollutant exceeding its AA-EQS.

Table 29. Concentrations and loads of the micropollutants exceeded AA-EQSs in the effluent of Olmuksan Int. Paper IWWTP (YESIL 69_IW) with related PC and relative increase

Micropollutants	**Avg. conc. (μg/L)**	**AA-EQS μg/L)**	**% EQS exceedance**	**Avg. pollution load (g/d)**	**PC**	**% Relative increase**
Cd	0.4	0.15*	282.3	0.2	0.004	**2.7**
Dichlorvos	0.006	0.0006	933.3	0.003	0.0001	**8.9**
Ni	6.9	4	171.5	3	0.07	1.6
Pb	1.9	1.2	166.2	0.9	0.02	1.6
4-Chloroaniline	0.03	0.005	660.0	0.02	0.0003	**6.3**
Al	5554.9	47.8	11621.2	25412	53	**110.6**
Azinphos methyl	0.1	0.05	276.0	0.06	0.001	**2.6**
Bromide	376.1	31	1213.2	172	3.6	**11.6**
Co	0.7	0.3	226.0	0.31	0.006	**2.2**
Cu	20.6	13.2	156.0	9	0.2	1.5
Endrin	0.06	0.01	632.0	0.03	0.001	**6.0**
Fe	195.7	98.6	198.5	90	1.9	1.9
Free CN	1.5	1.2	128.8	0.7	0.02	1.2
Petroleum hydrocarbons	235.0	96	244.8	108	2.2	**2.3**
Sb	8.6	7.8	109.9	4	0.08	1.0
Si	8915.0	1830	487.2	4079	84.9	**4.6**
V	5.8	1.6	361.4	3	0.06	**3.4**
Zn	45.6	5.9	773.5	21	0.4	**7.4**
Chlorfenapyr	0.03	0.007	465.7	0.02	0.0003	**4.4**
Fenpropimorph	0.2	0.1	246.4	0.11	0.002	**2.3**
Avg. flowrate (m^3/h)			**19.07**			

*AA-EQS for Class 4

The average upstream flowrate of Olmuksan Int. Paper IWWTP was measured as 1983.6 m^3/h while the average discharge flowrate of the IWWTP was 19.07 m^3/h. Although the effluent flowrate of the plant was very low according to the upstream flowrate, its impact on the receiving water was highly significant. Al had a relative increase ratio greater than 100%. According to these results, it can be estimated that Olmuksan Int. Paper IWWTP has a significant pollution impact on the environment. Additionally, the IWWTP is the source for various organic micropollutants like dichlorvos, 4-chloroaniline, azinphos methyl, endrin, chlorfenapyr, and fenpropimorph. The other micropollutants exceeding AA-EQSs were mostly metals. Azinphos methyl is a toxic insecticide using for apples, cherries, cranberries, grapes, etc. It is heavier than water and insoluble [87]. Endrin is also an insecticide used on crops. It is persistent and half-life could be up to 12 years. Aquatic species are very sensitive to endrin exposure [88]. The other are also pesticides. This shows that Olmuksan Int. Paper had significant discharge in terms of pesticides.

To be able to see the effect of the significant discharges, upstream and downstream of the plant were compared in terms of pollution loads values. This comparison can be seen in Figure 44 and Table 30.

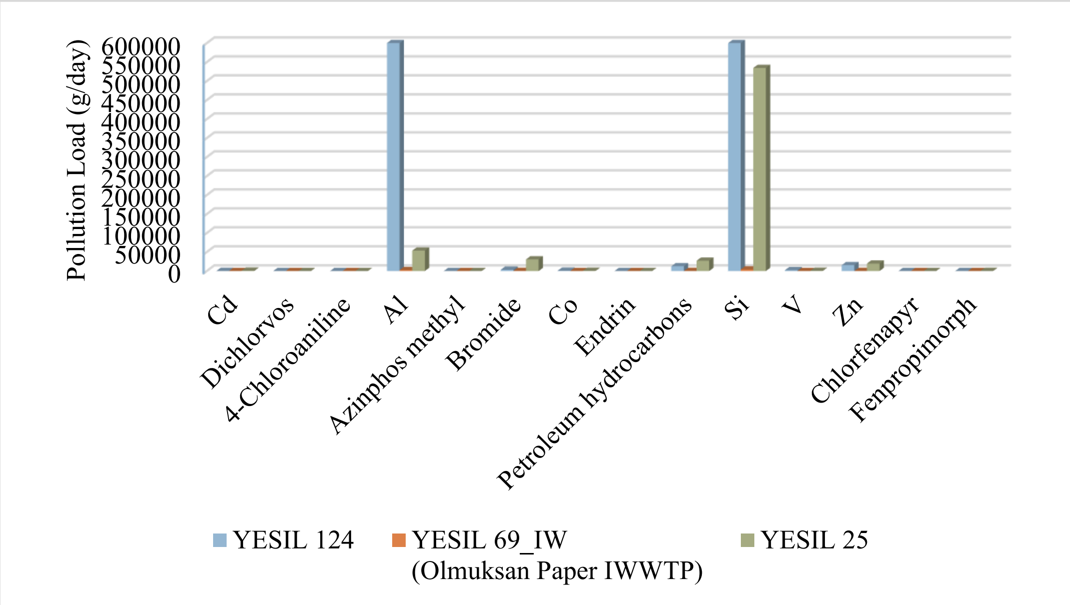

Figure 44. Pollution load comparison between upstream (YESIL 124) and downstream (YESIL 25) stations of Olmuksan Int. Paper IWWTP (YESIL 69_IW)

Table 30. Comparison of the significant micropollutants from the discharge of Olmuksan International Paper IWWTP with its upstream and downstream

Micropollutants	**AA-EQS (µg/L)**	**YESIL 124 (Upstream)**		**YESIL 69_IW (Olmuksan Int. Paper IWWTP)**		**YESIL 25 (Downstream)**		**% Change in load**
		Concentration (µg/L)	**Load (g/day)**	**Concentration (µg/L)**	**Load (g/day)**	**Concentration (µg/L)**	**Load (g/day)**	
Cd	0.15*	0.977	47	0.4	0.2	8.9	755	93.8
Dichlorvos	0.0006	0.00025 (<LOD)	0.01	0.006	0.003	0.05	4	99.7
4-Chloroaniline	0.005	0.0025 (<LOD)	0.1	0.03	0.02	0.0025 (<LOD)	0.2	43.6
Al	47.8	13138.0	625453	5554.9	2542	636.2	53705	**-1064.6**
Azinphos methyl	0.05	0.025 (<LOD)	1.2	0.1	0.06	0.025 (<LOD)	2	43.6
Bromide	31	68.7	3271	376.1	1723	361.6	30521	89.3
Co	0.3	14.2	675	0.7	0.3	5.8	485	**-39.1**
Endrin	0.01	0.0025 (<LOD)	0.12	0.06	0.03	0.0025 (<LOD)	0.2	43.6
Petroleum hydrocarbons	96	263.0	12520	235.0	108	320.4	270467	53.7
Si	1830	16814.0	800454	8915.0	4079	6331.4	534470	**-49.8**
V	1.6	42.7	2034	5.8	3	6.2	520	**-291.3**
Zn	5.9	324.3	15439	45.6	21	231.8	19571	21.1
Chlorfenapyr	0.007	0.0025 (<LOD)	0.12	0.03	0.02	0.0025 (<LOD)	0.2	43.6
Fenpropimorph	0.1	0.05 (<LOD)	2.4	0.2	0.11	0.3	23	89.6
Avg. flowrate (m^3/h)		1983.6		19.07		3517.31		

*AA-EQS for Class 4

Both bar graphs in Figure 44 and data in Table 30 show how pollution load changed after the discharge of Olmuksan Int. Paper IWWTP effluent into the river. Loads of most of the micropollutants exceeding AA-EQSs and were determined as significant discharges increased in the downstream, considerably. Besides, concentrations of the micropollutants discharged from the IWWTP were noticeably high. Especially, dichlorvos and fenpropimorph were important micropollutants. Although they could not be detected in the upstream, their average concentrations in the downstream were higher than their AA-EQSs. Consequently, Olmuksan Int. Paper IWWTP has significant discharge especially in terms of Cd, dichlorvos, bromide, and fenpropimorph. However, according to the comparison results, loads of Al, Co, Si, and V decreased in the downstream. The distance between the IWWTP and the downstream station is 25 km, which is a very long distance. It should be noted that this distance could be the reason for increases or decreases in the pollution loads.

Additionally, tridecane is not one of the significant micropollutants discharged from the Olmuksan IWWTP according to the analysis results. However, the higher tridecane concentrations were expected in the discharges of the Olmuksan IWWTP since tridecane is a solvent mostly used in the paper industry.

5.2.2.8 Özmaya (Lesaffre) IWWTP

Özmaya is a yeast production factory in Amasya. Its name has changed as Lesaffre and it produces dry fresh liquid yeasts, crumbled yeast, bread improvers, blends, and bread mixes. Özmaya is the first yeast factory in Turkey to install its WWTP [89]. Özmaya IWWTP treats an average of 2,400 m^3 wastewater per day and the treated wastewater is discharged to the Yeşilırmak River. The biological units of the IWWTP consist of an anaerobic sludge blanket reactor (UASB) and 2-stage aerobic tanks. The treated wastewater is sent to Derinçay Creek. The detailed flow diagram of the plant is shown in Figure 45.

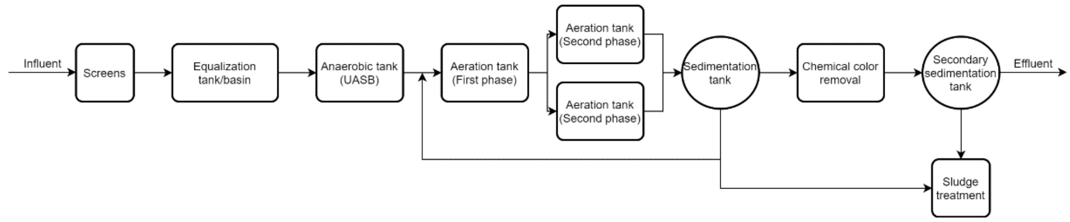

Figure 45. Process flow diagram of Özmaya IWWTP

The samples from the discharge of Özmaya IWWTP, which was coded as YESIL 70_IW, were taken for five periods between April 2017 and January 2018. The upstream station of the plant is YESIL 19, which has a distance of 15 km to the plant, while the downstream station of the plant is YESIL 33, which is 14 km away from the plant. Figure 46 illustrates the locations of these stations in the streamline.

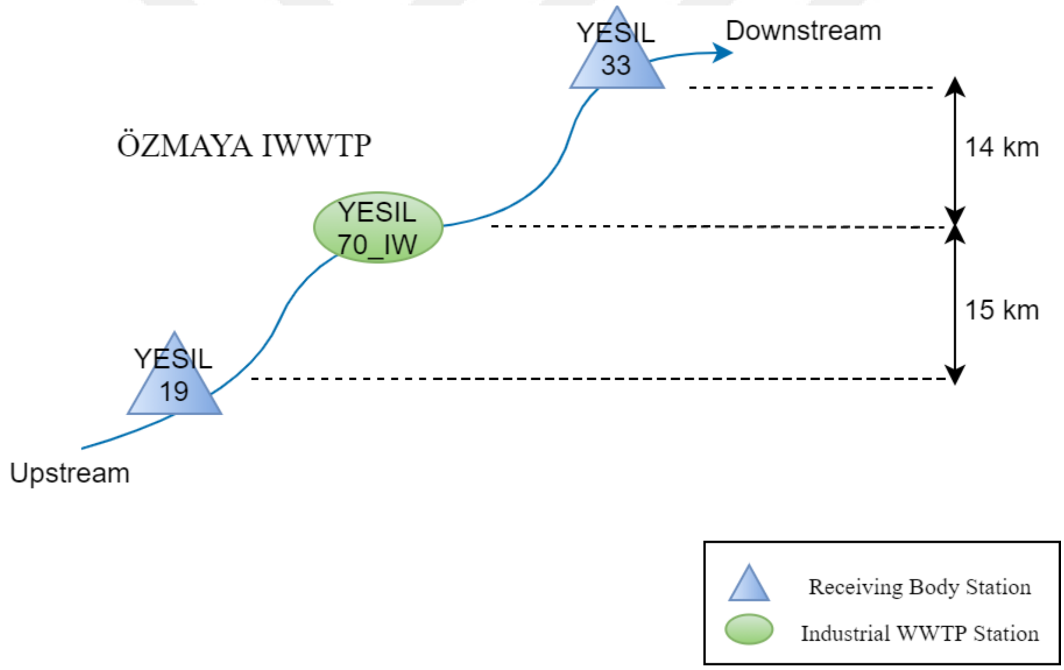

Figure 46. Illustration of the stations that locate in the same streamline, where Özmaya IWWTP is and distances between them

According to the analysis results, 16 priority substances and 61 basin-specific pollutants, in total 77 micropollutants, were detected in the effluent of Özmaya IWWTP. After applying tier 0, 59 micropollutants were eliminated because their average concentrations were below the AA-EQS values. The number of the micropollutants whose average concentrations exceeded their AA-EQSs was 18 and five of them were priority substances (Cd, fluoranthene, Ni, nonylphenols, and Pb). The other micropollutants exceeding AA-EQSs were 4-chloroaniline, Al, bromide, Co, Cr, Cu, Fe, free CN, PCB 153, pyrene, Si, tridecane, and Zn. After micropollutants that exceeded AA-EQSs were determined, PC and relative increase for these chemicals were calculated (tier 1) and only one of the abovementioned micropollutants passed tier 1. The calculated data are given in Table 31 for each micropollutant exceeding its AA-EQS.

Table 31. Concentrations and loads of the micropollutants exceeded AA-EQSs in the effluent of Özmaya IWWTP (YESIL 70_IW) with related PC and relative increase

Micropollutants	Avg. conc. (µg/L)	AA-EQS µg/L)	% EQS exceedance	Avg. pollution load (g/d)	PC	% Relative increase
Cd	0.14	0.09*	56.3	0.08	0.0001	0.1
Fluoranthene	0.16	0.0063	2468.3	0.09	0.0001	1.8
Ni	4.1	4	3.5	2	0.003	0.1
Nonylphenols (4-Nonylphenol)	1.5	0.3	414.0	0.9	0.001	0.4
Pb	4.6	1.2	282.7	3	0.003	0.3
4-Chloroaniline	0.02	0.005	364.0	0.01	0.00002	0.3
Al	152.9	47.8	219.9	85	0.1	0.2
Bromide	220.8	31	612.1	123	0.2	0.5
Co	0.6	0.3	83.3	0.3	0.0004	0.1
Cr	3.1	1.6	92.6	2	0.002	0.1
Cu	30.0	13.2	127.1	17	0.02	0.2
Fe	357.5	98.6	262.5	199	0.2	0.3
Free CN	2.6	1.2	112.7	1.4	0.002	0.1
PCB 153	0.01	0.01	22.0	0.01	0.00001	0.1
Pyrene	0.14	0.1	41.8	0.08	0.0001	0.1
Si	5297.8	1830	189.5	2948	3.7	0.2
Tridecane	3.4	0.05	6629.6	2	0.002	**4.7**
Zn	141.0	5.9	2296.0	79	0.1	1.7
Avg. flowrate (m^3/h)			**23.18**			

*AA-EQS for Class 3

The average upstream flowrate of Özmaya IWWTP was measured as 33,485.05 m^3/h while the average discharge flowrate of the IWWTP was 23.18 m^3/h. Since the effluent flowrate of the plant was very low according to the upstream flowrate, its impact on the receiving water was not significant although the discharged concentrations of some of the micropollutants were high. Tridecane had the highest relative increase ratio with 4.66% and it is the only micropollutant whose relative increase ratio was greater than 2% since its discharged average concentration was very high according to its AA-EQS. According to these results, it is estimated that discharge from Özmaya IWWTP has a significant impact on the receiving body in terms of tridecane. The average concentrations of PCB 153 and pyrene also exceeded their AA-EQS values although relative increases that they caused were not significant. PCB 153 is one of the polychlorinated biphenyls (PCB) and is used in industrial activities as hydraulic fluids, coolants, lubricating, etc. [90]. Pyrene is one of PAHs, which is generated due to incomplete combustion and used in industrial activities [91].

To be able to see the effect of the significant discharges, upstream and downstream of the plant were compared in terms of pollution loads values. This comparison can be seen in Figure 47 and Table 32.

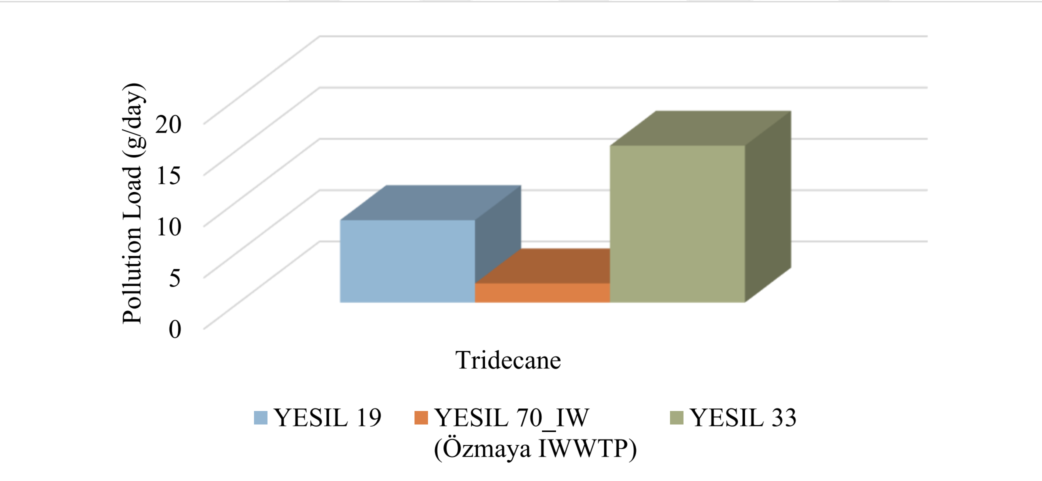

Figure 47. Pollution load comparison between upstream (YESIL 19) and downstream (YESIL 33) stations of Özmaya IWWTP (YESIL 70_IW)

Table 32. Comparison of the significant micropollutants from the discharge of Özmaya IWWTP with its upstream and downstream

Micropollutants	AA-EQS (µg/L)	YESIL 19 (Upstream)		YESIL 70_IW (Özmaya IWWTP)		YESIL 33 (Downstream)		% Change in load
		Concentration (µg/L)	Load (g/day)	Concentration (µg/L)	Load (g/day)	Concentration (µg/L)	Load (g/day)	
Tridecane	0.05	0.01 (<LOD)	8	3.4	2	0.01 (<LOD)	15	47.5
Avg. flowrate (m^3/h)		33485.05		23.18		63744.36		

Both bar graphs in Figure 47 and data in Table 32 show how pollution load changed after the discharge of Özmaya IWWTP effluent into the river. The average load of tridecane in the downstream was higher than the load in the upstream. It is estimated that discharge from Özmaya IWWTP contributed to that increase. However, since tridecane could not be detected in neither upstream nor downstream, that increase might also be due to the higher flowrate in the downstream. Also, as it was indicated previously, tridecane is a solvent mostly used in the paper or rubber industries. Hence, high tridecane discharges were not expected from a food (yeast) factory. The other micropollutants whose concentrations exceeded their EQSs were also unexpected from a yeast factory.

5.2.2.9 Eti Copper IWWTP

Eti Copper Co. located in Samsun is the only factory that produces copper from ore in Turkey. Eti Copper Co. Samsun includes a smelter and anode casting plant, sulphuric acid plant, concentrator plant, and electrolysis/copper cathode plant. The production capacity of the plant is 70,000 tons/year for each of the blister, anode, and cathode copper production [92]. The plant has three different WWTPs. Two of them are for domestic wastewaters and one of them is for industrial wastewaters. The treatment capacity of the IWWTP is 3,120 m^3/day and the average flowrate of the IWWTP is 1,700 m^3/day. The detailed flow diagram of the plant is shown in Figure 48.

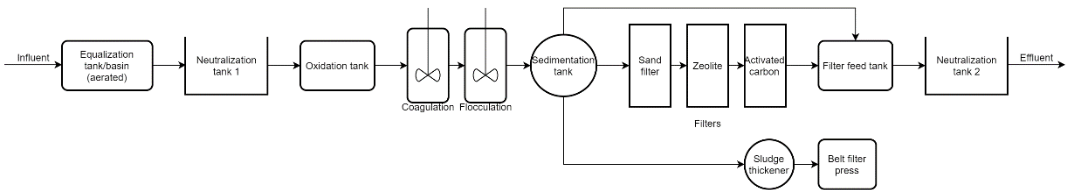

Figure 48. Process flow diagram of Eti Copper IWWTP

The samples from the discharge of Eti Copper IWWTP, which was coded as YESIL 71_IW, were taken for two periods in November and August 2017. There were no upstream and downstream stations of Eti Copper IWWTP. Hence, only tier 0 was applied to the analysis results of the IWWTP. According to the analysis results, 4 priority substances and 19 basin-specific pollutants, in total 23 micropollutants, were detected in the effluent of Eti Copper IWWTP. After applying tier 0, 15 micropollutants were eliminated because their average concentrations were below the AA-EQS values. The number of the micropollutants whose average concentrations exceeded their AA-EQSs was 8 and two of them were priority substances (Cd, and Pb). The others were Al, Cu, Fe, petroleum hydrocarbons, Si, and Zn. Since there were no upstream flowrate knowledge, PC and the relative increase could not be calculated for the effluent of Eti Copper IWWTP. The calculated average concentrations, EQS exceedances, and discharged average loads are given in Table 33 for each micropollutant exceeding its AA-EQS.

Table 33. Concentrations and loads of the micropollutants exceeded AA-EQSs in the effluent of Eti Copper IWWTP (YESIL 71_IW)

Micropollutants	**Avg. conc. (μg/L)**	**AA-EQS μg/L)**	**% EQS exceedance**	**Avg. pollution load (g/d)**
Cd	0.08	0.08*	1.9	0.12
Pb	2.8	1.2	135	4
Al	88.7	47.8	85.5	133
Cu	24.0	13.2	83.5	36
Fe	145.0	98.6	47.0	217
Petroleum hydrocarbons	118.5	96	23.4	178
Si	2422.5	1830	32.4	3634
Zn	25.7	5.9	335.9	39
Avg. flowrate (m^3/h)			**62.5**	

*AA-EQS for Class 1 or 2

The average discharge flowrate of the IWWTP was measured as 62.5 m^3/h (approximately 1,500 m^3/day). According to the calculated pollution loads, it can be estimated that Eti Copper IWWTP may have a significant impact on the receiving environment in terms of metal pollution. Because the average concentrations of metals (Pb, Al, Cu, Fe, and Zn) exceeded their AA-EQS values considerably. Especially, Zn pollution is likely to be caused by discharge from Eti Copper IWWTP.

5.2.2.10 Yemsel Poultry and Livestock IWWTP

Yemsel Poultry and Livestock Inc. is in poultry and feed production as the name implies. White meat production is the main activity in the plant and the plant has its own WWTP. The IWWTP is operated intermittently. However, any further information could not be found for the Yemsel Poultry IWWTP.

The samples from the discharge of Yemsel Poultry IWWTP, which was coded as YESIL 73_IW, were taken for four periods between June 2017 and January 2018. There were no upstream and downstream stations of Yemsel Poultry IWWTP. Hence, only tier 0 was applied to the analysis results of the IWWTP. According to the analysis results, 6 priority substances and 24 basin-specific pollutants, in total 30 micropollutants, were detected in the effluent of Yemsel Poultry IWWTP. After applying tier 0, 21 micropollutants were eliminated because their average concentrations were below the AA-EQS values. The number of the micropollutants whose average concentrations exceeded their AA-EQSs was 9 and two of them were priority substances (Ni and Pb). The others were bromide, Co, Cu, Fe, petroleum hydrocarbons, Si, and Zn. Since there were no upstream flowrate knowledge, PC and the relative increase could not be calculated for the effluent of Yemsel Poultry IWWTP. The calculated average concentrations, EQS exceedances, and discharged average loads are given in Table 34 for each micropollutant exceeding its AA-EQS.

Table 34. Concentrations and loads of the micropollutants exceeded AA-EQSs in the effluent of Yemsel Poultry IWWTP (YESIL 73_IW)

Micropollutants	Avg. conc. (µg/L)	AA-EQS µg/L)	% EQS exceedance	Avg. pollution load (g/d)
Ni	4.9	4	23.5	0.2
Pb	1.4	1.2	15.2	0.05
Bromide	50.2	31	61.8	1.8
Co	0.8	0.3	157.5	0.03
Cu	18.0	13.2	36.3	0.7
Fe	154.1	98.6	56.3	6
Petroleum hydrocarbons	98.5	96	2.6	4
Si	6308.7	1830	244.7	229
Zn	112.9	5.9	1813.0	4
Avg. flowrate (m^3/h)			**1.51**	

The average discharge flowrate of the IWWTP was measured as 1.51 m^3/h (approximately 36.24 m^3/day). According to the calculated pollution loads, it can be estimated that Yemsel Poultry IWWTP might have a significant impact on the receiving environment especially in terms of Co, Si, and Zn. Because the average concentrations of these micropollutants exceeded their AA-EQS values highly. On the other hand, the average flowrate of the effluent was very low. Therefore, the relative increase ratios of Yemsel Poultry IWWTP may not be significant. The upstream flowrate must be known for any estimation.

5.2.2.11 Yuva Viol and Package IWWTP

Yuva Viol was started to operate in 1997 in Çorum. In the plant, packaging materials are being produced such as egg trays, vegetable and fruit trays, industrial material trays, medical disposables made of moulded paper, etc. [93]. The wastewater generated from the production process is sent to the WWTP of Yuva Viol. The capacity of Yuva Viol IWWTP is 50 m^3/day, and the plant is operated intermittently. It was learned from the facility authorities that the IWWTP is currently undergoing revision. The detailed flow diagram of the plant is shown in Figure 49.

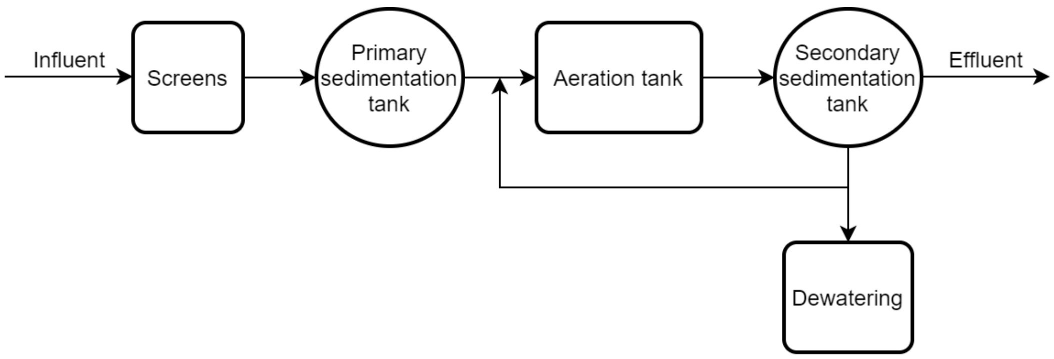

Figure 49. Process flow diagram of Yuva Viol IWWTP

The samples from the discharge of Yuva Viol IWWTP, which was coded as YESIL 76_IW, were taken for three periods in August 2017, November, and August 2017.

There were no upstream and downstream stations of Yuva Viol IWWTP. Hence, only tier 0 was applied to the analysis results of the IWWTP. According to the analysis results, 7 priority substances and 25 basin-specific pollutants, in total 32 micropollutants, were detected in the effluent of Yuva Viol IWWTP. After applying tier 0, 20 micropollutants were eliminated because their average concentrations were below the AA-EQS values. The number of the micropollutants whose average concentrations exceeded their AA-EQSs was 12 and four of them were priority substances (benzo(a)pyrene, Cd, dichlorvos, and Pb). The others were Al, bromide, Co, Fe, petroleum hydrocarbons, Si, V, and Zn. Since there were no upstream flowrate knowledge, PC and the relative increase could not be calculated for the effluent of Yuva Viol IWWTP. The calculated average concentrations, EQS exceedances, and discharged average loads are given in Table 35 for each micropollutant exceeding its AA-EQS.

Table 35. Concentrations and loads of the micropollutants exceeded AA-EQSs in the effluent of Yuva Viol IWWTP (YESIL 76_IW)

Micropollutants	Avg. conc. (μg/L)	AA-EQS μg/L)	% EQS exceedance	Avg. pollution load (g/d)
Benzo(a)pyrene	0.006	0.00017	3252.9	0.0002
Cd	0.2	0.08*	156.3	0.007
Dichlorvos	0.004	0.0006	594.4	0.0001
Pb	3.3	1.2	177.5	0.1
Al	138.1	47.8	188.9	5
Bromide	324.6	31	947.1	11
Co	0.6	0.3	100.0	0.02
Fe	537.1	98.6	444.8	18
Petroleum hydrocarbons	168.0	96	75.0	6
Si	10261.0	1830	460.7	345
V	13.2	1.6	722.9	0.4
Zn	96.4	5.9	1534.6	3
Avg. flowrate (m^3/h)			**1.4**	

*AA-EQS for Class 1-2

The average discharge flowrate of the IWWTP was measured as 1.4 m^3/h (approximately 33.6 m^3/day). The average concentrations of the listed micropollutants exceeded their AA-EQS values considerably and almost all EQS exceedances of the listed micropollutants were higher than 100%. Especially, Zn and benzo(a)pyrene may have relative increase ratios greater than 2%. However, the average flowrate of the effluent was very low. This situation decreases the probability of Yuva Viol IWWTP having significant discharges.

5.2.2.12 Et-Bir Suluova Slaughterhouse IWWTP

Et-Bir Suluova Slaughterhouse was previously operated by the Municipality of Suluova and had a WWTP which was not operated properly. Then, it was privatized and the WWTP was improved. Et-Bir Slaughterhouse IWWTP has a capacity of 290 m^3/day. The average wastewater flowrate coming to the IWWTP is 60 m^3/day and the treated wastewater in the physical and biological treatment units is discharge to Tersakan Creek. The detailed flow diagram of the plant is shown in Figure 50.

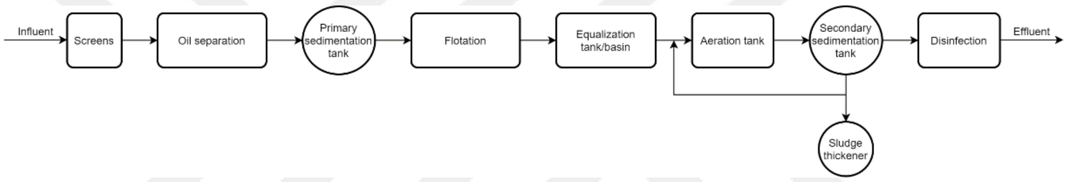

Figure 50. Process flow diagram of Et-Bir Slaughterhouse IWWTP

The samples from the discharge of Et-Bir Slaughterhouse IWWTP, which was coded as YESIL 77_IW, were taken for four periods between June 2017 and January 2018. The upstream station of the plant is YESIL 123, which has a distance of 0.2 km to the plant, while the downstream station of the plant is YESIL 32, which is 8 km away from the plant. Figure 51 illustrates the locations of these stations in the streamline.

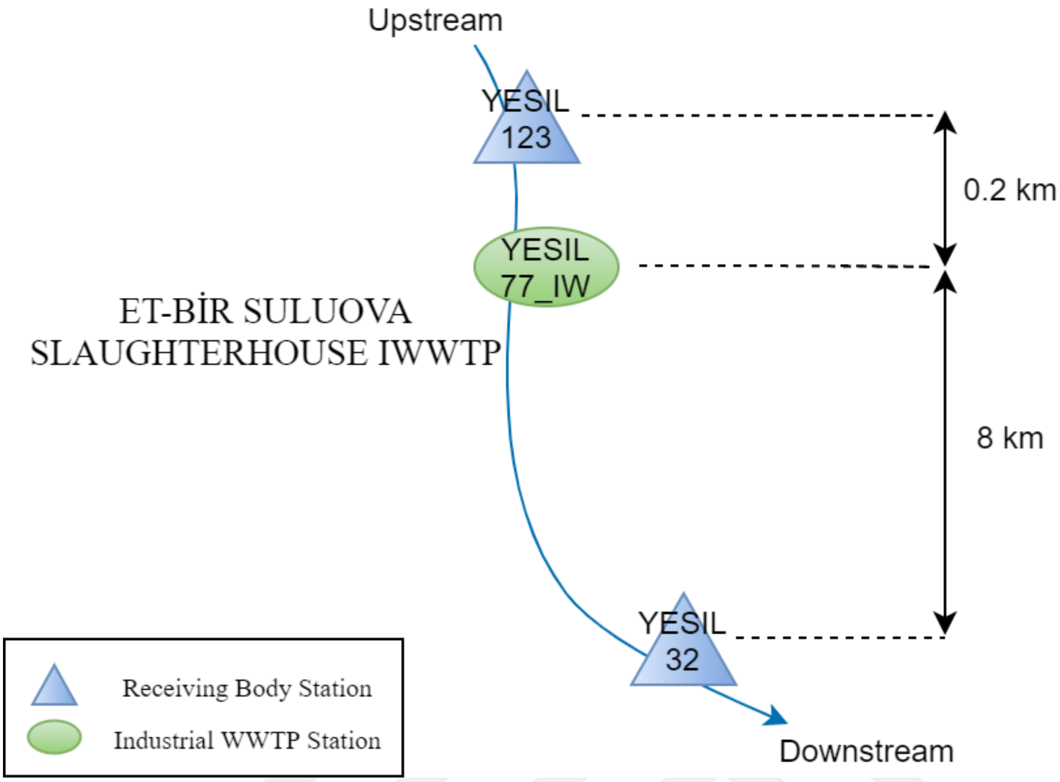

Figure 51. Illustration of the stations that locate in the same streamline, where Et-Bir Slaughterhouse IWWTP is and distances between them

According to the analysis results, 5 priority substances and 28 basin-specific pollutants, in total 33 micropollutants, were detected in the effluent of Et-Bir Slaughterhouse IWWTP. After applying tier 0, 20 micropollutants were eliminated because their average concentrations were below the AA-EQS values. The number of the micropollutants whose average concentrations exceeded their AA-EQSs was 13 and two of them were priority substances (Ni and Pb). The other micropollutants exceeding AA-EQSs were Al, bis(2-ethylhexyl) terephthalate, bromide, Co, Cu, Fe, free CN, petroleum hydrocarbons, Si, V, and Zn. After micropollutants that exceeded AA-EQSs were determined, PC and relative increase for these chemicals were calculated (tier 1) and only two of the listed micropollutants passed tier 1, i.e., their relative increases were greater than 2%. The calculated data are given in Table 36 for each micropollutant exceeding its AA-EQS.

Table 36. Concentrations and loads of the micropollutants exceeded AA-EQSs in the effluent of Et-Bir Slaughterhouse IWWTP (YESIL 77_IW) with related PC and relative increase

Micropollutants	**Avg. conc. (μg/L)**	**AA-EQS μg/L)**	**% EQS exceedance**	**Avg. pollution load (g/d)**	**PC**	**% Relative increase**
Ni	5.3	4	33.4	0.6	0.02	0.5
Pb	2.0	1.2	68.5	0.2	0.007	0.6
Al	82.0	47.8	71.5	10	0.3	0.6
Bis(2-ethylhexyl) terephthalate	0.3	0.1	172.6	0.03	0.001	1.0
Bromide	40583.0	31	130814.3	4928	150.4	**485.2**
Co	0.9	0.3	194.2	0.1	0.003	1.1
Cu	24.5	13.2	85.6	3	0.1	0.7
Fe	263.3	98.6	167	32	1.0	**1.0**
Free CN	1.5	1.2	27.1	0.2	0.01	0.5
Petroleum hydrocarbons	128.0	96	33.3	16	0.5	0.5
Si	7383.0	1830	303.4	897	27.4	1.5
V	1.7	1.6	3.3	0.2	0.01	0.4
Zn	90.5	5.9	1433.9	11	0.3	**5.7**
Avg. flowrate (m^3/h)			**5.06**			

The average upstream flowrate of Et-Bir Slaughterhouse IWWTP was measured as 1,360.08 m^3/h while the average discharge flowrate of the IWWTP was 5.06 m^3/h. Since the effluent flowrate of the plant was very low according to the upstream flowrate, its impact on the receiving water was not significant although the discharged concentrations of some of the micropollutants were high. Bromide had the highest relative increase ratio with 485.2%. Its average concentration exceeded the relative AA-EQS by 130,814%. Zn had the second relative increase ratio with 5.69%. Its average concentration was much higher than the relative AA-EQS by exceeding 1,434%. According to these results, it is estimated that discharge from Et-Bir Slaughterhouse IWWTP has a significant impact on the receiving body in terms of bromide and Zn. The average concentration of bis(2-ethylhexyl) terephthalate also exceeded its AA-EQS values although its relative increase ratio was not significant. Bis(2-ethylhexyl) terephthalate is a plasticizer used in the manufacturing of PVC, vinyl chloride, dyes, etc. Some acute and chronic effects have been observed in the animals due to exposure through mostly food [94].

To be able to see the effect of the significant discharges, upstream and downstream of the plant were compared in terms of pollution loads values. This comparison can be seen in Figure 52 and Table 37.

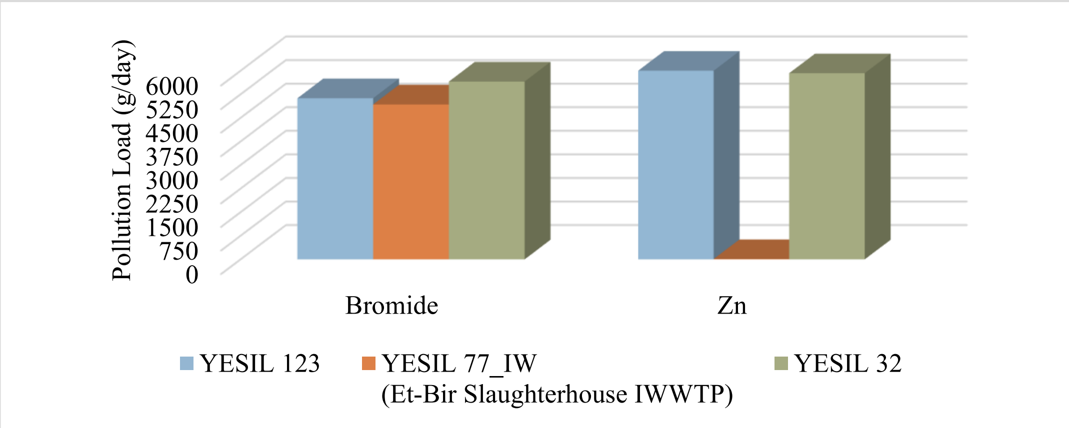

Figure 52. Pollution load comparison between upstream (YESIL 123) and downstream (YESIL 32) stations of Et-Bir Slaughterhouse IWWTP (YESIL 77_IW)

Table 37. Comparison of the significant micropollutants from the discharge of Et-Bir Slaughterhouse IWWTP with its upstream and downstream

Micropollutants	AA-EQS (µg/L)	YESIL 123 (Upstream)		YESIL 77_IW (Et-Bir Slaughterhouse IWWTP)		YESIL 32 (Downstream)		% Change in load
		Concentration (µg/L)	Load (g/day)	Concentration (µg/L)	Load (g/day)	Concentration (µg/L)	Load (g/day)	
Bromide	31	157.0	5126	40583.0	4928	95.5	5657	9.4
Zn	5.9	298.0	9726	90.5	11	100.0	5922	**-64.2**
Avg. flowrate (m^3/h)		1360.08		5.06		2467.71		

Both bar graphs in Figure 52 and data in Table 37 show how pollution load changed after the discharge of Et-Bir Slaughterhouse IWWTP effluent into the river. The average load of bromide in the downstream was higher than the load in the upstream. However, the load increase in the downstream seems lower than expected because bromide load contributed by the IWWTP was very high. On the other hand, the average load of Zn in the downstream was lower than the load in the upstream despite the high relative increase ratio. This may be because of the fate of Zn in the environment.

5.2.2.13 Kozlu Food IWWTP

Kozlu Food has several facilities in Turkey and one of them is in Suluova, which is a county of Amasya. The main activity of the company is the manufacturing of floor, animal feeds, and eggs [95]. The facility in Suluova produces animal feeds and eggs. Any technical information about Kozlu Food IWWTP could not be found. Therefore, a more detailed process flow diagram could not be figured.

The samples from the discharge of Kozlu Food IWWTP, which was coded as YESIL 78_IW, were taken for four periods between June 2017 and January 2018. The upstream station of the plant is YESIL 122, which has a distance of 0.1 km to the plant, while the downstream station of the plant is YESIL 125, which is 20 km away from the plant. Figure 53 illustrates the locations of these stations in the streamline.

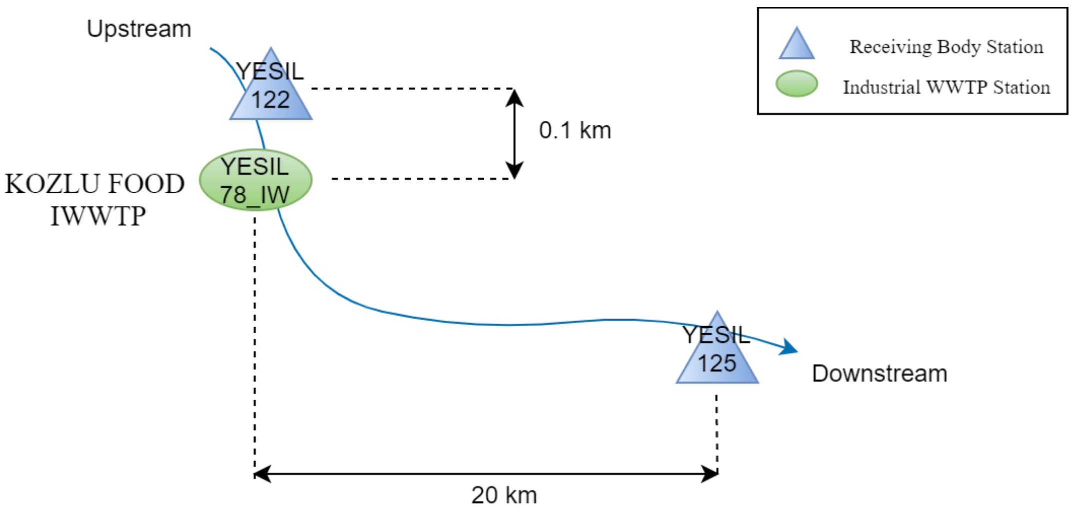

Figure 53. Illustration of the stations that locate in the same streamline, where Kozlu Food IWWTP is and distances between them

According to the analysis results, 5 priority substances and 31 basin-specific pollutants, in total 36 micropollutants, were detected in the effluent of Kozlu Food IWWTP. After applying tier 0, 23 micropollutants were eliminated because their average concentrations were below the AA-EQS values. The number of the micropollutants whose average concentrations exceeded their AA-EQSs was 13 and only two of them were priority substances (Ni and Pb). The other micropollutants exceeding AA-EQSs were Al, bis(2-ethylhexyl) terephthalate, bromide, Co, Cr, Cu, Fe, petroleum hydrocarbons, Si, V, and Zn. After micropollutants that exceeded AA-EQSs were determined, PC and relative increase for these chemicals were calculated (tier 1) and relative increases of all abovementioned micropollutants were smaller than 2%. The calculated data are given in Table 38 for each micropollutant exceeding its AA-EQS.

Table 38. Concentrations and loads of the micropollutants exceeded AA-EQSs in the effluent of Kozlu Food IWWTP (YESIL 78_IW) with related PC and relative increase

Micropollutants	**Avg. conc. (µg/L)**	**AA-EQS µg/L)**	**% EQS exceedance**	**Avg. pollution load (g/d)**	**PC**	**% Relative increase**
Ni	4.3	4	7.0	0.1	0.002	0.1
Pb	3.3	1.2	175.8	0.1	0.002	0.1

Table 38. (cont'd)

Micropollutants	Avg. conc. (μg/L)	AA-EQS μg/L)	% EQS exceedance	Avg. pollution load (g/d)	PC	% Relative increase
Al	417.9	47.8	774.2	11	0.2	0.4
Bis(2-ethylhexyl) terephthalate	0.4	0.1	335.1	0.01	0.0002	0.2
Bromide	135.3	31	336.4	4	0.07	0.2
Co	0.6	0.3	115.8	0.02	0.0001	0.1
Cr	8.6	1.6	438.1	0.2	0.004	0.3
Cu	21.4	13.2	62.3	0.6	0.01	0.1
Fe	574.2	98.6	482.3	15	0.3	0.3
Petroleum hydrocarbons	235.0	96	144.8	6	0.1	0.1
Si	13865.0	1830	657.7	370	6.9	0.4
V	19.5	1.6	1116.6	0.5	0.01	0.6
Zn	232.3	5.9	3837.5	6	0.1	1.9
Avg. flowrate (m^3/h)			**1.11**			

The average upstream flowrate of Kozlu Food IWWTP was measured as 2,233.63 m^3/h while the average discharge flowrate of the IWWTP was 1.11 m^3/h. In the comparison of the flowrates, the effluent flowrate was negligibly small. As a result of this situation, relative increase ratios of all micropollutants exceeding AA-EQSs were calculated smaller than 2%. Therefore, a comparison of pollution loads in the upstream and downstream was not needed. In conclusion, the discharges of Kozlu Food IWWTP does not have a significant impact on the receiving body.

5.2.2.14 Bakraç Dairies IWWTP

Bakraç Dairies is one of the biggest companies in the milk and milk products manufacturing sector in Tukey. The production facility of Bakraç Dairies in Amasya processes the supplied milk to produce UHT milk, yogurt, butter, and cheeses [96]. The facility has a WWTP with a capacity of 200 m^3/day. Bakraç Dairies IWWTP consists of physical, chemical, and biological treatment units, and the average wastewater flowrate coming to the IWWTP is 150 m^3/day. The treated wastewater is discharged to Tersakan Creek. The detailed flow diagram of the plant is shown in Figure 54.

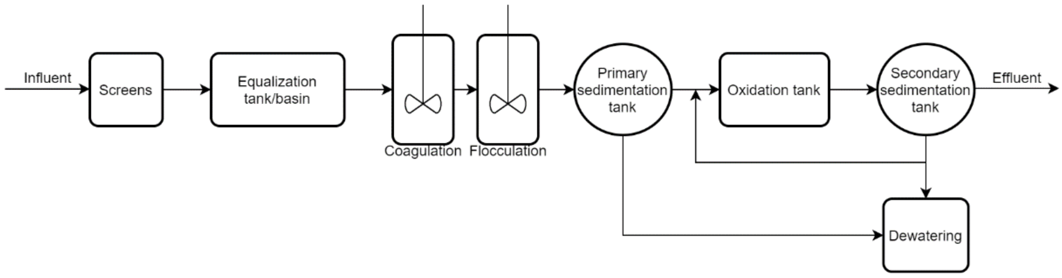

Figure 54. Process flow diagram of Bakraç Dairies IWWTP

The samples from the discharge of Bakraç Dairies IWWTP, which was coded as YESIL 79_IW, were taken for four periods between June 2017 and January 2018. The upstream station of the plant is YESIL 125, which has a distance of 0.3 km to the plant, while the downstream station of the plant is YESIL 20, which is 10 km away from the plant. Figure 55 illustrates the locations of these stations in the streamline.

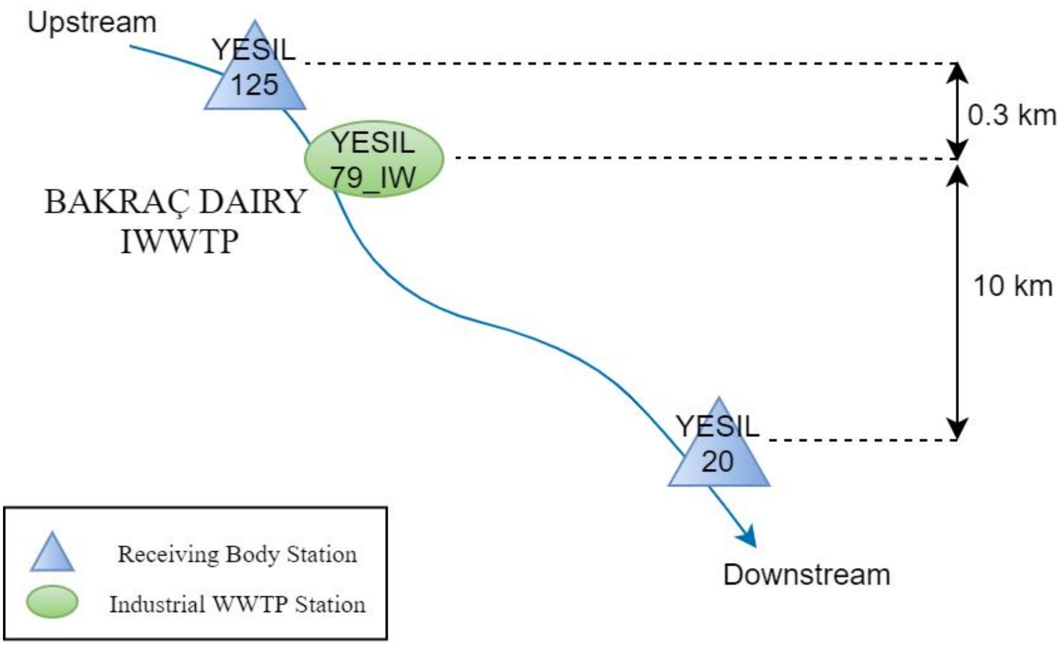

Figure 55. Illustration of the stations that locate in the same streamline, where Bakraç Dairies IWWTP is and distances between them

According to the analysis results, 4 priority substances and 22 basin-specific pollutants, in total 26 micropollutants, were detected in the effluent of Bakraç Dairies

IWWTP. After applying tier 0, 16 micropollutants were eliminated because their average concentrations were below the AA-EQS values. The number of the micropollutants whose average concentrations exceeded their AA-EQSs was 10 and three of them were priority substances (Hg, Ni, and Pb). The other micropollutants exceeding AA-EQSs were Al, bromide, Co, Cu, Fe, Si, and Zn. After micropollutants that exceeded AA-EQSs were determined, PC and relative increase for these chemicals were calculated (tier 1) and three of the listed micropollutants passed tier 1, i.e., their relative increases were greater than 2%. The calculated data are given in Table 39 for each micropollutant exceeding its AA-EQS.

Table 39. Concentrations and loads of the micropollutants exceeded AA-EQSs in the effluent of Bakraç Dairies IWWTP (YESIL 79_IW) with related PC and relative increase

Micropollutants	**Avg. conc. (µg/L)**	**AA-EQS µg/L)**	**% EQS exceedance**	**Avg. pollution load (g/d)**	**PC**	**% Relative increase**
Hg	0.1	0.07*	47.6	0.02	0.0004	0.6
Ni	16.0	4	301.2	3	0.06	1.5
Pb	2.0	1.2	69.2	0.4	0.01	0.6
Al	67.0	47.8	40.1	14	0.3	0.5
Bromide	139.0	31	348.5	29	0.5	1.7
Co	2.7	0.3	796.7	0.6	0.01	**3.4**
Cu	17.8	13.2	35.0	4	0.07	0.5
Fe	2484.2	98.6	2419.5	509	9.4	**9.6**
Si	3706.0	1830	102.5	760	14.1	0.77
Zn	556.7	5.9	9334.7	114	2.1	**35.8**
Avg. flowrate (m^3/h)			**8.54**			

*MAC-EQS

The average upstream flowrate of Bakraç Dairies IWWTP was measured as 2,239.2 m^3/h while the average discharge flowrate of the IWWTP was 5.06 m^3/h. Since the effluent flowrate of the plant was very low according to the upstream flowrate, its impact on the receiving water was not significant although the discharged concentrations of the micropollutants were high. The highest EQS exceedances belonged to Zn, Fe, and Co. Hence, these metals had relative increase ratios greater than 2%. Besides, Ni and bromide exceeded their AA-EQS values by 301% and 349%, respectively. However, their relative increase ratios were smaller than 2%.

According to these results, it is estimated that discharge from Bakraç Dairies IWWTP has a significant impact on the receiving body in terms of metal pollution (Co, Fe, and Zn).

To be able to see the effect of the significant discharges, upstream and downstream of the plant were compared in terms of pollution loads values. This comparison can be seen in Figure 56 and Table 40.

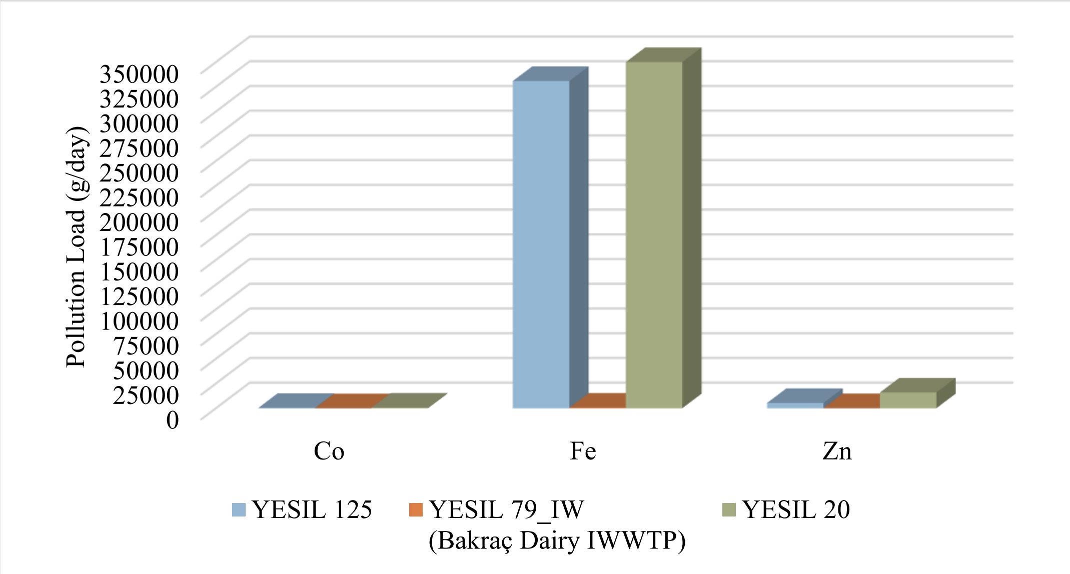

Figure 56. Pollution load comparison between upstream (YESIL 125) and downstream (YESIL 20) stations of Bakraç Dairies IWWTP (YESIL 79_IW)

Both bar graphs in Figure 56 and data in Table 40 show how pollution load changed after the discharge of Bakraç Dairies IWWTP effluent into the river. The average loads of the significantly effective micropollutants were higher than the loads in the upstream. However, the reason for the increase in the pollution loads was also the higher flowrate in the downstream. When concentrations are compared, it can be seen that dilution is effective due to the increase in the flowrate of the downstream. Nevertheless, Bakraç Dairies IWWTP has significant discharge to the receiving body, especially for Fe and Zn.

Table 40. Comparison of the significant micropollutants from the discharge of Bakraç Dairies IWWTP with its upstream and downstream

Micropollutants	AA-EQS (µg/L)	YESIL 125 (Upstream)		YESIL 79_IW (Bakraç Dairies IWWTP)		YESIL 20 (Downstream)		% Change in load
		Concentration (µg/L)	Load (g/day)	Concentration (µg/L)	Load (g/day)	Concentration (µg/L)	Load (g/day)	
Co	0.3	5.4	292	2.7	0.6	3.4	588	50.4
Fe	98.6	6156.3	330844	2484.2	509	2871.4	500762	33.9
Zn	5.9	98.8	5311	556.7	114	91.1	15885	66.6
Avg. flowrate (m^3/h)		2239.2		8.54		7266.52		

5.3 Micropollutant Removal in WWTPs

There is not a certain technology for the removal of all micropollutants with high efficiency. It is known that micropollutant removal efficiencies of conventional biological treatment systems are lower than the efficiencies of advanced treatment systems. However, even in the advanced treatment methods, all kinds of micropollutants cannot be removed efficiently. The removal conditions change according to each micropollutant. Additionally, sometimes, concentrations of micropollutants are observed to increase at the effluent of treatment units (negative removal) due to the cleavage of conjugated residues [97]. The other reason for the negative removal is to not consider HRT so that the effluent does not show the result of the sampled influent [47]. Nevertheless, micropollutant removal is possible with the proper choice of treatment method in concurrence with the accurate characterization of the relevant wastewater.

The micropollutant removal efficiencies of five of the WWTPs examined in Section 5.2 were evaluated in this section. The WWTPs that had influent wastewater data were Tokat UWWTP, Çorum UWWTP, Amasya UWWTP, Merzifon OIZ IWWTP, and Meray Oil IWWTP. During the monitoring study, the influent data of these WWTPs were also coded. In Table 41, the given codes and relative WWTPs of the influents are listed with the number of monitored periods. Sampling analysis results of the influent stations of UWWTPs and IWWTPs for all monitoring periods with the LOD and AA-EQS values of the relative micropollutants are given in Appendix H.

Table 41. The WWTPs that had influent data and their codes

Code for Influent	Relative WWTP	# of monitored periods
YESIL 104_INF	Tokat UWWTP	3
YESIL 105_INF	Çorum UWWTP	3
YESIL 106_INF	Amasya UWWTP	3
YESIL 102_INF	Meray Oil IWWTP	2
YESIL 103_INF	Merzifon OIZ IWWTP	3

5.3.1 Tokat UWWTP

The Tokat UWWTP was one of the UWWTPs that had influent data and the code given for the influent data of the Tokat UWWTP was YESIL 104_INF. The samples from the influents of the Tokat UWWTP were taken for three periods between August 2017 and January 2018. Secondary treatment is applied in Tokat UWWTP, and a detailed flow diagram is given in Figure 13.

According to the analysis results, 8 priority substances and 31 basin-specific pollutants, in total 39 micropollutants, were detected in the influent of Tokat UWWTP. The number of the micropollutants whose average concentrations exceeded their AA-EQSs was 13 and three of them were priority substances (dichlorvos, Ni, and Pb). The others were Al, Co, Cr, Cu, Fe, free CN, petroleum hydrocarbons, Si, V, and Zn. The concentrations of dichlorvos, Ni, free CN, and V exceeded their AA-EQS values in the influent while they did not exceed the relative AA-EQS values in the effluent samples. This can be the result of the treatment.

To be able to see the removal efficiencies of micropollutants in Tokat UWWTP, the average concentrations and loads of the micropollutants exceeding in the influent and effluent were compared. The comparisons can be seen in Table 42 and Figure 57.

Table 42. Average concentrations of the micropollutants exceeding the relative AA-EQS values in the influent and effluent of Tokat UWWTP

Micropollutants	**Avg. concentration (µg/L)**		**% Removal efficiency**
	Influent (YESIL 104_INF)	**Effluent (YESIL 45_UW)**	
Dichlorvos	0.01	0.00025(<LOD)	98.2
Ni	19.7	3.8	80.9
Pb	3.1	2.2	25.9
Al	189.3	149.2	21.2
Co	0.4	0.3	10.3
Cr	5.2	3.1	39.9
Cu	22.3	27.9	**-24.9**
Fe	352.9	146.1	58.6
Free CN	2.4	0.5 (<LOD)	78.7

Table 42. (cont'd)

Micropollutants	Avg. concentration (μg/L)		% Removal efficiency
	Influent (YESIL 104_INF)	Effluent (YESIL 45_UW)	
Petroleum hydrocarbons	293.0	246.0	16.0
Si	7304.3	8428.7	**-15.4**
Tridecane	0.01 (<LOD)	0.2	**-2170.0**
V	2.7	0.5	82.1
Zn	82.0	80.4	2.0
Imidacloprid	0.01 (<LOD)	0.1	**-1330.0**
Avg. flowrate (m^3/h)	830.3	623.9	

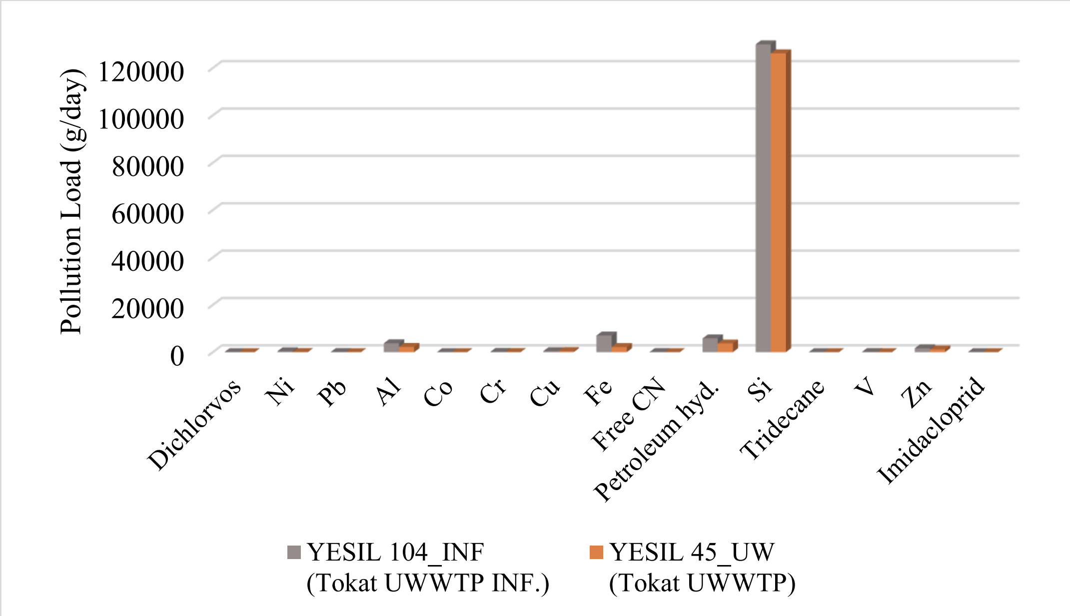

Figure 57. Average pollution load comparison between influent (YESIL 104_INF) and effluent (YESIL 45_UW) of Tokat UWWTP

According to the results, dichlorvos, Ni, Fe, free CN, and V were removed with high efficiencies while Pb, Al, Co, Cr, petroleum hydrocarbons, and Zn were removed with lower efficiencies. On the other hand, negative removal was observed for Cu, Si, tridecane, and imidacloprid. Tridecane and imidacloprid could not be detected in the influent sample of the UWWTP although their average concentrations exceeded the relative AA-EQS values in the effluent. Therefore, it was expected to observe negative removals for these micropollutants.

5.3.2 Çorum UWWTP

The Çorum UWWTP was the other UWWTP that had influent data and the code given for the influent data of the Çorum UWWTP was YESIL 105_INF. The samples from influents of the Çorum UWWTP were taken for three periods between August 2017 and January 2018. Secondary treatment is applied in the Çorum UWWTP, and a detailed flow diagram is given in Figure 19.

According to the analysis results, 9 priority substances and 30 basin-specific pollutants, in total 39 micropollutants, were detected in the influent of the Çorum UWWTP. The number of the micropollutants whose average concentrations exceeded their AA-EQSs was 16 and four of them were priority substances (Cd, Ni, Pb, and trichloromethane). The others were Al, bromide, Co, Cr, Cu, Fe, free CN, petroleum hydrocarbons, Si, Ti, V, and Zn. The concentrations of trichloromethane, Ti, and V exceeded their AA-EQS values in the influent while they did not exceed the relative AA-EQS values in the effluent samples. This can be the result of the treatment.

To be able to see the removal efficiencies of micropollutants in the Çorum UWWTP, the average concentrations and loads of the micropollutants exceeding in the influent and effluent were compared. The comparisons can be seen in Table 43 and Figure 58.

Table 43. Average concentrations of the micropollutants exceeding the relative AA-EQS values in the influent and effluent of the Çorum UWWTP

Micropollutants	**Avg. concentration (µg/L)**		**% Removal efficiency**
	Influent (YESIL 105_INF)	**Effluent (YESIL 48_UW)**	
Cd	0.8	1.2	**-49.4**
Dichlorvos	0.00025(<LOD)	0.01	**-3650.0**
Ni	16.1	5.9	63.2
Nonylphenols	0.01	0.4	**-3100.6**
Octylphenols	0.01	0.1	**-1995.2**
Pb	27.5	3.8	86.2
Trichloromethane	2.5	1.1	56.2
Al	2321.5	171.4	92.6

Table 43. (cont'd)

Micropollutants	Avg. concentration (μg/L)		% Removal efficiency
	Influent (YESIL 105_INF)	Effluent (YESIL 48_UW)	
Bromide	580.5	259.6	55.3
Co	2.8	3.9	**-37.7**
Cr	12.1	2.1	83.1
Cu	57.1	24.1	57.7
Fe	2952.3	498.3	83.1
Free CN	3.2	1.4	54.9
Petroleum hydrocarbons	749.0	133.3	82.2
Si	8440.0	6213.0	26.4
Ti	26.7	3.8(<LOD)	85.6
V	10.5	1.5	86.2
Zn	343.6	115.2	66.5
Ethalfluralin	0.0025(<LOD)	0.7	**-26783.3**
Avg. flowrate (m^3/h)	2200	2291.67	

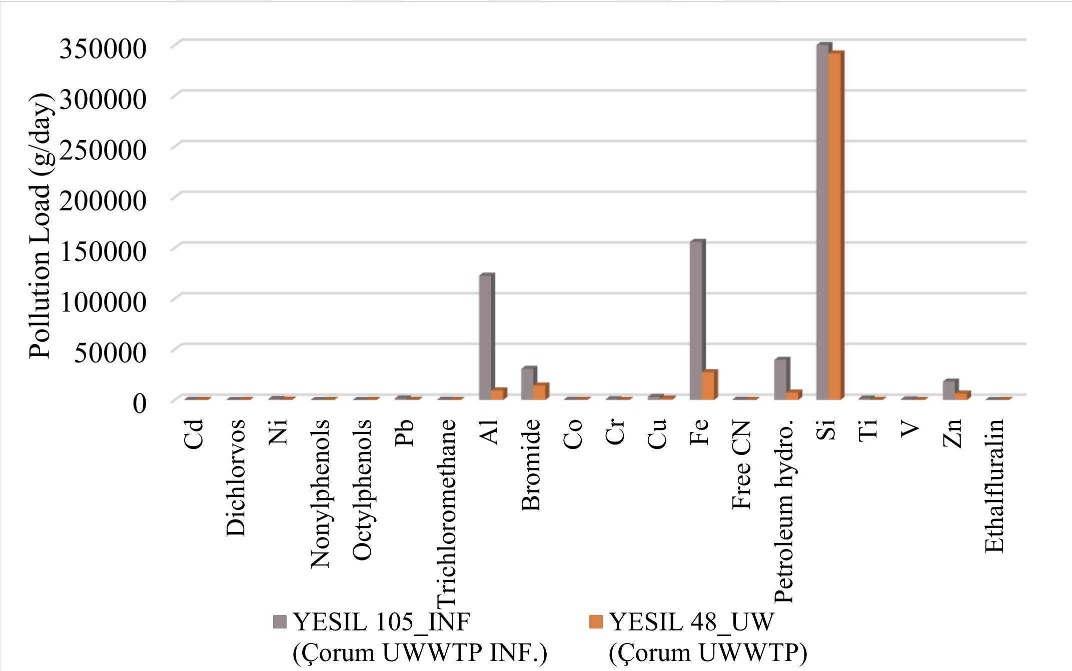

Figure 58. Average pollution load comparison between influent (YESIL 105_INF) and effluent (YESIL 48_UW) of the Çorum UWWTP

According to the results, Ni, Pb, Al, Cr, Fe, petroleum hydrocarbons, Ti, V, and Zn were removed with high efficiencies while trichloromethane, bromide, Cu, free CN, and Si were removed with lower efficiencies. On the other hand, negative removal was observed for Cd, dichlorvos, nonylphenols, octylphenols, Co, and ethalfluralin. Dichlorvos, nonylphenols, octylphenols, and ethalfluralin could not be detected in the influent sample of the UWWTP although their average concentrations exceeded the relative AA-EQS values in the effluent. Therefore, it was expected to observe negative removals for these micropollutants.

5.3.3 Amasya UWWTP

The Amasya UWWTP was the last UWWTP that had influent data and the code given for the influent data of the Amasya UWWTP was YESIL 106_INF. The samples from influents of the Amasya UWWTP were taken for three periods between August 2017 and January 2018. Secondary treatment is also applied in the Amasya UWWTP, and a detailed flow diagram is given in Figure 23.

According to the analysis results, 8 priority substances and 29 basin-specific pollutants, in total 37 micropollutants, were detected in the influent of Amasya UWWTP. The number of the micropollutants whose average concentrations exceeded their AA-EQSs was 17 and five of them were priority substances (Cd, dichlorvos, Ni, Pb, and trichloromethane). The others were Al, bis(2-ethylhexyl) terephthalate, Co, Cr, Cu, Fe, free CN, petroleum hydrocarbons, propylbenzene, Si, V, and Zn. The concentrations of Cd, dichlorvos, Ni, trichloromethane, bis(2-ethylhexyl) terephthalate, and propylbenzene exceeded their AA-EQS values in the influent while they did not exceed the relative AA-EQS values in the effluent samples. This can be the result of the treatment.

To be able to see the removal efficiencies of micropollutants in the Amasya UWWTP, the average concentrations and loads of the micropollutants exceeding in the influent and effluent were compared. The comparisons can be seen in Table 44 and Figure 59.

Table 44. Average concentrations of the micropollutants exceeding the relative AA-EQS values in the influent and effluent of the Amasya UWWTP

Micropollutants	Avg. concentration (µg/L)		% Removal efficiency
	Influent (YESIL 106_INF)	Effluent (YESIL 107_UW)	
Cd	0.3	0.0295(<LOD)	90.1
Dichlorvos	0.01	0.00025(<LOD)	97.9
Ni	9.5	3.2	65.8
Pb	7.6	2.1	72.7
Trichloromethane	5.6	1.1	81.2
Al	1275.9	50.0	96.1
Bis(2-ethylhexyl) terephthalate	0.4	0.0005(<LOD)	99.9
Bromide	15.0(<LOD)	60.9	**-306.2**
Co	1.2	0.4	67.8
Cr	9.6	1.9	80.7
Cu	53.1	17.6	66.8
Fe	2308.6	349.2	84.9
Free CN	3.0	1.2	58.3
Petroleum hydrocarbons	308.0	128.0	58.4
Propylbenzene	1.0	0.05(<LOD)	94.8
Si	9577.3	8238.7	14
V	7.1	1.9	73.6
Zn	333.8	110.8	66.8
Avg. flowrate (m^3/h)	683.34	644.28	

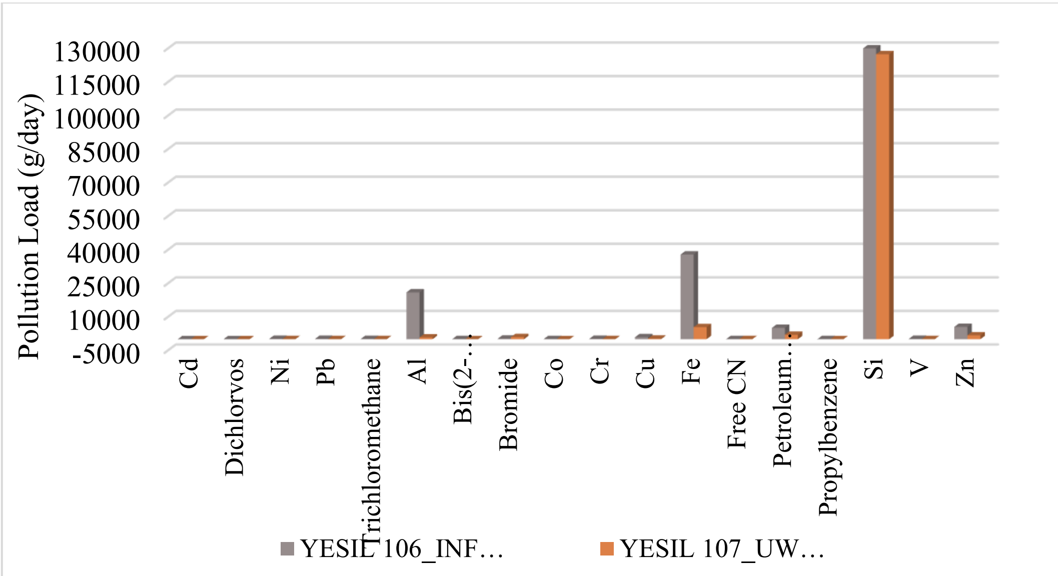

Figure 59. Average pollution load comparison between influent (YESIL 106_INF) and effluent (YESIL 107_UW) of the Amasya UWWTP

According to the results, Cd, dichlorvos, Ni, Pb, trichloromethane, Al, bis(2-ethylhexyl) terephthalate, Co, Cr, Cu, Fe, propylbenzene, V, and Zn were removed with high efficiencies while free CN, petroleum hydrocarbons, and Si were removed with lower efficiencies. On the other hand, negative removal was observed for bromide. Bromide could not be detected in the influent sample of the UWWTP although its average concentration exceeded the relative AA-EQS value in the effluent. Therefore, it was expected to observe negative removal for this micropollutant. Amasya UWWTP had the highest removal efficiencies among the other UWWTPs.

5.3.4 Meray Oil IWWTP

Meray Oil IWWTP was one of two IWWTPs that had influent data and the code given for the influent data of Meray Oil IWWTP was YESIL 102_INF. The samples from influents of Meray Oil IWWTP were taken for two periods in November 2017 and January 2018. Secondary treatment with chemical treatment and disinfection units are applied in Meray Oil IWWTP, and a detailed flow diagram is given in Figure 40.

According to the analysis results, 8 priority substances and 27 basin-specific pollutants, in total 35 micropollutants, were detected in the influent of Meray Oil IWWTP. The number of the micropollutants whose average concentrations exceeded their AA-EQSs was 19 and five of them were priority substances (Cd, dichlorvos, Ni, Pb, and trichloromethane). The others were Al, bromide, Co, Cr, Cu, Fe, free CN, o,p'-DDT, petroleum hydrocarbons, Sb, Si, Ti, V, and Zn. The concentrations of Cd, trichloromethane, free CN, o,p'-DDT, petroleum hydrocarbons, and Ti exceeded their AA-EQS values in the influent while they did not exceed the relative AA-EQS values in the effluent samples. This can be the result of the treatment.

To be able to see the removal efficiencies of micropollutants in Meray Oil IWWTP, the average concentrations and loads of the micropollutants exceeding in the influent and effluent were compared. The comparisons can be seen in Table 45 and Figure 60.

Table 45. Average concentrations of the micropollutants exceeding the relative AA-EQS values in the influent and effluent of Meray Oil IWWTP

Micropollutants	**Avg. concentration (µg/L)**		**% Removal efficiency**
	Influent (YESIL 102_INF)	**Effluent (YESIL 65_IW)**	
Cd	0.4	0.05	88.3
Dichlorvos	0.02	0.02	21.2
Ni	55.0	9.8	82.2
Pb	17.6	2.3	86.7
Trichloromethane	4.7	0.6	87.4
Al	5217.2	131.3	97.5
Bromide	13231.0	36.8	99.7
Co	4.8	0.5	89.2
Cr	72.8	3.6	95.1
Cu	38.1	16.8	56
Fe	14149.7	244.3	98.3
Free CN	24.3	0.8	96.7
o,p'-DDT	0.03	0.0025(<LOD)	91.2
Petroleum hydrocarbons	4195.5	71.7	98.3
Sb	8.0	10.0	**-24.7**
Si	16217.0	13078.0	19.4
Ti	209.2	3.835(<LOD)	98.2
V	12.5	8.9	28.7
Zn	272.8	71.7	73.7
Avg. flowrate (m^3/h)	15.84	9.38	

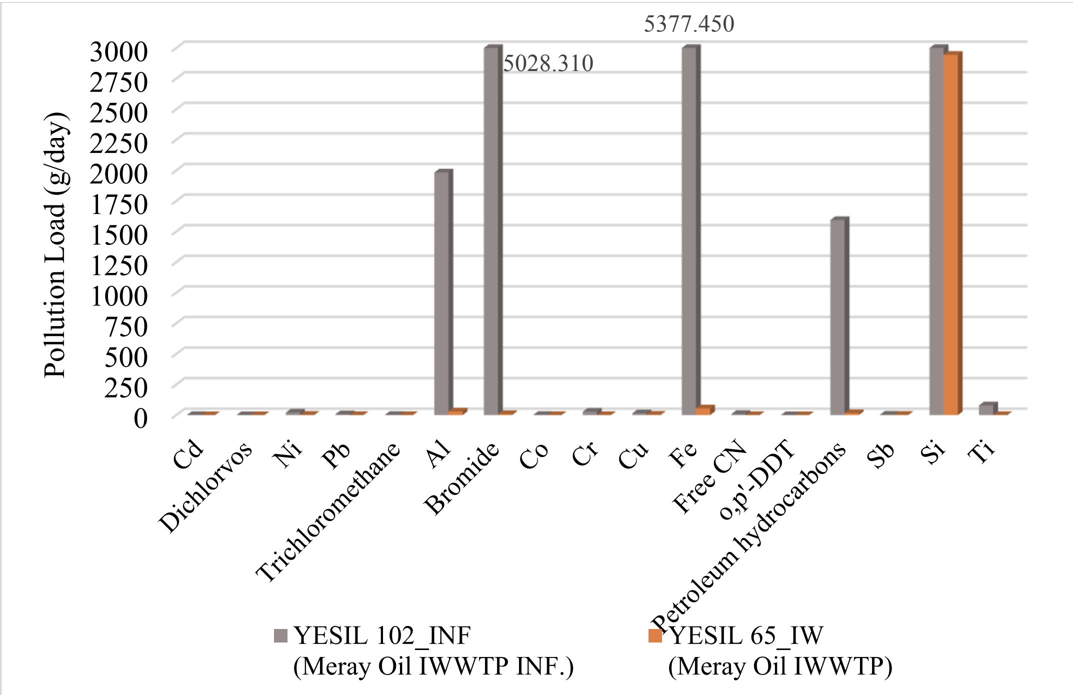

Figure 60. Average pollution load comparison between influent (YESIL 102_INF) and effluent (YESIL 65_IW) of Meray Oil IWWTP

According to the results, Cd, Ni, Pb, trichloromethane, Al, bromide, Co, Cr, Fe, free CN, o,p'-DDT, petroleum hydrocarbons, Ti, and Zn were removed with high efficiencies while dichlorvos, Cu, Si, and V were removed with lower efficiencies. On the other hand, negative removal was observed for Sb. Generally, the removal of micropollutants in Meray Oil IWWTP was achieved with high ratios.

5.3.5 Merzifon OIZ IWWTP

Merzifon OIZ IWWTP was the other IWWTP that had influent data and the code given for the influent data of Merzifon OIZ IWWTP was YESIL 103_INF. The samples from influents of Merzifon OIZ IWWTP were taken for three periods between August 2017 and January 2018. Secondary treatment with a conventional activated sludge system is applied in Merzifon OIZ IWWTP, and a detailed flow diagram is given in Figure 29.

According to the analysis results, 8 priority substances and 28 basin-specific pollutants, in total 36 micropollutants, were detected in the influent of Merzifon OIZ IWWTP. The number of the micropollutants whose average concentrations exceeded their AA-EQSs was 21 and seven of them were priority substances (bifenox, Cd, dichloromethane, Hg, Ni, Pb, and trichloromethane). The others were Al, B, bis(2-ethylhexyl) terephthalate, bromide, Co, Cr, Cu, Fe, free CN, petroleum hydrocarbons, Si, Ti, V, and Zn. The concentrations of bifenox, dichloromethane, trichloromethane, and bis(2-ethylhexyl) terephthalate exceeded their AA-EQS values in the influent while they did not exceed the relative AA-EQS values in the effluent samples. This can be the result of the treatment.

To be able to see the removal efficiencies of micropollutants in Merzifon OIZ IWWTP, the average concentrations and loads of the micropollutants exceeding in the influent and effluent were compared. The comparisons can be seen in Table 46 and Figure 61.

Table 46. Average concentrations of the micropollutants exceeding the relative AA-EQS values in the influent and effluent of Merzifon OIZ IWWTP

Micropollutants	**Avg. concentration (µg/L)**		**% Removal efficiency**
	Influent (YESIL 103_INF)	**Effluent (YESIL 58_IW)**	
Bifenox	0.1	0.0025(<LOD)	98.3
Cd	0.3	0.2	49.7
Dichloromethane	28.6	2.4	91.5
Hg	0.2	0.1	41.9
Ni	41.7	93.7	**-124.5**
Nonylphenols	0.03	0.8	**-2788.3**
Pb	10.8	7.1	34.2
Trichloromethane	3.2	0.8	74.8
4-Chloroaniline	0.0025(<LOD)	0.006	**-150**
Al	1520.7	1980.1	**-30.2**
B	1879.3	1257.8	33.1
Bis(2-ethylhexyl) terephthalate	0.3	0.001(<LOD)	99.9
Bromide	63.9	134.1	**-109.7**
Co	6.2	7.2	**-16.0**
Cr	12.3	19.5	**-58.0**
Cu	142.3	98.5	30.8
Diphenyl ether; Diphenyl oxide	0.001(<LOD)	7.8	**-1567316.7**
Fe	1337.8	2644.1	**-97.6**

Table 46. (cont'd)

Micropollutants	Avg. concentration (µg/L)		% Removal efficiency
	Influent (YESIL 103_INF)	Effluent (YESIL 58_IW)	
Free CN	6.9	8.0	**-17.1**
Petroleum hydrocarbons	1383.0	360.0	74.0
Si	14273.3	10079.8	29.4
Ti	221.4	41.4	81.3
Tridecane	0.01(<LOD)	1.5	**-14700.0**
V	5.6	3.4	39.7
Zn	7111.4	2158.3	69.6
Ethalfluralin	0.0025(<LOD)	1.1	**-43716.7**
Fenpropimorph	0.05(<LOD)	0.2	**-190.0**
Avg. flowrate (m^3/h)	20.0	13.7	

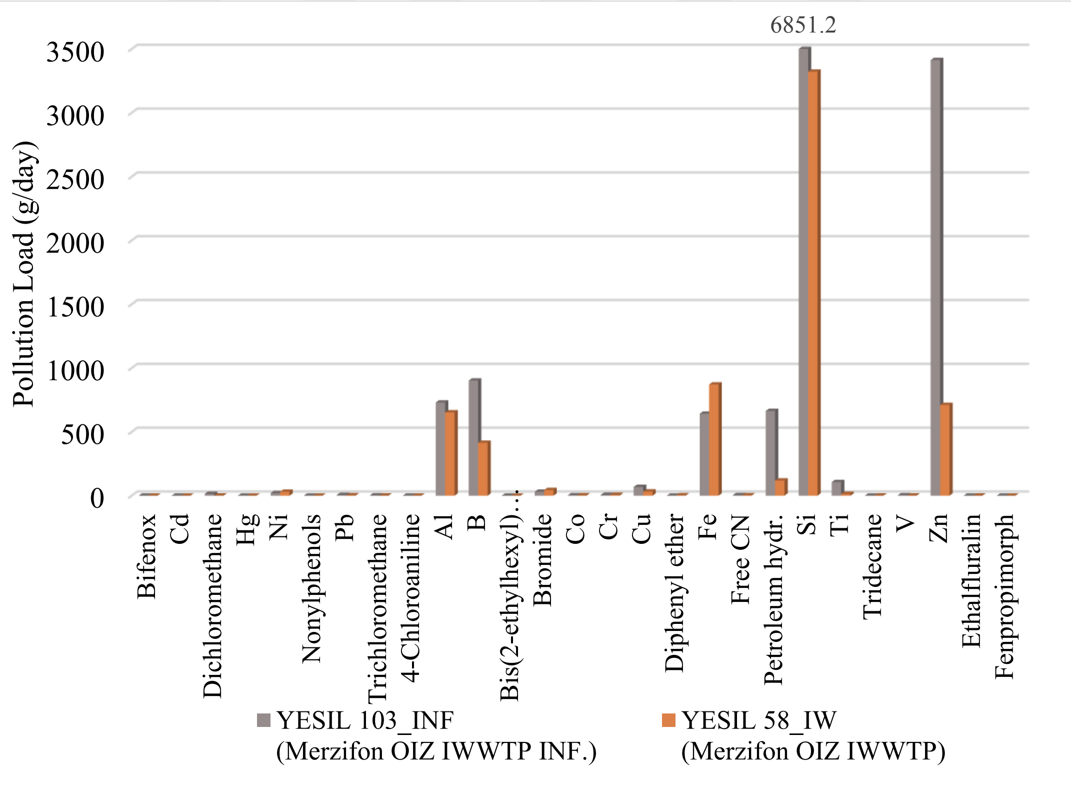

Figure 61. Average pollution load comparison between influent (YESIL 103_INF) and effluent (YESIL 58_UW) of Merzifon OIZ IWWTP

According to the results, bifenox, dichloromethane, trichloromethane, bis(2-ethylhexyl) terephthalate, petroleum hydrocarbons, Ti, and Zn were removed with high efficiencies while Cd, Hg, Pb, B, Cu, Si, and V were removed with lower efficiencies. On the other hand, negative removal was observed for Ni, nonylphenols, 4-chloroaniline, Al, bromide, Co, Cr, diphenyl ether, Fe, free CN, tridecane, ethalfluralin, and fenpropimorph. 4-chloroaniline, diphenyl ether, tridecane, ethalfluralin, and fenpropimorph could not be detected in the influent sample of the IWWTP although their average concentrations exceeded the relative AA-EQS values in the effluent. Therefore, it was expected to observe negative removals for these micropollutants. Nonylphenols were detected in the influent, but its average concentration did not exceed the AA-EQS value in the influent. Hence, it also had a negative removal ratio. However, the situation was different for Ni, Al, bromide, Co, Cr, Fe, and free CN. Their negative removal could be because of the HRT difference. Merzifon OIZ had the most various micropollutants in its influent and effluent samples and the lowest micropollutant removal percentages among all the WWTPs whose removal efficiencies were evaluated.

5.4 UWWTPs' Contributions to the Pollution Load in the Yeşilırmak River

The discharged water characteristics of UWWTPs differ from one to another depending on the type of the treatment process, characteristics of the coming wastewater, the population which the relative UWWTP serves, and the location of the UWWTP. To be able to determine the most significant UWWTPs among the six UWWTPs which had been studied and to see which micropollutants were mostly discharged from the corresponding UWWTPs, a comparison study was conducted. The comparison can be seen in Table 47.

Table 47. Comparison of the UWWTPs in terms of their highest pollutant contributions and the related shares

Name of UWWTP	WWTP Type	Three micropollutants with the highest loads			Share in total load (%)
		Micropollutant	Load (g/day)	PC	
Tokat UWWTP	N-Removing	Si	126207	452.6	18.2
		Petroleum hydrocarbons	3684	13.2	23.9
		Al	2235	8.0	16.3
Erbaa UWWTP	N and P Removing	Si	78510	52.3	11.3
		Petroleum hydrocarbons	2237	1.5	14.5
		Fe	1917	1.3	5.1
Çorum UWWTP	Conventional C Removing	Si	341715	3330.3	49.4
		Fe	27405	267.1	73.6
		Bromide	14276	139.1	90.3
Mecitözü UWWTP	Conventional C Removing	Si	1041	-	0.2
		Fe	18	-	0.1
		Al	15	-	0.1
Amasya UWWTP	N and P Removing	Si	127392	115.5	18.4
		Fe	5400	6.6	14.5
		Petroleum hydrocarbons	1979	2.4	12.8
Havza UWWTP	Conventional C Removing + Chlorination	Si	16966	152.2	2.5
		Fe	303	2.7	0.8
		Al	192	1.7	1.4

The micropollutants which had been discharged from the studied UWWTPs are Si, petroleum hydrocarbons, Al, Fe, and bromide. It can be easily estimated that the UWWTPs in the Yeşilırmak Basin cause significant pollution of these micropollutants. According to the comparison based on the load share of micropollutants with the highest discharges, the Çorum UWWTP had the most significant load impact on the Yeşilırmak River. The Çorum UWWTP is one of the UWWTPs which have a simple conventional carbon removing system. However, the impact of the Mecitözü UWWTP was very small since its flowrate was significantly low. In other words, the treatment system of the Çorum UWWTP is inadequate while it serves a relatively higher population. Hence, the responsible authorities should at first control the Çorum UWWTP. The results show that although the treatment processes of UWWTPs have an important effect on the caused load contribution, the higher population served caused a higher load contribution to the environment.

Further comparison was performed between three UWWTPs in terms of removal efficiencies of the most significant micropollutants. The comparison can be seen in Table 48. Although all three UWWTPs have activated sludge systems, the Amasya UWWTP and Tokat UWWTP have nutrient removal systems. Tha Amasya UWWTP has both N and P removal and it had the most efficient removal for Al and Fe. However, for the other micropollutants, the Çorum UWWTP had the biggest removal efficiencies although it has only a conventional C removal system. The pollution load contribution of the Çorum UWWTP was the highest one despite of the higher removal efficiencies. Hence, it can be said that for more efficient micropollutant removal, further treatment systems than the conventional ones must be applied. The conventional nutrient removal systems are not efficient, especially for Si.

Table 48. Comparison of the UWWTPs in terms of removal efficiencies

Name of UWWTP	**WWTP Type**	**The most significant micropollutants**			**Removal efficiency (%)**
		Micropollutant	**Influent Conc. (μg/L)**	**Effluent Conc. (μg/L)**	
Tokat UWWTP	N-Removing	Si	7304.3	8428.7	**-15.4**
		Petroleum hydrocarbons	293.0	246.0	16.0
		Al	189.3	149.2	21.2
		Fe	352.9	146.1	58.6
		Bromide	Not calculated (<EQS)		
Çorum UWWTP	Conventional C Removing	Si	8440.0	6213.0	26.4
		Petroleum hydrocarbons	749.0	133.3	82.2
		Al	2321.5	171.4	92.6
		Fe	2952.3	498.3	83.1
		Bromide	580.5	259.6	55.3
Amasya UWWTP	N and P Removing	Si	9577.3	8238.7	14
		Petroleum hydrocarbons	308.0	128.0	58.4
		Al	1275.9	50.0	96.1
		Fe	2308.6	349.2	84.9
		Bromide	15.0(<LOD)	60.9	**-306.2**

5.5 IWWTPs Contributions to the Pollution Load in the Yeşilırmak River

Similar to the UWWTPs, the discharged water characteristics of IWWTPs also differ depending on the industrial activity (characteristic of the coming wastewater), the capacity of the plant, type of the treatment process, etc. To be able to determine the most significant IWWTPs among the 14 IWWTPs which had been studied and to see which micropollutants were mostly discharged from the corresponding IWWTPs, another comparison study was conducted for the IWWTPs. The comparison can be seen in Table 49.

Table 49. Comparison of the IWWTPs in terms of their highest pollutant contributions and the related shares

Name of IWWTP	WWTP Type	Three micropollutants with the highest loads			Share in total load (%)
		Micropollutant	Load (g/day)	PC	
Merzifon OIZ IWWTP	Conventional C Removing	Si	3322	780.5	4.7
		Fe	872	204.7	0.6
		Zn	711	167.1	9.1
Samsun OIZ IWWTP	Chemical Treatment + Conventional C Removing	Si	13529	-	19.3
		Zn	6579	-	84.2
		Fe	3776	-	2.6
Dimes Food IWWTP	Conventional C Removing	Si	2860	7.9E+00	4.1
		Petroleum hydrocarbons	124	3.4E-01	10.3
		Fe	60	1.7E-01	0.04
Turhal Sugar IWWTP	N-Removing	Si	29395	88.2	41.9
		Fe	1308	3.9	0.9
		Petroleum hydrocarbons	304	0.9	25.4
Özdemir Antimony Mine IWWTP	Physical	Fe	139889	162.4	95.1
		Al	62869	73.0	92.9
		Sb	14864	17.3	99.8
Meray Oil IWWTP	Chemical Treatment + Conventional C Removing + Chlorination	Si	2945	1371.4	4.2
		Fe	55	25.6	0.04
		Al	30	13.8	0.04
Olmuksan Int. Paper IWWTP	Chemical Treatment + Conventional C Removing	Si	4079	84.9	5.8
		Al	2542	52.9	3.8
		Bromide	172	3.6	2.4

Table 49 (cont'd)

Name of IWWTP	WWTP Type	Three micropollutants with the highest loads			Share in total load (%)
		Micropollutant	Load (g/day)	PC	
Özmaya (Lesaffre) IWWTP	UASB + Chemical Treatment	Si	2948	3.7	4.2
		Fe	199	0.2	0.1
		Bromide	123	0.2	1.7
Eti Copper IWWTP	Conventional C Removing + Chemical Treatment +Activated Carbon Filter	Si	3634	-	5.2
		Fe	217	-	0.2
		Petroleum hydrocarbons	178	-	14.8
Yemsel Poultry and Livestock IWWTP	No detailed information	Si	229	-	0.3
		Fe	6	-	0
		Zn	4	-	0.05
Yuva Viol and Package IWWTP	Conventional C Removing	Si	345	-	0.5
		Fe	18	-	0.01
		Bromide	11	-	0.2
Et-Bir Suluova Slaughterhouse IWWTP	Conventional C Removing + Disinfection	Bromide	4928	150.4	68.2
		Si	897	27.4	1.3
		Fe	32	1.0	0.02
Kozlu Food IWWTP	No detailed information	Si	370	6.9	0.5
		Fe	15	0.3	0.01
		Al	11	0.2	0.02
Bakraç Dairies IWWTP	Chemical Treatment + Conventional C Removing	Si	760	14.1	1.1
		Fe	509	9.4	0.4
		Zn	114	2.1	1.5

The micropollutants which had been discharged from the studied IWWTPs are Si, Fe, Zn, petroleum hydrocarbons, Al, Sb, and bromide. The difference between UWWTPs and IWWTPs in terms of mostly discharged micropollutants is Sb and Zn. The IWWTPs in the Yeşilırmak Basin also cause significant pollution of the similar micropollutants. According to the comparison based on the load share of micropollutants with the highest discharges, the most significant IWWTPs are the Samsun OIZ IWWTP, Turhal Sugar IWWTP, and Özdemir Antimony Mine IWWTP. The Samsun OIZ IWWTP had the highest ratio for Zn whereas the Turhal Sugar IWWTP had the highest ratio for Si. The Özdemir Antimony Mine IWWTP had the most significant impact in terms of metals (Fe, Al, and Sb). The main reason is due to lack of proper treatment. The wastewater caused by the mining activity has only been waited on the sedimentation pond. Although the Et-Bir Suluova Slaughterhouse IWWTP had a very low load contribution, it had the biggest bromide load contribution to the Yeşilırmak with a ratio of 68.2%.

As a result, the responsible authorities should at first control the Samsun OIZ IWWTP, Turhal Sugar IWWTP, and Özdemir Antimony Mine IWWTP. The results show that although the treatment processes of IWWTPs have an important effect on the caused load contribution, the water characteristics and the amount of wastewater coming from the industry play a significant role.

Further comparison was also performed between two IWWTPs in terms of removal efficiencies of the most significant micropollutants. The comparison can be seen in Table 50. Although both of the IWWTPs have activated sludge systems, the Amasya UWWTP and Tokat UWWTP have nutrient removal systems. Tha Meral Oil IWWTP has also chemical treatment and chlorination. It had the more efficient removal for almost all significant micropollutants. However, for Si, the Merzifon OIZ IWWTP had the higher removal efficiencies although it has only a conventional C removal system. Hence, it can be said that for more efficient micropollutant removal, additional treatment systems like chemical treatment, chlorination, etc. can remove the micropollutants more efficiently.

Table 50. Comparison of the IWWTPs in terms of removal efficiencies

Name of IWWTP	**WWTP Type**	**The most significant micropollutants**			**Removal efficiency (%)**
		Micropollutant	**Influent Conc. (µg/L)**	**Effluent Conc. (µg/L)**	
Meray Oil IWWTP	Chemical Treatment + Conventional C Removing + Chlorination	Si	16217.0	13078.0	19.4
		Fe	14149.7	244.3	98.3
		Zn	272.8	71.7	73.7
		Petroleum hydrocarbons	4195.5	71.7	98.3
		Al	5217.2	131.3	97.5
		Sb	8.0	10.0	**-24.7**
		Bromide	13231.0	36.8	99.7

Table 50 (cont'd)

Name of IWWTP	**WWTP Type**	**The most significant micropollutants**			**Removal efficiency (%)**
		Micropollutant	**Influent Conc. (µg/L)**	**Effluent Conc. (µg/L)**	
Merzifon OIZ IWWTP	Conventional C Removing	Si	14273.3	10079.8	29.4
		Fe	1337.8	2644.1	**-97.6**
		Zn	7111.4	2158.3	69.6
		Petroleum hydrocarbons	1383.0	360.0	74.0
		Al	1520.7	1980.1	**-30.2**
		Sb	Not calculated (<EQS)		
		Bromide	63.9	134.1	**-109.7**

CHAPTER 6

CONCLUSION

The aim of this study was to evaluate the micropollutants occurrence in the effluents of both urban and industrial WWTPs, to determine the effect of the discharges from the WWTPs on the relative receiving bodies in terms of detected micropollutants, and to examine the micropollutant removal efficiencies of the WWTPs in the Yeşilırmak River Basin. In this regard, the data of the 2-year sampling and monitoring study carried out within the framework of the "Management of Point and Non-Point Pollution Sources in the Yeşilırmak River Basin (115Y013)" Project have been analyzed. The data set from this monitoring study included analysis for the 45 priority and 250 national river basin-specific pollutants of the WFD and Turkish SWQR in the samples taken from the effluents of WWTPs and surface waters. In total, 6 UWWTPs and 14 IWWTPs were taken into account. Additional to the WWTPs, 22 surface water stations, which were upstream or downstream of the evaluated WWTPs, were considered for the same micropollutants to be able to see the impact of WWTP discharges on the receiving water body.

According to the monitoring study carried out, 137 and 99 micropollutants among the 295 micropollutants were above their LOQ at least once in the effluents of IWWTPs and UWWTPs, respectively. Among these micropollutants; Al, As, B, Ba, Co, Cr, Cu, Fe, Ni, Pb, Si, V, and Zn were present in almost all samples from both IWWTP and UWWTP effluents, as well as in almost all samples from surface waters. When the average concentration of each micropollutant that was detected in the relative WWTP at least once was compared with the corresponding AA-EQS value, it appeared that the numbers of the micropollutants whose average concentrations exceeded their AA-EQS values in the effluents of IWWTPs and UWWTPs were 38 and 22, respectively. The most significant micropollutants discharged from the UWWTPs are Si, petroleum hydrocarbons, Al, Fe, and Bromide.

Whereas the most significant micropollutants discharged from the IWWTPs are Si, Fe, Zn, petroleum hydrocarbons, Al, Sb, and bromide. The average concentrations of Al, Cu, Fe, Pb, Si, and Zn exceed the relative AA-EQS values in almost all WWTPs with a few exceptions. The concentrations of metals generally were very high in most of the samples yet there were several organic micropollutants whose average concentrations exceeded their AA-EQS values in the various WWTPs, such as 4-chloroaniline, dichlorvos, ethalfluralin, fenpropimorph, free CN, nonylphenols, petroleum hydrocarbons, tridecane.

As it was indicated previously, Al, Cu, and Fe have significant natural background concentrations in the Basin, which were determined with a different study conducted under the same TUBITAK project, and their background concentrations were taken into account while calculating their relative increases. However, Br, Si, and V did not have background concentrations higher than their EQSs according to the background concentration study. Although, it is known that the concentrations of Br, Si, and V are generally very high in Turkey. Therefore, it should be noted that the high discharged concentrations of Br, Si, and V may also be because of the nature of the Yeşilırmak River Basin.

The next step in the determination of significant discharges was the calculation of the PC and relative increase for each micropollutant exceeding the corresponding AA-EQS in the effluents of WWTPs. The micropollutants that caused the relative increase higher than 2% were considered significant. The significance of a discharge depends on the discharged micropollutant concentration, flowrate of the discharged effluent, and the size of the receiving body. Some cases showed that even though the discharged average concentration was very high, the calculated relative increase was lower than 2% since the effluent flowrate was very low or the size of the receiving body was big (i.e., stream flowrate was high). Co, Fe, Si, V, and Zn were the generally determined significant micropollutants. To be able to see the effect of significant discharges, the pollution loads in the effluents and the related upstream and downstream were compared and it was seen that the micropollutants determined as significant in the effluents of WWTPs also presented in the surface waters. The comparison study showed that the WWTPs generally caused the increase in pollutant loads in the downstreams. Therefore, the WWTPs must be designed and controlled by considering the micropollutants discharged to the environment. So that the negative effects of micropollutants on human health and the environment can be minimized.

This study also included an evaluation of the micropollutant removal efficiencies of five WWTPs, 3 UWWTPs, and 2 IWWTPs. The removal studies showed that the treatment processes and conditions affected the removal of micropollutants along with the type and variety of micropollutants presented in the relative wastewater. Besides, it was concluded that the secondary treatment is not fully effective for micropollutants removal. However, it should be noted that the HRT values could not be considered while collecting samples from the influents and effluents of WWTPs and the conjugates might be produced.

As a result of the data analysis performed in this thesis study, the Çorum UWWTP had the most significant effect on the environment among the all studied UWWTPs whereas the Samsun OIZ IWWTP, Turhal Sugar IWWTP, and Özdemir Antimony Mine IWWTP had the highest effect on the environment among the all studied IWWTPs. The load contribution of the WWTPs depends on the treatment process and amount and characteristics of the treated wastewater. While comparing the removal efficiencies, it was seen that none of the studied WWTPs was effective on removal of the all significant micropollutants. Especially, Si had the lowest removal efficiencies in all five WWTPs. The removal studies showed that the treatment processes and conditions affected the removal of micropollutants along with the type and variety of micropollutants presented in the relative wastewater. Besides, it was concluded that the secondary treatment is not fully effective for micropollutants removal.

In conclusion, the WWTPs are very important point sources of the micropollutants due to the wide variety of micropollutants content and inefficient micropollutant removal. Hence, they require special attention. The wastewater characterization of each WWTP must be analyzed and the treatment methods and processes must be determined according to the target micropollutants because each micropollutant requires different methods and conditions. Also, it was seen that wastewater contents of the WWTPs change depending on the type of the WWTPs (industrial or urban). Geographic conditions, population density, agricultural profile, and type of industrial activities are the other important factors.

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APPENDICES

A. Priority Substances and Specific Pollutants Listed in the Surface Water Quality Regulation of Turkey (in Annex V Table 4 and Table 5)

Table A. 1. Specific Pollutants Listed in Table 4 of Surface Water Quality Regulation and their Environmental Quality Standards

No	Kimyasal Adı	CAS No	YO-ÇKS Nehirler/ Göller (µg/L)	MAK-ÇKS Nehirler/ Göller (µg/L)	YO-ÇKS Kıyı ve Geçiş Suları (µg/L)	MAK-ÇKS Kıyı ve Geçiş Suları (µg/L)
1	1,1-Dikloroetan	75-34-3	1000	10000	1000	10000
2	1,2,4,5-tetraklorobenzen	95-94-3	6	24	6	24
3	1,2,4-trimetilbenzen	95-63-6	7,4	516	0,3	516
4	1,3,5-trimetilbenzen; Mesitilen	108-67-8	9	150	0,8	150
5	1,3-diklorobenzen	541-73-1	58	599	58	599
6	1,4-diklorobenzen	106-46-7	38	284	38	284
7	17-alfa-etinilestradiyol	57-63-6	0,5	0,9	0,5	0,9
8	17-beta-estradiyol	50-28-2	0,5	0,5	0,5	0,5
9	1-kloro-2,4-dinitrobenzen	97-00-7	5	20	5	20
10	1-Kloronaftalin	90-13-1	0,7	7	0,7	7
11	1-metilnaftalin	90-12-0	1,5	29	1,5	29
12	2,3,4,5,6-Pentaklorotoluen; Pentaklorotoluen	877-11-2	1,3	1,3	0,004	0,07
13	2,4,6-tri-tert-butilfenol	732-26-3	0,06	0,6	0,06	0,6
14	2,6-di-ter-butilfenol; 2,6-di-tersiyer-butilfenol	128-39-2	7,6	76	7,6	76
15	2,6-ksilenol	576-26-1	54	112	1,1	112
16	2-amino-4-klorofenol	95-85-2	10	100	10	100
17	2-kloronaftalin	91-58-7	1,6	40	1	40
18	3,6-dimetilfenantren	1576-67-6	2	2	0,05	0,13
19	4,4'-DDD	72-54-8	0,025	0,025	0,01	0,025
20	4,4'-Dibromodifenil eter	2050-47-7	1,5	1,5	0,004	0,07
21	4,5-dikloro-2-oktil-2H-izotiyazol-3-on	64359-81-5	0,17	0,34	0,17	0,34
22	4-Aminoazobenzen	60-09-3	0,7	46	0,7	7
23	4-Kloro-3-metilfenol; Paraklorometakresol	59-50-7	37	366	37	366
24	4-kloroanilin	106-47-8	0,005	85	0,26	85
25	Aldrin	309-00-2	0,01	-	0,01	-
26	Alüminyum*	7429-90-5	2,2	27	2,2	22
27	Antimon*	7440-36-0	7,8	103	4,5	45
28	Arsenik*	7440-38-2	53	53	10	20
29	Asenaften	83-32-9	6	66	6	66
30	Asetaklor; 2-kloro-N-(etoksimetil)-N-(2-etil-6-metilfenil)asetamid	34256-82-1	0,3	10,1	0,3	10,1
31	Azinfos-metil	86-50-0	0,05	0,4	0,05	0,4
32	Bakır*	7440-50-8	1,6	3,1	1,3	5,7
33	Baryum	7440-39-3	680	680	680	680
34	Benzil benzoat	120-51-4	1000	10000	1000	10000
35	Benzilbutilfitalat (BBP)	85-68-7	2,7	44	2,7	27
36	Benzo(a)floren	238-84-6	0,1	1	0,1	1
37	Benzo(e)piren	192-97-2	0,6	0,6	0,05	0,05
38	Berilyum	7440-41-7	2,5	3,9	2,5	3,9
39	Bifenil	92-52-4	46	87	46	87

No	Kimyasal Adı	CAS No	YO-ÇKS Nehirler/ Göller (µg/L)	MAK-ÇKS Nehirler/ Göller (µg/L)	YO-ÇKS Kıyı ve Geçiş Suları (µg/L)	MAK-ÇKS Kıyı ve Geçiş Suları (µg/L)
40	Bis(2-etilhekzil) terefitalat	6422-86-2	0,1	0,15	0,1	0,15
41	Bisfenol-A	80-05-7	6,5	252	6,5	65
42	Bor*	7440-42-8	707	1472	707	1472
43	Bromür	7726-95-6	31	46	31	46
44	Çinko*	7440-66-6	5,9	231	5,33	76
45	DDT (toplam)	50-29-3	0,01	0,65	0,01	0,1
46	Dekametilsiklopentasiloksan; Siloksan-D5	541-02-6	0,6	0,6	0,6	0,6
47	Demeton	8065-48-3	20	20	20	20
48	Demir*	7439-89-6	36	101	36	101
49	Diazinon	333-41-5	0,9	4	0,9	4
50	Dibutilfitalat (DBP)	84-74-2	16	96	1,5	96
51	Dibutilkalay oksit	818-08-6	4	67	4	40
52	Dieldrin	60-57-1	0,02	0,93	0,02	0,93
53	Dietil Fitalat	84-66-2	72	1920	72	1920
54	Difenil eter; difenil oksit	101-84-8	6	60	1	60
55	Difenilamin	122-39-4	37	100	44	440
56	Diizobütil adipat	141-04-8	8,7	9	11	11
57	Diklofenak	15307-79-6	100	100	100	100
58	Dioktil fitalat (DnOP)	117-84-0	1680	16800	1680	16800
59	EDTA	60-00-4	39	39	39	39
60	Endrin	72-20-8	0,01	-	0,01	-
61	Etilentiyoüre (ETU); İmidazolidin-2-tiyon; Etilentiyoüre (ETU)	96-45-7	248	2000	248	2000
62	Fenantren	85-01-8	1,4	11,2	1,4	11,2
63	Fenitrotiyon (ISO); O,O-dimetil O-4-nitro-m-tolil fosforotiyoat	122-14-5	3,5	103	3,5	103
64	Fentiyon	55-38-9	0,05	1,1	0,05	1,1
65	Floren	86-73-7	3,4	47	3,4	47
66	Gümüş*	7440-22-4	1,5	1,5	1,5	1,5
67	Izopropilbenzen	98-82-8	35	260	35	260
68	İsodrin	465-73-6	0,01	-	0,01	-
69	Kalay*	7440-31-5	13	13	13	13
70	Karbontetraklorür	56-23-5	7,2	130	7,2	130
71	Klofibrik asit	882-09-7	0,3	89	0,5	89
72	Kloroasetik asit	79-11-8	0,5	5	0,5	5
73	Klorotalonil	1897-45-6	0,3	4,2	0,3	2
74	Kobalt*	7440-48-4	0,3	2,6	0,3	2,6
75	Krisen	218-01-9	1,9	19	1,9	19
76	Krom*	7440-47-3	1,6	142	4,2	88
77	Ksilen (m)	108-38-3	24	273	1,4	273
78	Ksilen (o)	95-47-6	24	585	1,8	585
79	Ksilen misk	81-15-2	5,6	56	5,6	56
80	Linuron	330-55-2	3	7	3	7
81	Merkaptobenzotiyazol (MBT); Benzotiyazol-2-tiyol; 2-Merkaptobenzotiyazol (MBT)	149-30-4	50	50	50	50
82	N,N,N',N'-tetrametil-4,4'-metilenedianilin (Michler's bazı)	101-61-1	20	20	0,26	3
83	n-bütilkalay triklorür	1118-46-3	1,2	12	1,2	12
84	Nitrobenzen	98-95-3	187	3516	187	3516
85	p-(1,1-dimetilpropil)fenol	80-46-6	9	14	0,07	14
86	Poliklorlubifeniller (PCB'ler)	1336-36-3	0,31	0,37	0,07	0,14
87	PCB 101	37680-73-2	0,25	0,25	0,01	0,02
88	PCB 138	35065-28-2	0,01	0,02	0,01	0,02
89	PCB 153	35065-27-1	0,01	0,02	0,01	0,02
90	PCB 180	35065-29-3	0,01	0,02	0,01	0,02

No	Kimyasal Adı	CAS No	YO-ÇKS Nehirler/ Göller (µg/L)	MAK-ÇKS Nehirler/ Göller (µg/L)	YO-ÇKS Kıyı ve Geçiş Suları (µg/L)	MAK-ÇKS Kıyı ve Geçiş Suları (µg/L)
91	PCB 28	7012-37-5	0,01	0,02	0,01	0,02
92	PCB 31	16606-02-3	0,01	0,02	0,01	0,02
93	PCB 52	35693-99-3	0,01	0,02	0,01	0,02
94	Perilen	198-55-0	0,6	0,6	0,01	0,03
95	Permetrin	52645-53-1	0,12	0,12	0,12	0,12
96	Petrol Hidrokarbonları	-	96	100	96	100
97	Piren	129-00-0	0,1	0,4	0,02	0,4
98	Piriproksifen	95737-68-1	0,02	7,5	0,02	7,5
99	Prokloraz; N-propil-N-[2-(2,4,6-triklorofenoksi)etil]-1H-imidazol-1-karboksamid	67747-09-5	11	13	11	13
100	Propetamfos	31218-83-4	0,05	0,7	1,5	15
101	Propilbenzen	103-65-1	0,2	1,7	0,2	1,7
102	Serbest CN	57-12-5	1,2	6	1,2	6
103	Silisyum	7440-21-3	1830	1830	610	6891
104	Stiren; Vinilbenzen	100-42-5	6,3	575	5,1	575
105	Sülfametoksazol	723-46-6	5	50	5	50
106	Ter-bütil-4-metoksifenol	25013-16-5	0,9	9	0,9	9
107	Tetrabromobisfenol A (TBBP-A)	79-94-7	2	20	2	20
108	Titanyum*	7440-32-6	26	42	26	42
109	Triadimenol; α-ter-bütil-β-(4-klorofenoksi)-1H-1,2,4-triazol-1-etanol	55219-65-3	32	250	1,5	15
110	Tribromodifenil eter	49690-94-0	1,6	1,6	0,004	0,08
111	Tributil fosfat	126-73-8	53	326	53	326
112	Tridekan	629-50-5	0,05	0,05	0,05	0,05
113	Trifenilkalay; Fentin	668-34-8	0,5	0,5	0,5	0,5
114	Trikloroetilen (TRI)	79-01-6	177	8163	177	8163
115	Triklosan	3380-34-5	0,12	1,1	0,12	1,1
116	Tris(nonilfenil) fosfit	26523-78-4	10	10	10	10
117	Vanadyum*	7440-62-2	1,6	97	1,6	16
118	2,4,5-triklorofenoksiasetikasit (2,4,5-t)	93-76-5	400	829	1	829
119	2,4-d isooktil ester	25168-26-7	0,2	26	2,8	26
120	2,4-d; (2,4-diklorofenoksi)asetik asit	94-75-7	5,3	583	5,3	583
121	2-metil-4,6-dinitro-fenol DNOK	534-52-1	20	23	20	23
122	Asetamiprid	135410-20-7	42	42	42	42
123	Atrazin-desetil	6190-65-4	0,3	3	0,3	3
124	Azoksistrobin	131860-33-8	0,2	6	0,2	6
125	Bentazon	25057-89-0	4,5	832	4,5	832
126	Lindan (γ-bhc, 1α,2α,3β,4α,5α,6β-hekzaklorosiklohekzan)	58-89-9	1,4	4	1,4	1,4
127	Boskalid	188425-85-6	19	113	19	113
128	Bromofos-etil	4824-78-6	0,01	0,1	0,01	0,1
129	Bromofos-metil	2104-96-3	0,001	0,1	0,001	0,01
130	Bromopropilat	18181-80-1	0,12	23	0,12	1,2
131	Bromoksinil	1689-84-5	36	262	0,8	262
132	Buprofezin	69327-76-0	3,5	3,5	3,5	3,5
133	Butralin	33629-47-9	0,1	4,1	0,1	4,1
134	Kadusafos	95465-99-9	0,01	0,02	0,01	0,02
135	Kaptan	133-06-2	1,6	8,5	1,6	8,5
136	Karbaril	63-25-2	9	34	0,04	34
137	Karbendazim	10605-21-7	2,7	77	2,7	77

No	Kimyasal Adı	CAS No	YO-ÇKS Nehirler/ Göller (µg/L)	MAK-ÇKS Nehirler/ Göller (µg/L)	YO-ÇKS Kıyı ve Geçiş Suları (µg/L)	MAK-ÇKS Kıyı ve Geçiş Suları (µg/L)
138	Karbofuran	1563-66-2	2,3	2,3	0,05	1,6
139	Karboksin; vitavaks	5234-68-4	11	11	5	5
140	Klorantraniliprol	500008-45-7	0,09	1,4	12	12
141	Klorobenzilat	510-15-6	6	60	0,8	8
142	Klordan	57-74-9	42	42	42	42
143	Klorfenapir	122453-73-0	0,007	0,4	0,007	0,4
144	Kloridazon; pirazon	1698-60-8	6	6	0,01	0,1
145	Klorsulfuron	64902-72-3	0,02	0,6	2000	2000
146	Klofentezin	74115-24-5	0,12	0,5	0,025	0,25
147	Klopiralid	1702-17-6	200	200	200	200
148	Klotianidin	210880-92-5	1,2	1,2	1,2	1,2
149	Siklanilid	113136-77-9	2,5	10	2,5	10
150	Siflutrin; beta siflutrin	68359-37-5	0,001	0,003	0,001	0,003
151	Siprodinil	121552-61-2	4,3	21	4,3	21
152	Siromazin	66215-27-8	0,2	16	0,3	3
153	4,4′-dde; 1,1-dikloro-2,2-bis(4-klorofenil) etin	72-55-9	0,02	0,2	0,02	0,2
154	Diklobenil	1194-65-6	0,6	187	74	187
155	Dietofenkarb	87130-20-9	0,7	910	0,7	7
156	Difenokonazol	119446-68-3	0,2	5,5	0,2	5,5
157	Diflubenzuron	35367-38-5	0,13	0,13	0,02	0,02
158	Diflufenikan	83164-33-4	0,01	0,01	0,01	0,01
159	Dimetenamid	87674-68-8	0,4	1,5	0,4	1,5
160	Dimetoat	60-51-5	15	15	15	15
161	Dimetomorf	110488-70-5	3,5	61	3,5	61
162	Dimetilaminosulfanilid	4710-17-2	100	9560	100	1000
163	Dinobuton	973-21-7	0,05	0,5	0,05	0,5
164	Epoksikonazol	133855-98-8	0,8	0,8	0,03	0,3
165	Etalfluralin	55283-68-6	0,3	0,5	0,5	0,5
166	Etofumesat	26225-79-6	48	324	48	324
167	Etoprofos	13194-48-4	0,21	6,4	0,21	0,35
168	Fenamifos	22224-92-6	0,01	0,08	0,01	0,08
169	Fenarimol	60168-88-9	0,07	0,07	0,07	0,07
170	Fenbutatin ksit	13356-08-6	0,1	0,5	0,1	0,5
171	Feneksamid	126833-17-8	28	28	28	28
172	Fenpropatrin	39515-41-8	0,01	0,01	0,01	0,01
173	Fenpropimorf	67564-91-4	0,1	30	0,1	1
174	Fluazifop-p-butil	79241-46-6	4,8	53	4,8	48
175	Fludioksonil	131341-86-1	1,2	3,1	1,2	3,1
176	Fluopiram	658066-35-4	50	275	22	43
177	Flukinkonazol	136426-54-5	3,1	3,1	3,1	3,1
178	Fluroksipir	69377-81-7	5600	5600	5600	5600
179	Flutolanil	66332-96-5	55	975	0,6	0,6
180	Flutriafol	76674-21-0	25	79	25	79
181	Fosetil al	39148-24-8	25	330	25	330
182	Fostiazat	98886-44-3	42	42	42	42
183	Hekzakonazol	79983-71-4	11	115	11	115
184	Hekzitiazoks	78587-05-0	0,4	0,4	0,4	0,4

No	Kimyasal Adı	CAS No	YO-ÇKS Nehirler/ Göller (µg/L)	MAK-ÇKS Nehirler/ Göller (µg/L)	YO-ÇKS Kıyı ve Geçiş Suları (µg/L)	MAK-ÇKS Kıyı ve Geçiş Suları (µg/L)
185	Imazalil	35554-44-0	50	73	50	73
186	Imazapir	81334-34-1	1900	1900	1590	1840
187	Imidakloprid	138261-41-3	0,14	1,4	0,14	1,4
188	Lenasil	2164-08-1	1	1	1	1
189	Malation	121-75-5	42	42	42	42
190	Mandipropamid	374726-62-2	46	250	46	250
191	Mepikuat klorit	24307-26-4	20	20	20	20
192	Mesotrion	104206-82-8	44	705	44	705
193	Metalaksil	57837-19-1	17	5320	1	10
194	Metam potasyum	137-41-7	24	240	24	240
195	Metamitron	41394-05-2	2	4,5	2	4,5
196	Metazaklor	67129-08-2	42	42	42	42
197	Metamidofos	10265-92-6	0,2	0,2	0,2	0,2
198	Metidation	950-37-8	42	42	42	42
199	Metomil	16752-77-5	42	42	42	42
200	Metoksifenozid	161050-58-4	11	110	11	110
201	Metolaklor	51218-45-2	3,3	88	3,3	88
202	Metrafenon	220899-03-6	12	13	1	13
203	Molinat	2212-67-1	136	460	136	460
204	Monokrotofos	6923-22-4	0,4	45	1	45
205	Miklobutanil	88671-89-0	9,6	9,6	9,6	9,6
206	Nikosulfuron	111991-09-4	0,05	0,2	0,05	0,2
207	Nitrofen	1836-75-5	0,2	90	0,2	2
208	Ometoat	1113-02-6	16	16	85	85
209	Okzadiazon	19666-30-9	0,3	9	0,3	9
210	Okzadiksil	77732-09-3	306	306	306	306
211	Paration-metil	298-00-0	1,4	2,5	0,01	2,5
212	Penkonazol	66246-88-6	1,2	1,9	1,2	1,9
213	Pendimetalin	40487-42-1	0,5	8	0,5	8
214	Fentoat	2597-03-7	0,05	0,5	0,05	0,5
215	Pikloram	1918-02-1	55	1401	12	120
216	Piperonil butoksit	51-03-6	3,3	350	0,8	350
217	Pirimikarb	23103-98-2	3,3	21	3,3	21
218	Prosimidon	32809-16-8	12	12	12	12
219	Prometrin	7287-19-6	0,3	2	0,3	2
220	Propamokarb HCL	25606-41-1	2240	3914	185	3914
221	Propazin	139-40-2	0,3	4,1	0,3	4,1
222	Profam	122-42-9	1	989	1	10
223	Propikonazol	60207-90-1	0,7	50	0,7	50
224	Propizamid	23950-58-5	23	112	23	112
225	Protiofos	34643-46-4	0,1	16	0,1	16
226	Piraklostrobin	175013-18-0	0,08	0,08	0,08	0,08
227	Piridaben	96489-71-3	0,25	0,25	0,25	0,25
228	Pirimetanil	53112-28-0	12	139	12	139
229	Kuinalfos	13593-03-8	0,2	1,4	0,2	1,4
230	Kuizalofop-p-etil	100646-51-3	1	1	1	1
231	Spiroksamin	118134-30-8	42	42	42	42
232	Tebukonazol	107534-96-3	23	121	1,6	121
233	Tebutiuron	34014-18-1	0,18	7,4	0,18	7,4
234	Teknazen	117-18-0	1	10	1	10

No	Kimyasal Adı	CAS No	YO-ÇKS Nehirler/ Göller (µg/L)	MAK-ÇKS Nehirler/ Göller (µg/L)	YO-ÇKS Kıyı ve Geçiş Suları (µg/L)	MAK-ÇKS Kıyı ve Geçiş Suları (µg/L)
235	Teflutrin	79538-32-2	0,002	0,002	0,002	0,002
236	Terbutilazin	5915-41-3	0,2	3,5	0,01	3,5
237	Tiabendazol	148-79-8	0,5	28	0,5	28
238	Tiakloprid	111988-49-9	0,13	2	0,13	2
239	Tiametokzam	153719-23-4	20	20	20	20
240	Tidiazuron	51707-55-2	10	61	10	61
241	Tiometon	640-15-3	0,01	47	0,01	0,1
242	Tiofanat-metil	23564-05-8	42	42	42	42
243	Tolklofos-metil	57018-04-9	1,2	7	1,2	7
244	Tolfenpirad	129558-76-5	0,2	0,2	0,2	0,2
245	Triasulfuron	82097-50-5	0,012	0,12	1,8	1,8
246	Tribenuron-metil	101200-48-0	0,04	0,08	0,04	0,08
247	Trifloksistrobin	141517-21-7	42	42	42	42
248	Triflumuron	64628-44-0	0,23	0,23	0,23	0,23
249	Trinekzapak-etil	95266-40-3	13	86	13	86
250	Vinklozolin	50471-44-8	1,1	84	1,1	84

Table A. 2. Priority Substances Listed in Table 5 of Surface Water Quality Regulation and their Environmental Quality Standards

No	Madde Adı	CAS No	YO-ÇKS Nehirler/Göller (µg/L)	MAK-ÇKS Nehirler/Göller (µg/L)	YO-ÇKS Kıyı ve Geçiş Suları (µg/L)	MAK-ÇKS Kıyı ve Geçiş Suları (µg/L)
1	Alaklor	15972-60-8	0,3	0,7	0,3	0,7
2	Antrasen	120-12-7	0,1	0,4	0,1	0,4
3	Atrazin	1912-24-9	0,6	2,0	0,6	2,0
4	Benzen	71-43-2	10	50	8	50
5	Bromlu difenileter[1]	32534-81-9	-	0,14	-	0,014
6	Kadmiyum ve bileşikleri[2]	7440-43-9	< 0,08 (Sınıf 1) 0,08 (Sınıf 2) 0,09 (Sınıf 3) 0,15 (Sınıf 4) 0,25 (Sınıf 5)	< 0,45 (Sınıf 1) 0,45 (Sınıf 2) 0,6 (Sınıf 3) 0,9 (Sınıf 4) 1,5 (Sınıf 5)	0,2	< 0,45 (Sınıf 1) 0,45 (Sınıf 2) 0,6 (Sınıf 3) 0,9 (Sınıf 4) 1,5 (Sınıf 5)
7	C10-13-Kloroalkanlar	85535-84-8	0,4	1,4	0,4	1,4
8	Klorfenvinfos	470-90-6	0,1	0,3	0,1	0,3
9	Klorpirifos (Klorpirifos-etil)	2921-88-2	0,03	0,1	0,03	0,1
10	1,2-dikloroetan	107-06-2	10	-	10	-
11	Diklorometan	75-09-2	20	-	20	-
12	Di(2-etilhekzil)fitalat (DEHP)	117-81-7	1,3	-	1,3	-
13	Diuron	330-54-1	0,2	1,8	0,2	1,8
14	Endosulfan	115-29-7	0,005	0,01	0,0005	0,004
15	Floranten	206-44-0	0,0063	0,12	0,0063	0,12
16	Hekzakloro-benzen	118-74-1	-	0,05	-	0,05
17	Hekzakloro-bütadien	87-68-3	-	0,6	-	0,6

No	Madde Adı	CAS No	YO-ÇKS Nehirler/Göller (µg/L)	MAK-ÇKS Nehirler/Göller (µg/L)	YO-ÇKS Kıyı ve Geçiş Suları (µg/L)	MAK-ÇKS Kıyı ve Geçiş Suları (µg/L)
18	Hekzakloro-siklohekzan	608-73-1	0,02	0,04	0,002	0,02
19	Isoproturon	34123-59-6	0,3	1,0	0,3	1,0
20	Kurşun ve bileşikleri[3]	7439-92-1	1,2	14	1,3	14
21	Cıva ve bileşikleri	7439-97-6	-	0,07	-	0,07
22	Naftalin	91-20-3	2	130	2	130
23	Nikel ve bileşikleri[3]	7440-02-0	4	34	8,6	34
24	Nonilfenoller (4-Nonilfenol)	84852-15-3	0,3	2,0	0,3	2,0
25	Oktilfenol ((4-(1,1' ,3,3' -tetrametilbütil)-fenol))	140-66-9	0,1	-	0,01	-
26	Pentakloro-benzen	608-93-5	0,007	-	0,0007	-
27	Pentakloro-fenol	87-86-5	0,4	1	0,4	1
28	Poliaromatik hidrokarbonlar (PAH)	-	-	-	-	-
	Benzo(a)piren	50-32-8	$1,7 \times 10^{-4}$	0,27	$1,7 \times 10^{-4}$	0,027
	Benzo(b)floranten	205-99-2	-	0,017	-	0,017
	Benzo(k)floranten	207-08-9	-	0,017	-	0,017
	Benzo(g,h,i)perilen	191-24-2	-	$8,2 \times 10^{-3}$	-	$8,2 \times 10^{-4}$
	Indeno(1,2,3-cd)piren	193-39-5	-	-	-	-
29	Simazin	122-34-9	1	4	1	4
30	Tributilkalay bileşikleri (Tributilkalay-katyonu)	36643-28-4	0,0002	0,0015	0,0002	0,0015
31	Trikloro-benzenler	12002-48-1	0,4	-	0,4	-
32	Trikloro-metan	67-66-3	2,5	-	2,5	-
33	Trifluralin	1582-09-8	0,03	-	0,03	-
34	Dikofol	115-32-2	$1,3 \times 10^{-3}$	-	$3,2 \times 10^{-5}$	-
35	Perflorooktan sülfonik asit ve türevleri (PFOS)	1763-23-1	$6,5 \times 10^{-4}$	36	$1,3 \times 10^{-4}$	7,2
36	Kinoksifen	124495-18-7	0,15	2,7	0,015	0,54
37	Dioksinler ve dioksin benzeri bileşikler[4]		-	-	-	-
38	Aklonifen	74070-46-5	0,12	0,12	0,012	0,012
39	Bifenoks	42576-02-3	0,012	0,04	0,0012	0,004
40	Sibutrin	28159-98-0	0,0025	0,016	0,0025	0,016
41	Sipermetrin[5]	52315-07-8	8×10^{-5}	6×10^{-4}	8×10^{-6}	6×10^{-5}
42	Diklorvos	62-73-7	6×10^{-4}	7×10^{-4}	6×10^{-5}	7×10^{-5}
43	Hekzabromo-siklododekanlar (HBCDD)[6]		0,0016	0,5	0,0008	0,05
44	Heptaklor ve heptaklor epoksit	76-448/1024-57-3	2×10^{-7}	3×10^{-4}	1×10^{-8}	3×10^{-5}
45	Terbutrin	886-50-0	0,065	0,34	0,0065	0,034

B. All Wastewater Treatment Plants Monitored in the TÜBİTAK Yeşilırmak Project

Table B. 1. All Urban WWTPs Monitored in the Yeşilırmak Project

No	UWWTP	Status in the Current Thesis Study
1	Demircili WWTP	Not included
2	Tokat UWWTP	Included
3	Çaylı WWTP	Not included
4	Erbaa UWWTP	Included
5	Çorum UWWTP	Included
6	Güzelbeyli WWTP	Not included
7	Evrenköy WWTP	Not included
8	Büyükhırka WWTP	Not included
9	Kazankaya WWTP	Not included
10	Aydıncık WWTP	Not included
11	Ozan WWTP	Not included
12	Oluközü WWTP	Not included
13	Ağcagüney WWTP	Not included
14	Terme WWTP	Not included
15	Mecitözü UWWTP	Included
16	Amasya UWWTP	Included
17	Havza UWWTP	Included

Table B. 2. All Industrial WWTPs Monitored in the Yeşilırmak Project

No	IWWTP	Status in the Current Thesis Study
1	Merzifon OIZ IWWTP	Included
2	Samsun OIZ IWWTP	Included
3	Dimes Food IWWTP	Included
4	Turhal Sugar IWWTP	Included
5	Özdemir Antimony Mine IWWTP	Included
6	Hayat Paper and Energy IWWTP	Not included
7	Pan-Et Slaughterhouse and Meat Products IWWTP	Not included
8	Meray Oil IWWTP	Included
9	Eski Çeltek Coal Mine IWWTP	Not included
10	Çarşamba Sugar Factory IWWTP	Not included
11	Sames (Samsun Slaughterhouse and Meat Integrated Industry) IWWTP	Not included
12	Olmuksan International Paper IWWTP	Included
13	Özmaya (Lesaffre) IWWTP	Included
14	Eti Copper IWWTP	Included
15	Nesko Mine IWWTP	Not included
16	Yemsel Poultry and Livestock IWWTP	Included
17	Hasanusta Food IWWTP	Not included
18	Yuva Viol and Package IWWTP	Included
19	Et-Bir Suluova Slaughterhouse IWWTP	Included
20	Kozlu Food IWWTP	Included
21	Bakraç Dairies IWWTP	Included
22	Aktan Food IWWTP	Not included
23	Beşgöz Araboğulları Flour IWWTP	Not included
24	Gürmin Energy Mine IWWTP	Not included
25	Otat Food IWWTP	Not included
26	Temiz Meat Products IWWTP	Not included

Table B.2 (cont'd)

No	IWWTP	Status in the Current Thesis Study
27	Amasya Sugar Factory IWWTP	Not included
28	Aydınoğlu Flour Food IWWTP	Not included
29	Doğa Water Food IWWTP	Not included
30	Akçansa Cement IWWTP	Not included
31	Dem-Ak Mine IWWTP	Not included
32	Makro-Win IWWTP	Not included
33	Özpar (Parlar) Plastic IWWTP	Not included
34	Ekmekçioğulları Zinc Copper Lead IWWTP	Not included
35	Gülşim Flour and Semolina IWWTP	Not included
36	Kanoğlu Flour Food Agriculture IWWTP	Not included
37	Nur Flour IWWTP	Not included
38	Yeni Teşvikiye Feed IWWTP	Not included

C. Receiving Body Sampling Stations Information

Table C. 1. List and information of receiving body stations

Station Code	Definition	Coordination	# of monitored periods
YESIL 11	Upstream station of Tokat UWWTP	N 40° 21' 01" E 36° 37' 42"	8
YESIL 18	Upstream station of Özdemir Antimony IWWTP and downstream station of Turhal Sugar IWWTP	N 40° 24' 57" E 36° 05' 56"	8
YESIL 19	Upstream station of Amasya UWWTP and Özmaya IWWTP	N 40° 37' 09" E 35° 48' 41"	8
YESIL 20	Downstream station of Bakraç Dairy IWWTP	N 40° 40' 34" E 35° 50' 03"	8
YESIL 25	Downstream station of Çorum UWWTP and Olmuksan Paper IWWTP	N 40° 22' 43" E 35° 03' 27"	8
YESIL 31	Downstream station of Merzifon OIZ IWWTP	N 40° 46' 49" E 35° 29' 33"	8
YESIL 32	Downstream station of Et-Bir Slaughterhouse IWWTP	N 40° 45' 55" E 35° 37' 26"	8
YESIL 33	Downstream station of Amasya UWWTP and Özmaya IWWTP	N 40° 44' 56" E 36° 01' 27"	8
YESIL 36	Downstream station of Erbaa UWWTP	N 40° 46' 06" E 36° 30' 44"	8
YESIL 37	Upstream station of Erbaa UWWTP	N 40° 42' 11" E 36° 34' 31"	8
YESIL 95	Upstream station of Dimes Food IWWTP and downstream station of Tokat UWWTP	N 40° 20' 21" E 36° 27' 22"	3
YESIL 96*	Upstream station of Meray Oil IWWTP	N 40° 48' 36" E 35° 24' 37"	0
YESIL 97	Upstream station of Merzifon OIZ IWWTP and downstream station of Meray Oil IWWTP	N 40° 47' 58" E 35° 26' 42"	3
YESIL 98	Tributary station of Meray Oil IWWTP	N 40° 48' 20" E 35° 24' 46"	1**
YESIL 99	Downstream station of Özdemir Antimony IWWTP	N 40° 25' 30" E 36° 06' 40"	3
YESIL 109	Upstream station of Havza UWWTP	N 40° 57' 01" E 35° 39' 30"	3
YESIL 120	Downstream station of Dimes Food IWWTP	N 40° 20' 18" E 36° 25' 25"	3
YESIL 122	Upstream station of Kozlu Food IWWTP	N 40° 48' 16" E 35° 39' 44"	3
YESIL 123	Upstream station of Et-Bir Slaughterhouse IWWTP and downstream station of Havza UWWTP	N 40° 49' 30" E 35° 37' 14"	3
YESIL 124	Upstream station of Çorum UWWTP and Olmuksan Paper IWWTP	N 40° 31' 39" E 34° 54' 49"	2
YESIL 125	Upstream station of Bakraç Dairy IWWTP and downstream station of Kozlu Food IWWTP	N 40° 43' 40" E 35° 46' 15"	2
YESIL 126	Upstream station of Turhal Sugar IWWTP	N 40° 23' 52" E 36° 05' 09"	2

*No data available due to dry riverbed
**Only one flowrate datum

D. Micropollutants Exceeding LOD

Table D. 1. Micropollutants exceeding LOD in the effluent of UWWTPs with the frequency of occurrence (n_{UWWTP}=28)

Micropollutants	Frequency of occurrence (%)	Micropollutants	Frequency of occurrence (%)
1,2-Dichloroethane	10.7	Co	100
Anthracene	7.1	Cr	100
Benzene	3.6	Cu	100
Benzo(b)fluoranthene	7.1	Cyprodinil	3.6
Benzo(g,h,i)-perylene	7.1	Diazinon	3.6
Benzo(k)fluoranthene	7.1	Diflubenzuron	7.1
Cd	35.7	Diflufenican	3.6
Dichloromethane	3.6	Dimethoate	3.6
Dichlorvos	3.6	Dinobuton	3.6
Diuron	17.9	Diphenyl ether; Diphenyl oxide	10.7
Fluoranthene	3.6	Diphenylamine	7.1
Hexachlorobenzene	7.1	Epoxiconazole	7.1
Indeno(1,2,3-cd)-pyrene	7.1	Ethalfluralin	7.1
Naphthalene	7.1	Fe	82.1
Ni	100	Fluopyram	7.1
Nonylphenols (4-Nonylphenol)	7.1	Fluorene	7.1
Octylphenols ((4-(1,1′,3,3′-tetramethylbutyl)-phenol))	7.1	Flutriafol	3.6
Pb	100	Free CN	17.9
Terbutryn	3.6	Imidacloprid	42.9
Trichloromethane	64.3	Mercaptobenzothiazole (MBT); 2-Benzothiazolethiol; 2-Mercaptobenzothiazole	7.1
1,1-Dichloroethane	7.1	Metalaxyl	3.6
1,2,4-trimethylbenzene	3.6	Metam potassium	7.1
1,4-Dichlorobenzene	39.3	Methamidophos	3.6
1-Chloro-2,4-Dinitrobenzene	7.1	n-butyltin trichloride	7.1
1-Methylnaphthalene	10.7	Nicosulfuron	3.6
2,4-D; (2,4-Dichlorophenoxy) acetic acid	21.4	o,p'-DDT	3.6
3,6-Dimethylphenanthrene	7.1	p-(1,1-dimethylpropyl)phenol	3.6
4-Chloro-3-methylphenol; Parachlorometacresol	7.1	p,p'-DDE	3.6
4-Chloroaniline	3.6	PCB 28	7.1
Acenaphthene	17.9	PCB 52	3.6
Ag	78.6	Permethrin	3.6
Al	100	Petroleum hydrocarbons	53.6
As	100	Phenanthrene	7.1
Atrazine-desethyl	17.9	Piperonyl butoxide	10.7
B	100	Pirimicarb	3.6
Ba	100	Procymidone	3.6
Be	14.3	Propiconazole	3.6
Benzo(e)pyrene	3.6	Pyrene	7.1
Benzyl benzoate	7.1	Pyrimethanil	3.6
Biphenyl	7.1	Sb	96.4
Bis(2-ethylhexyl) terephthalate	3.6	Si	100
Bisphenol-A	7.1	Sulfamethoxazole	32.1
Bromide	60.7	Tebuconazole	17.9
Captan	3.6	Thiacloprid	3.6
Carbendazim	39.3	Thiamethoxam	25
Carbofuran	7.1	Tridecane	7.1
Chloridazon; Pyrazon	3.6	Trinexapac-ethyl	7.1
Chlorothalonil	3.6	V	100

Table D.1 (cont'd)

Micropollutants	Frequency of occurrence (%)	Micropollutants	Frequency of occurrence (%)
Chrysene	7.1	Zn	100
Clopyralid	7.1	Total: 99 micropollutants	

Blue: Priority substances
Purple: River basin specific pollutants

Table D. 2. Micropollutants exceeding LOD in the effluent of IWWTPs with the frequency of occurrence (n_{IWWTP}=59)

Micropollutants	Frequency of occurrence (%)	Micropollutants	Frequency of occurrence (%)
1,2-Dichloroethane	11.9	Diclofenac	1.7
Anthracene	16.9	Diethyl phthalate	1.7
Atrazine	3.4	Diflubenzuron	1.7
Benzene	6.8	Diisobutyl adipate	5.1
Benzo(a)pyrene	3.4	Dimethoate	1.7
Benzo(b)fluoranthene	3.4	Dinobuton	1.7
Benzo(g,h,i)-perylene	6.8	Dioctyl phthalate (DnOP)	1.7
Benzo(k)fluoranthene	1.7	Diphenyl ether; Diphenyl oxide	10.2
Cd	50.8	Diphenylamine	11.9
Dichloromethane	22	Endrin	1.7
Dichlorvos	6.8	Epoxiconazole	3.4
Dioxins	3.4	Ethalfluralin	6.8
Fluoranthene	8.5	Ethofumesate	3.4
Hexachlorobenzene	10.2	Fe	100
Hg	3.4	Fenpropimorph	5.1
Indeno(1,2,3-cd)-pyrene	5.1	Fluopyram	1.7
Isoproturon	1.7	Fluorene	10.2
Naphthalene	1.7	Flutriafol	1.7
Ni	100	Fosetyl-al	1.7
Nonylphenols (4-Nonylphenol)	10.2	Free CN	22
Octylphenols ((4-(1,1′,3,3′-tetramethylbutyl)-phenol))	8.5	Imazalil	1.7
Pb	100	Imidacloprid	5.1
Trichloromethane	54.2	Isodrin	1.7
1,1-Dichloroethane	16.9	Lenacil	1.7
1,2,4-Trimethylbenzene	10.2	Mepiquat chloride	1.7
1,3,5-Trimethylbenzene; Mesitylene	10.2	Mercaptobenzothiazole (MBT); 2-Benzothiazolethiol; 2-Mercaptobenzothiazole	3.4
1,4-Dichlorobenzene	10.2	Mesotrione	3.4
1-Chloro-2,4-Dinitrobenzene	6.8	Metalaxyl	10.2
1-Chloronaphthalene	6.8	Metam potassium	5.1
1-Methylnaphthalene	10.2	Metamitron	6.8
2,4,6-Tri-tert-butylphenol	5.1	Methamidophos	3.4
2,4-D; (2,4-Dichlorophenoxy) acetic acid	22	Methidathion	5.1
2,6-Xylenol	6.8	Metrafenone	3.4
3,6-Dimethylphenanthrene	6.8	n-butyltin trichloride	11.9
4,4'-DDD	6.8	p-(1,1-dimethylpropyl) phenol	13.6
4,4'-DDE; 1,1-Dichloro-2,2-bis(p-chlorophenyl)ethylene	1.7	p,p'-DDT	3.4
4-Chloro-3-methylphenol; Parachlorometacresol	10.2	PCB 101	3.4
4-Chloroaniline	6.8	PCB 138	1.7
Acenaphthene	27.1	PCB 153	1.7
Ag	78	PCB 180	1.7
Al	100	PCB 28	10.2
As	100	PCB 52	10.2

Table D.2 (cont'd)

Micropollutants	**Frequency of occurrence (%)**	**Micropollutants**	**Frequency of occurrence (%)**
Atrazine-desethyl	18.6	Permethrin	1.7
Azinphos methyl	1.7	Petroleum hydrocarbons	52.5
Azoxystrobin	1.7	Phenanthrene	13.6
B	100	Picloram	1.7
Ba	100	Piperonyl butoxide	10.2
Be	25.4	Procymidone	8.5
Benzo(e)pyrene	1.7	Propamocarb hydrochloride (Propamocarb HCL)	1.7
Benzyl benzoate	10.2	Propylbenzene	3.4
Biphenyl	13.6	Pyrene	5.1
Bis(2-ethylhexyl) terephthalate	6.8	Sb	93.2
Bisphenol-A	8.5	Si	96.6
Bromide	76.3	Sn	1.7
Buprofezin	1.7	Sulfamethoxazole	1.7
Cadusafos	1.7	Tebuconazole	8.5
Captan	8.5	Tetrabutyltin	1.7
Carbaryl	1.7	Thiacloprid	3.4
Carbendazim	10.2	Thiamethoxam	11.9
Chlorfenapyr	5.1	Thiophanate-methyl	1.7
Chloridazon; Pyrazon	3.4	Ti	13.6
Chlorothalonil	3.4	Tridecane	10.2
Chrysene	3.4	Trinexapac-ethyl	8.5
Clopyralid	5.1	V	100
Co	100	Vinclozolin	1.7
Cr	100	Xylene (m)	3.4
Cu	100	Xylene (o)	1.7
Decamethylcyclopentasiloxane; Siloxane D5	1.7	Zn	100
Demeton	1.7	Total: 137 micropollutants	

Blue: Priority substances
Purple: River basin specific pollutants

E. Results of UWWTPs Effluents for all Monitoring Periods and related Calculations

Table E. 1. Results of the Tokat UWWTP (YESIL 45_UW) Effluents for all Monitoring Periods and related Calculations

YESIL 45_UW (TOKAT UWWTP)	LOD (µg/L)	1.Period (µg/L) Aug-16	2.Period (µg/L) Oct-16	3.Period (µg/L) Feb-17	4.Period (µg/L) Apr-17	5.Period (µg/L) Jun-17	6.Period (µg/L) Aug-17	7.Period (µg/L) Nov-17	8.Period (µg/L) Jan-18	Avg. Conc. (µg/L)	AA-EQS (µg/L)	% EQS Exceedance	Avg. Pollution Load (g/day)	Process Contribution (PC)	% Relative increase
Pb	0.066	-	-	1.65	1.22	5.46	1.33	2.03	2	2.282	1.2	90.1	34.165	0.123	10.209
Al	0.512	-	-	171.17	52.8	295	54	73.16	249.29	149.237	47.8	212.2	2234.61	8.013	16.764
Co	0.026	-	-	0.31	0.2	0.26	0.55	0.22	0.49	0.338	0.3	12.8	5.066	0.018	6.055
Cr	0.2	-	-	3.24	2.17	4.09	2.35	2.13	4.61	3.098	1.6	93.6	46.393	0.166	10.398
Cu	0.263	-	-	21.59	18.76	72.9	10.7	16.25	26.91	27.852	13.2	111.0	417.04	1.495	11.329
Fe	2.172	-	-	178.47	77.63	157.48	66.9	106.81	289.46	146.125	98.6	48.2	2188.017	7.846	7.957
Petroleum hydrocarbons	50	-	-	248	476	-	-	73	187	246	96	156.3	3683.506	13.209	13.759
Si	19.7	-	-	8276	8236	7688	8681	8560	9131	8428.667	1830	360.6	126207.483	452.568	24.730
Tridecane	0.02	-	-	0.01	1.312	0.01	0.01	0.01	0.01	0.227	0.05	354.0	3.399	0.012	24.377
Zn	0.667	-	-	75.05	38.57	202.86	52.23	43.88	69.71	80.383	5.9	1262.4	1203.628	4.316	73.154
Imidacloprid	0.02	-	-	0.026	0.757	0.01	0.044	0.01	0.01	0.143	0.14	2.0	2.139	0.008	5.478
Avg. Flowrate (m^3/h)		-	-	123.2	123.2	1078	555	653	1211	**623.9**					

Blue: Priority substances
Purple: River basin specific pollutants

Table E. 2. Results of Erbaa UWWTP (YESIL 47_UW) Effluents for all Monitoring Periods and related Calculations

YESIL 47_UW (Erbaa UWWTP)	LOD (µg/L)	1.Period (µg/L) Aug-16	2.Period (µg/L) Oct-16	3.Period (µg/L) Feb-17	4.Period (µg/L) Apr-17	5.Period (µg/L) Jun-17	6.Period (µg/L) Aug-17	7.Period (µg/L) Nov-17	8.Period (µg/L) Jan-18	Avg. Conc. (µg/L)	AA-EQS (µg/L)	% EQS Exceedance	Avg. Pollution Load (g/day)	Process Contribution (PC)	% Relative Increase
Pb	0.066	-	-	0.85	1.23	3.12	2.54	3.04	1.51	2.048	1.2	170.694	17.275	0.012	0.958
Al	0.512	-	-	86.45	120.39	217	103	91.6	167.55	130.998	47.8	274.055	1104.772	0.735	1.539
Co	0.026	-	-	0.29	0.4	0.31	0.52	0.32	0.42	0.377	0.3	125.556	3.177	0.002	0.705
Cr	0.2	-	-	2.01	2.398	2.79	1.68	1.75	2.18	2.135	1.6	133.417	18.003	0.012	0.749
Cu	0.263	-	-	13.98	13.76	19.2	18.7	15.38	12.53	15.592	13.2	118.119	131.492	0.088	0.663
Fe	2.172	-	-	115.7	139.37	573.68	136.1	156.92	241.99	227.293	98.6	230.521	1916.874	1.276	1.294
Petroleum hydrocarbons	50	-	-	192	589	-	-	25	255	265.250	96	276.302	2236.981	1.489	1.551
Si	19.7	-	-	9043	9878	9111	9572	9405	8847	9309.333	1830	508.707	78510.076	52.267	2.856
V	0.021	-	-	1.12	1.61	3.87	1.42	1.77	1.76	1.925	1.6	120.313	16.234	0.011	0.675
Zn	0.667	-	-	26.68	33.5	120.37	78.32	12.34	29.93	50.190	5.9	850.678	423.276	0.282	4.776
Imidacloprid	0.02	-	-	0.599	-	0.01	0.364	0.01	0.204	0.237	0.14	169.571	2.002	0.001	0.952
Nicosulfuron	0.02	-	-	0.01	-	0.01	0.01	0.01	0.811	0.170	0.05	340.400	1.435	0.001	1.911
Avg. Flowrate (m^3/h)		-	-	395	438	229.17	335.6	335.6	375	**351.395**					

Blue: Priority substances
Purple: River basin specific pollutants

Table E. 3. Results of Çorum UWWTP (YESIL 48_UW) Effluents for all Monitoring Periods and related Calculations

YESIL 48_UW (Çorum UWWTP)	LOD (µg/L)	1.Period (µg/L) Aug-16	2.Period (µg/L) Oct-16	3.Period (µg/L) Feb-17	4.Period (µg/L) Apr-17	5.Period (µg/L) Jun-17	6.Period (µg/L) Aug-17	7.Period (µg/L) Nov-17	8.Period (µg/L) Jan-18	Avg. Conc. (µg/L)	AA-EQS (µg/L)	% EQS Exceedance	Avg. Pollution Load (g/day)	Process Contribution (PC)	% Relative increase
Cd	0.059	-	-	4.971	0.869	0.256	0.311	0.132	0.529	1.178	0.15*	685.3	64.790	0.631	420.961
Dichlorvos	0.0005	-	-	0.055	0.00025	0.00025	0.00025	0.00025	0.00025	0.009	0.0006	1462.5	0.516	0.005	837.545
Ni	0.073	-	-	5.73	5.67	6.57	5.91	5.04	6.52	5.907	4	47.7	324.867	3.166	79.154
Nonylphenols (4-Nonylphenol)	0.001	-	-	0.0005	2.686	0.0005	0.0005	0.0005	0.0005	0.448	0.3	49.4	24.645	0.240	80.062
Octylphenols	0.005	-	-	0.0025	0.843	0.0025	0.0025	0.027	0.0025	0.147	0.1	46.7	8.067	0.079	78.618
Pb	0.066	-	-	6.74	2.72	3.04	2.02	2.91	5.42	3.808	1.2	217.4	209.458	2.041	170.115
Al	0.512	-	-	286.93	143.9	180	130	164.54	123.29	171.443	47.8	258.7	9429.383	91.899	192.256
Bromide	30	-	-	50	134	194.6	272.5	41.5	864.8	259.567	31	737.3	14276.167	139.135	448.823
Co	0.026	-	-	0.62	0.51	0.47	0.59	0.49	20.65	3.888	0.3	1196.1	213.858	2.084	694.753
Cr	0.2	-	-	2.29	1.52	3.43	2.15	1.64	1.29	2.053	1.6	28.3	112.933	1.101	68.790
Cu	0.263	-	-	35.18	21.42	28.4	18.2	20.8	20.77	24.128	13.2	82.8	1327.058	12.933	97.981
Fe	2.172	-	-	394.53	288.61	238.85	155.4	348.38	1563.88	498.275	98.6	405.3	27405.125	267.090	270.882
Free CN	1	-	-	0.5	0.5	0.5	0.5	6.13	0.5	1.438	1.2	19.9	79.108	0.771	64.249
Petroleum hydrocarbons	50	-	-	191	215	-	-	25	102	133.250	96	38.8	7328.750	71.426	74.402
Si	19.7	-	-	6229	6263	6563	5952	6340	5931	6213	1830	239.5	341715	3330.348	181.986
Zn	0.667	-	-	162.71	49.89	75.4	146.41	37.72	218.99	115.187	5.9	1852.3	6335.267	61.743	1046.498
Ethalfluralin	0.005	-	-	0.0025	4.02	0.0025	0.0025	0.0025	0.0025	0.672	0.3	124.0	36.965	0.360	120.085
Avg. Flowrate (m^3/h)		-	-	2350	2620	2300	2265	2265	1950	**2291.67**					

Blue: Priority substances
Purple: River basin specific pollutants
* Upstream water quality of YESIL 48 is (which is YESIL 124) Class 4.

Table E. 4. Results of Mecitözü UWWTP (YESIL 75_UW) Effluents for all Monitoring Periods and related Calculations

YESIL 75_UW (Mecitözü UWWTP)	LOD (µg/L)	1.Period (µg/L) Aug-16	2.Period (µg/L) Oct-16	3.Period (µg/L) Feb-17	4.Period (µg/L) Apr-17	5.Period (µg/L) Jun-17	6.Period (µg/L) Aug-17	7.Period (µg/L) Nov-17	8.Period (µg/L) Jan-18	Avg. Conc. (µg/L)	AA-EQS (µg/L)	% EQS Exceedance	Avg. Pollution Load (g/day)	Process Contribution (PC)	% Relative increase
Avg. Flowrate (m^3/h)		-	-	-	-	4.5	1.8	5	15	6.575					
Pb	0.066	-	-	-	-	3.57	2.17	2.64	0.79	2.293	1.2	191.042	0.362	Could not be calculated because there were no upstream and downstream stations data.	
Trichloromethane	0.1	-	-	-	-	14.96	0.05	0.05	2.58	4.41	2.5	176.4	0.696		
Al	0.512	-	-	-	-	178	64	63.51	73.45	94.74	47.8	198.201	14.95		
Bromide	30	-	-	-	-	15	69.2	50.4	52.3	46.73	31	150.726	7.37		
Co	0.026	-	-	-	-	0.22	0.28	0.77	0.43	0.425	0.3	141.667	0.067		
Cu	0.263	-	-	-	-	19.4	16.9	12.66	15.86	16.205	13.2	122.77	2.557		
Fe	2.172	-	-	-	-	115.5	102.7	109.47	126.46	113.533	98.6	115.145	17.915		
Si	19.7	-	-	-	-	5730	6715	7665	6270	6595	1830	360.383	1040.691		
V	0.021	-	-	-	-	3.95	2.25	2.72	2.49	2.853	1.6	178.281	0.45		
Zn	0.667	-	-	-	-	115.15	56.93	12.72	19.71	51.128	5.9	866.568	8.068		
Avg. Flowrate (m^3/h)		-	-	-	-	4.5	1.8	5	15	**6.575**					

Blue: Priority substances
Purple: River basin specific pollutants

Table E. 5. Results of Amasya UWWTP (YESIL 107_UW) Effluents for all Monitoring Periods and related Calculations

YESIL 107_UW (Amasya UWWTP)	LOD (µg/L)	1.Period (µg/L) Aug-16	2.Period (µg/L) Oct-16	3.Period (µg/L) Feb-17	4.Period (µg/L) Apr-17	5.Period (µg/L) Jun-17	6.Period (µg/L) Aug-17	7.Period (µg/L) Nov-17	8.Period (µg/L) Jan-18	Avg. Conc. (µg/L)	AA-EQS (µg/L)	% EQS Exceedance	Avg. Pollution Load (g/day)	Process Contribution (PC)	% Relative increase
Pb	0.066	-	-	-	-	-	1.24	3.83	1.15	2.073	1.2	72.8	32.059	0.039	3.262
Al	0.512	-	-	-	-	-	40	43.27	66.63	49.97	47.8	4.5	772.621	0.943	1.973
Bromide	30	-	-	-	-	-	99.3	30.1	53.4	60.93	31	96.6	942.195	1.150	3.711
Co	0.026	-	-	-	-	-	0.36	0.35	0.45	0.387	0.3	28.9	5.979	0.007	2.433
Cr	0.2	-	-	-	-	-	1.2	2.03	2.32	1.85	1.6	15.6	28.606	0.035	2.183
Cu	0.263	-	-	-	-	-	19	14.5	19.39	17.63	13.2	33.6	272.608	0.333	2.521
Fe	2.172	-	-	-	-	-	256.2	288.07	503.37	349.21	98.6	254.2	5399.788	6.592	6.686
Free CN	1	-	-	-	-	-	1.33	1.89	0.5	1.24	1.2	3.3	19.174	0.023	1.951
Petroleum hydrocarbons	50	-	-	-	-	-	-	58	198	128	96	33.3	1979.228	2.416	2.517
Si	19.7	-	-	-	-	-	7416	9130	8170	8238.7	1830	350.2	127392.2	155.53	8.499
V	0.034	-	-	-	-	-	2.17	2.04	1.41	1.873	1.6	17.1	28.967	0.035	2.210
Zn	0.667	-	-	-	-	-	118.84	58.37	155.07	110.76	5.9	1777.3	1712.651	2.091	35.439
Avg. Flowrate (m^3/h)		-	-	-	-	-	602.84	650	680	**644.28**					

Blue: Priority substances
Purple: River basin specific pollutants

Table E. 6. Results of Havza UWWTP (YESIL 108_UW) Effluents for all Monitoring Periods and related Calculations

YESIL 108_UW (Havza UWWTP)	LOD (µg/L)	1.Period (µg/L) Aug-16	2.Period (µg/L) Oct-16	3.Period (µg/L) Feb-17	4.Period (µg/L) Apr-17	5.Period (µg/L) Jun-17	6.Period (µg/L) Aug-17	7.Period (µg/L) Nov-17	8.Period (µg/L) Jan-18	Avg. Conc. (µg/L)	AA-EQS (µg/L)	% EQS Exceedance	Avg. Pollution Load (g/day)	Process Contribution (PC)	% Relative Increase
Al	0.512	-	-	-	-	-	26	52.23	169.75	82.660	47.8	172.929	192.432	1.726	3.611
Bromide	30	-	-	-	-	-	15	42.6	41.2	32.933	31	106.237	76.669	0.688	2.218
Cu	0.263	-	-	-	-	-	17.1	14.2	17.22	16.173	13.2	122.525	37.652	0.338	2.558
Fe	2.172	-	-	-	-	-	49.6	71.19	269.78	130.19	98.6	132.039	303.082	2.718	2.757
Si	19.7	-	-	-	-	-	7932	7155	6777	7288	1830	398.251	16966.464	152.173	8.315
Zn	0.667	-	-	-	-	-	22.59	6.87	25.03	18.163	5.9	307.853	42.284	0.379	6.428
Avg. Flowrate (m^3/h)		-	-	-	-	-	97	97	-	**97**					

Purple: River basin specific pollutants

F. Results of IWWTPs Effluents for all Monitoring Periods and related Calculations

Table F. 1. Results of Merzifon OIZ IWWTP (YESIL 58_IW) Effluents for all Monitoring Periods and related Calculations

YESIL 58_IW (Merzifon OIZ IWWTP)	LOD (µg/L)	1.Period (µg/L) Aug-16	2.Period (µg/L) Oct-16	3.Period (µg/L) Feb-17	4.Period (µg/L) Apr-17	5.Period (µg/L) Jun-17	6.Period (µg/L) Aug-17	7.Period (µg/L) Nov-17	8.Period (µg/L) Jan-18	Avg. Conc. (µg/L)	AA-EQS (µg/L)	% EQS Exceedance	Avg. Pollution Load (g/day)	Process Contribution (PC)	% Relative increase
Cd	0.059	-	-	0.122	0.106	0.361	0.157	0.106	0.169	0.17	0.09*	89.1	0.056	0.013	14.641
Hg	0.13	-	-	0.2	0.065	0.065	-	-	0.065	0.10	0.07**	41.1	0.033	0.008	10.924
Ni	0.073	-	-	26.31	67.23	182.44	60.51	160.75	64.88	93.69	4	2242.2	30.879	7.255	181.365
Nonylphenols (4-Nonylphenol)	0.001	-	-	0.0005	4.561	0.0005	0.0005	0.0005	0.0005	0.76	0.3	153.5	0.251	0.059	19.632
Pb	0.066	-	-	2.84	4.48	13.33	5.41	8.82	7.77	7.11	1.2	492.4	2.343	0.550	45.869
4-Chloroaniline	0.005	-	-	0.0025	0.025	0.0025	0.0025	0.0025	0.0025	0.006	0.005	25.0	0.002	0.0005	9.679
Al	0.512	-	-	487.77	611.27	3075	2112	1147.29	4447.26	1980.10	47.8	4042.5	652.640	153.329	320.771
B	0.067	-	-	1200.65	894.25	1503	1480	1318.35	1150.49	1257.79	707	77.9	414.568	97.397	13.776
Bromide	30	-	-	130	161	168.7	125.3	62.1	157.2	134.05	31	332.4	44.183	10.380	33.484
Co	0.026	-	-	7.26	10.1	10.55	4.04	4.24	6.94	7.19	0.3	2296.1	2.369	0.557	185.543
Cr	0.2	-	-	14.73	28.41	37.07	16.83	6.68	13.15	19.48	1.6	1117.4	6.420	1.508	94.269
Cu	0.263	-	-	74.45	78.18	190.8	27.5	71.73	148.59	98.54	13.2	646.5	32.479	7.631	57.807
Diphenyl ether; Diphenyl oxide	0.001	-	-	0.0005	47.02	0.0005	0.0005	0.0005	0.0005	7.84	6	30.6	2.583	0.607	10.114
Fe	2.172	-	-	1091.12	2089.74	3686.36	1983.6	2051.93	4962.08	2644.14	98.6	2581.7	871.508	204.749	207.656
Free CN	1	-	-	0.5	0.5	0.5	0.5	45.68	0.5	8.03	1.2	569.2	2.647	0.622	51.817
Petroleum hydrocarbons	50	-	-	212	561	-	-	134	532	359.75	96	274.7	118.574	27.857	29.018
Si	19.7	-	-	13120	1217	13130	15000	9971	8041	10079.83	1830	450.8	3322.313	780.531	42.652

Table F.1. (cont'd)

YESIL 58_IW (Merzifon OIZ IWWTP)	LOD (µg/L)	1.Period (µg/L) Aug-16	2.Period (µg/L) Oct-16	3.Period (µg/L) Feb-17	4.Period (µg/L) Apr-17	5.Period (µg/L) Jun-17	6.Period (µg/L) Aug-17	7.Period (µg/L) Nov-17	8.Period (µg/L) Jan-18	Avg. Conc. (µg/L)	AA-EQS (µg/L)	% EQS Exceedance	Avg. Pollution Load (g/day)	Process Contribution (PC)	% Relative increase
Ti	7.67	-	-	54	20	80	3.835	28.8	61.59	41.37	26	59.1	13.636	3.204	12.321
Tridecane	0.02	-	-	0.01	8.83	0.01	0.01	0.01	0.01	1.48	0.05	2860.0	0.488	0.115	229.207
V	0.021	-	-	2.89	3.64	5.66	2.98	1.66	3.5	3.39	1.6	111.8	1.117	0.262	16.398
Zn	0.667	-	-	1192.81	1256.99	3929.7	2809.24	1051.17	2710.04	2158.33	5.9	36481.8	711.384	167.130	2832.706
Ethalfluralin	0.005	-	-	0.0025	6.56	0.0025	0.0025	0.0025	0.0025	1.10	0.3	265.1	0.361	0.085	28.274
Fenpropimorph	0.1	-	-	0.05	0.62	0.05	0.05	0.05	0.05	0.145	0.1	45.0	0.048	0.011	11.228
Avg. Flowrate (m^3/h)		-	-	12.5	12.5	7.4	20	15	15	**13.73**					

Blue: Priority substances
Purple: River basin specific pollutants
* Upstream water quality of YESIL 58 (which is YESIL 97) Class 3.
** MAC-EQS

Table F. 2. Results of Samsun OIZ IWWTP (YESIL 59_IW) Effluents for all Monitoring Periods and related Calculations

YESIL 59_IW (Samsun OIZ IWWTP)	LOD (µg/L)	1.Period (µg/L) Aug-16	2.Period (µg/L) Oct-16	3.Period (µg/L) Feb-17	4.Period (µg/L) Apr-17	5.Period (µg/L) Jun-17	6.Period (µg/L) Aug-17	7.Period (µg/L) Nov-17	8.Period (µg/L) Jan-18	Avg. Conc. (µg/L)	AA-EQS (µg/L)	% EQS Exceedance	Avg. Pollution Load (g/day)	Process Contribution (PC)	% Relative increase
Cd	0.059	-	-	0.0295	0.076	0.135	0.203	-	-	0.111	0.08*	38.6	0.171	Could not be calculated because there were no upstream and downstream stations data.	
Fluoranthene	0.001	-	-	0.0005	0.103	0.0005	0.0005	-	-	0.03	0.0063	314.7	0.04		
Ni	0.073	-	-	247.53	267.11	349.28	404.65	-	-	317.143	4	7828.6	489.99		
Nonylphenols (4-Nonylphenol)	0.001	-	-	0.0005	1.498	0.0005	0.0005	-	-	0.375	0.3	25.0	0.579		
Pb	0.066	-	-	1.46	2.7	4.71	7.93	-	-	4.2	1.2	250.0	6.489		
4-Chloroaniline	0.005	-	-	0.0025	0.019	0.0025	0.0025	-	-	0.007	0.005	32.5	0.010		
Al	0.512	-	-	355.81	453.88	557	1388	-	-	688.673	47.8	1340.7	1063.99		
B	0.067	-	-	668.19	663.56	979	824	-	-	783.688	707	10.8	1210.8		
Bromide	30	-	-	1193.9	996	1130.8	935.2	-	-	1063.98	31	3332.2	1643.84		
Co	0.026	-	-	128.04	36.91	486.52	245.57	-	-	224.260	0.3	74653.3	346.48		
Cr	0.2	-	-	189.66	90.02	310.21	492.34	-	-	270.558	1.6	16809.8	418.01		
Cu	0.263	-	-	21.84	22.9	24.3	26	-	-	23.760	13.2	80.0	36.709		
Fe	2.172	-	-	253.26	395.61	636.28	8489.7	-	-	2443.71	98.6	2378.4	3775.54		
Petroleum hydrocarbons	50	-	-	148	158	-	-	-	-	153.000	96	59.4	236.385		
Si	19.7	-	-	8349	7524	9338	9816	-	-	8756.75	1830	378.5	13529.2		
Tridecane	0.02	-	-	0.01	0.639	0.01	0.01	-	-	0.167	0.05	234.5	0.258		
V	0.021	-	-	3.72	3.11	6.27	4.11	-	-	4.303	1.6	168.9	6.647		
Zn	0.667	-	-	767.3	1062.2	9258.9	5944.6	-	-	4258.26	5.9	72073.9	6579.01		
Chlorfenapyr	0.005	-	-	0.0025	0.047	0.0025	0.0025	-	-	0.014	0.007	94.6	0.021		
Ethalfluralin	0.005	-	-	0.0025	7.705	0.0025	0.0025	-	-	1.928	0.3	542.7	2.98		
Avg. Flowrate (m^3/h)		-	-	47.5	40	80	90	-	-	**64.38**					

Blue: Priority substances
Purple: River basin specific pollutants
* There is no information about the water quality of the receiving body of Samsun OIZ IWWTP. An ideal situation was assumed and AA-EQS of Cd was taken as 0.08 (Class 1-2).

Table F. 3. Results of Dimes Food IWWTP (YESIL 60_IW) Effluents for all Monitoring Periods and related Calculations

YESIL 60_IW (Dimes IWWTP)	LOD (µg/L)	1.Period (µg/L) Aug-16	2.Period (µg/L) Oct-16	3.Period (µg/L) Feb-17	4.Period (µg/L) Apr-17	5.Period (µg/L) Jun-17	6.Period (µg/L) Aug-17	7.Period (µg/L) Nov-17	8.Period (µg/L) Jan-18	Avg. Conc. (µg/L)	AA-EQS (µg/L)	% EQS Exceedance	Avg. Pollution Load (g/day)	Process Contribution (PC)	% Relative Increase
Cd	0.059	-	-	0.0295	0.0295	0.0295	0.409	0.0295	0.0295	0.093	0.09*	103.1	0.032	8.9E-05	0.099
Pb	0.066	-	-	0.84	1.31	2.95	11.61	4.42	2.19	3.887	1.2	323.9	1.347	3.7E-03	0.311
Al	0.512	-	-	49.79	32.72	130	103	110.61	37.53	77.275	47.8	161.7	26.780	7.4E-02	0.155
Bromide	30	-	-	15	111	45.3	15	15	132.1	55.567	31	179.2	19.257	5.3E-02	0.172
Co	0.026	-	-	0.11	0.1	0.19	1.44	0.21	0.11	0.360	0.3	120.0	0.125	3.5E-04	0.115
Cr	0.2	-	-	1.45	0.82	1.03	6.48	3.91	1.35	2.507	1.6	156.7	0.869	2.4E-03	0.150
Cu	0.263	-	-	12.09	12.63	16.5	46.2	19.64	18.72	20.963	13.2	158.8	7.265	2.0E-02	0.152
Fe	2.172	-	-	79.38	73.58	111.08	471.7	220.01	85.47	173.537	98.6	176.0	60.141	1.7E-01	0.169
Free CN	1	-	-	0.5	0.5	0.5	0.5	5.26	0.5	1.293	1.2	107.8	0.448	1.2E-03	0.103
Petroleum hydrocarbons	50	-	-	165	533	-	-	206	525	357.250	96	372.1	123.809	3.4E-01	0.357
Si	19.7	-	-	8328	9023	8096	8910	7155	8003	8252.500	1830	451.0	2859.986	7.9E+00	0.433
V	0.021	-	-	2.82	0.78	5.55	1	3.26	2.34	2.625	1.6	164.1	0.910	2.5E-03	0.157
Zn	0.667	-	-	48.19	31.41	56.16	426.16	59.49	72.14	115.592	5.9	1959.2	40.059	1.1E-01	1.880
Fenpropimorph	0.1	-	-	0.05	1.174	0.05	0.05	0.05	0.05	0.237	0.1	237.3	0.082	2.3E-04	0.228
Avg. Flowrate (m^3/h)		-	-	16.67	16.67	16.5	17.4	17.4	2	**14.44**					

Blue: Priority substances
Purple: River basin specific pollutants
* Upstream water quality of YESIL 60 is (which is YESIL 95) Class 3.

Table F. 4. Results of Turhal Sugar Factory IWWTP (YESIL 61_IW) Effluents for all Monitoring Periods and related Calculations

YESIL 61_IW (Turhal Sugar IWWTP)	LOD (µg/L)	1.Period (µg/L) Aug-16	2.Period (µg/L) Oct-16	3.Period (µg/L) Feb-17	4.Period (µg/L) Apr-17	5.Period (µg/L) Jun-17	6.Period (µg/L) Aug-17	7.Period (µg/L) Nov-17	8.Period (µg/L) Jan-18	Avg. Conc. (µg/L)	AA-EQS (µg/L)	% EQS Exceedance	Avg. Pollution Load (g/day)	Process Contribution (PC)	% Relative Increase
Cd	0.059	-	-	-	-	-	-	0.172	0.0295	0.101	0.09*	111.944	0.314	0.001	1.048
Ni	0.073	-	-	-	-	-	-	34.57	18.7	26.635	4	665.875	83.101	0.249	6.232
Pb	0.066	-	-	-	-	-	-	7.12	0.78	3.95	1.2	329.167	12.324	0.037	3.081
Al	0.512	-	-	-	-	-	-	92.33	38.62	65.475	47.8	136.977	204.282	0.613	1.282
Bromide	30	-	-	-	-	-	-	15	67.8	41.400	31	133.548	129.168	0.387	1.250
Co	0.026	-	-	-	-	-	-	9.35	5.43	7.4	0.3	2463.333	23.057	0.069	23.053
Cr	0.2	-	-	-	-	-	-	5.38	2.47	3.925	1.6	245.313	12.246	0.037	2.296
Cu	0.263	-	-	-	-	-	-	18.9	13.26	16.08	13.2	121.818	50.170	0.150	1.140
Fe	2.172	-	-	-	-	-	-	552.49	285.79	419.14	98.6	425.091	1307.717	3.923	3.978
Free CN	1	-	-	-	-	-	-	3.18	0.5	1.84	1.2	153.333	5.741	0.017	1.435
Petroleum hydrocarbons	50	-	-	-	-	-	-	64	131	97.5	96	101.563	304.200	0.912	0.950
Si	19.7	-	-	-	-	-	-	13270	5573	9421.50	1830	514.836	29395.080	88.172	4.818
V	0.021	-	-	-	-	-	-	32.24	11.15	21.695	1.6	1355.938	67.688	0.203	12.690
Zn	0.667	-	-	-	-	-	-	7.97	9.04	8.505	5.9	144.153	26.536	0.080	1.349
Avg. Flowrate (m^3/h)		-	-	-	-	-	-	250	10	**130**					

Blue: Priority substances
Purple: River basin specific pollutants
* Upstream water quality of YESIL 61 (which is YESIL 126) Class 3.

Table F. 5. Results of Özdemir Antimony Mine IWWTP (YESIL 62_IW) Effluents for all Monitoring Periods and related Calculations

YESIL 62_IW (Özdemir Antimony IWWTP)	LOD (µg/L)	1.Period (µg/L) Aug-16	2.Period (µg/L) Oct-16	3.Period (µg/L) Feb-17	4.Period (µg/L) Apr-17	5.Period (µg/L) Jun-17	6.Period (µg/L) Aug-17	7.Period (µg/L) Nov-17	8.Period (µg/L) Jan-18	Avg. Conc. (µg/L)	AA-EQS (µg/L)	% EQS Exceedance	Avg. Pollution Load (g/day)	Process Contribution (PC)	% Relative Increase
Cd	0.059	-	-	0.0295	0.0295	0.112	0.069	6.348	0.0295	1.1	0.09*	1225.463	0.160	0.0002	0.207
Ni	0.073	-	-	75.41	60.06	126.36	81.18	13176.4	263.01	2297.070	4	57426.750	333.810	0.388	9.688
Pb	0.066	-	-	23.94	39.35	47.42	30.15	50.5	50.23	40.3	1.2	3355.417	5.851	0.007	0.566
Ag	0.021	-	-	0.0105	0.04	0.1	0.13	21.368	0.0105	3.610	1.5	240.656	0.525	0.001	0.041
Al	0.512	-	-	69.45	77.86	184	59	2595028.37	314.13	432622.135	47.8	905067.2	62868.649	72.987	152.693
As	0.209	-	-	230.76	238.37	277.21	179.03	481299.09	567.91	80465.40	53	151821.5	11693.231	13.575	25.614
B	0.067	-	-	447.52	517.1	640	532	10978.16	1401.43	2419.37	707	342.202	351.583	0.408	0.058
Ba	0.447	-	-	3.51	4.96	52.7	4.6	22508.73	9.7	3764.0	680	553.534	546.989	0.635	0.093
Be	0.037	-	-	0.0185	0.0185	0.049	0.0185	77.906	0.049	13.0	2.5	520.397	1.891	0.002	0.088
Bromide	30	-	-	50	54	47.9	46.1	15	30.3	40.6	31	130.806	5.893	0.007	0.022
Co	0.026	-	-	1.08	1.15	3.2	0.91	3184.32	3.04	532.283	0.3	177427.8	77.351	0.090	29.934
Cr	0.2	-	-	0.8	1.09	2.78	0.76	7444.4	2.33	1242.027	1.6	77626.667	180.491	0.210	13.096
Cu	0.263	-	-	11.33	17.18	20.2	10.9	5042.6	42.73	857.490	13.2	6496.136	124.610	0.145	1.096
Fe	2.172	-	-	322.23	809.73	3309.17	259.1	5768657.97	2405.33	962627.26	98.6	976295.4	139888.993	162.404	164.710
Petroleum hydrocarbons	50	-	-	189	554	-	-	159	25	231.750	96	241.406	33.678	0.039	0.041
Sb	0.12	-	-	1694.17	1733.84	1912.49	2477.08	600822.49	5072.35	102285.403	7.8	1311351.3	14864.115	17.257	221.237
Si	19.7	-	-	6424	6835	6124	6347	172300	5573	33933.833	1830	1854.3	4931.265	5.725	0.313
Sn	10	-	-	5	5	5	5	96.79	5	20.298	13	156.141	2.950	0.003	0.026
Ti	7.67	-	-	3.835	3.835	3.835	3.835	3209.85	3.835	538.17	26	2069.888	78.207	0.091	0.349
Tridecane	0.02	-	-	0.01	1.32	0.01	0.01	0.01	0.01	0.23	0.05	456.667	0.033	0.00004	0.077
V	0.021	-	-	0.38	0.55	1.88	0.36	5911.25	1.79	986.0	1.6	61627.188	143.291	0.166	10.397
Zn	0.667	-	-	9.82	10.23	109.23	18.42	6509.93	25.83	1113.9	5.9	18879.831	161.873	0.188	3.185
Ethalfluralin	0.005	-	-	0.0025	15.872	0.0025	0.0025	0.0025	0.0025	2.647	0.3	882.472	0.385	0.000	0.149
Avg. Flowrate (m^3/h)		-	-	1.565	1.565	1.5	1.7	5	25	**6.055**					

Blue: Priority substances Purple: River basin specific pollutants

* Upstream water quality of YESIL 62 (which is YESIL 18) Class 3.

Table F. 6. Results of Meray Oil IWWTP (YESIL 65_IW) Effluents for all Monitoring Periods and related Calculations

YESIL 65_IW (Meray Oil IWWTP)	LOD (µg/L)	1.Period (µg/L) Aug-16	2.Period (µg/L) Oct-16	3.Period (µg/L) Feb-17	4.Period (µg/L) Apr-17	5.Period (µg/L) Jun-17	6.Period (µg/L) Aug-17	7.Period (µg/L) Nov-17	8.Period (µg/L) Jan-18	Avg. Conc. (µg/L)	AA-EQS (µg/L)	% EQS Exceedance	Avg. Pollution Load (g/day)	Process Contribution (PC)	% Relative increase
Dichlorvos	0.0005	-	-	0.033	-	0.00025	-	0.00025	0.041	0.02	0.0006	3004.2	0.004	0.002	294.624
Ni	0.073	-	-	16.41	-	6.08	-	8.6	7.97	9.77	4	144.1	2.199	0.927	23.170
Pb	0.066	-	-	3.3	-	3.48	-	1.5	1.09	2.34	1.2	95.2	0.527	0.222	18.528
Al	0.512	-	-	309.7	-	102	-	63.69	49.66	131.26	47.8	174.6	29.554	12.458	26.064
Bromide	30	-	-	50	-	15	-	67.2	15	36.80	31	18.7	8.286	3.493	11.267
Co	0.026	-	-	0.48	-	0.25	-	0.41	0.94	0.52	0.3	73.3	0.117	0.049	16.451
Cr	0.2	-	-	5.49	-	3.99	-	2.63	2.15	3.57	1.6	122.8	0.803	0.338	21.148
Cu	0.263	-	-	21.31	-	17.3	-	15.14	13.42	16.79	13.2	27.2	3.781	1.594	12.074
Fe	2.172	-	-	483.3	-	191.96	-	171.78	130.08	244.28	98.6	147.7	55.000	23.185	23.514
Sb	0.12	-	-	26.51	-	0.35	-	3.49	9.58	9.98	7.8	28.0	2.248	0.947	12.147
Si	19.7	-	-	13190	-	9522	-	14220	15380	13078.00	1830	614.6	2944.512	1241.263	67.829
V	0.021	-	-	18.33	-	9.86	-	3.61	3.85	8.91	1.6	457.0	2.007	0.846	52.869
Zn	0.667	-	-	56.31	-	178.49	-	29.1	22.71	71.65	5.9	1114.4	16.133	6.801	115.266
Avg. Flowrate (m^3/h)		-	-	0.315	-	2.5	-	7.71	27	**9.38**					

Blue: Priority substances
Purple: River basin specific pollutants

Table F. 7. Results of Olmuksan International Paper IWWTP (YESIL 69_IW) Effluents for all Monitoring Periods and related Calculations

YESIL 69_IW (Olmuksan Paper IWWTP)	LOD (µg/L)	1.Period (µg/L) Aug-16	2.Period (µg/L) Oct-16	3.Period (µg/L) Feb-17	4.Period (µg/L) Apr-17	5.Period (µg/L) Jun-17	6.Period (µg/L) Aug-17	7.Period (µg/L) Nov-17	8.Period (µg/L) Jan-18	Avg. Conc. (µg/L)	AA-EQS (µg/L)	% EQS Exceedance	Avg. Pollution Load (g/day)	Process Contribution (PC)	% Relative Increase
Cd	0.059	-	-	-	0.0295	0.104	0.0295	0.0295	1.925	0.424	0.15*	282.333	0.194	0.004	2.688
Dichlorvos	0.0005	-	-	-	0.00025	0.00025	0.00025	0.00025	0.027	0.006	0.0006	933.333	0.003	0.000	8.886
Ni	0.073	-	-	-	6.16	8.44	6.02	6.49	7.18	6.9	4	171.450	3.138	0.065	1.632
Pb	0.066	-	-	-	1.22	3.99	1.78	1.79	1.19	1.994	1.2	166.167	0.912	0.019	1.582
4-Chloroaniline	0.005	-	-	-	0.155	0.0025	0.0025	0.0025	0.0025	0.033	0.005	660.000	0.015	0.000	6.283
Al	0.512	-	-	-	180.51	1469	50	92.27	25982.86	5554.9	47.8	11621.188	2541.846	52.885	110.637
Azinphos methyl	0.05	-	-	-	0.59	0.025	0.025	0.025	0.025	0.138	0.05	276.000	0.063	0.001	2.628
Bromide	30	-	-	-	426	15	484.1	433.2	522.1	376.1	31	1213.161	172.088	3.580	11.550
Co	0.026	-	-	-	0.73	0.62	0.63	0.65	0.76	0.678	0.3	226.000	0.310	0.006	2.152
Cu	0.263	-	-	-	18.57	31.2	13.5	23.22	16.5	20.6	13.2	156.045	9.425	0.196	1.486
Endrin	0.005	-	-	-	0.306	0.0025	0.0025	0.0025	0.0025	0.063	0.01	632.000	0.029	0.001	6.017
Fe	2.172	-	-	-	130.74	413.86	87.7	130.43	215.89	195.72	98.6	198.503	89.560	1.863	1.890
Free CN	1	-	-	-	0.5	2.26	0.5	3.97	0.5	1.5	1.2	128.833	0.707	0.015	1.227
Petroleum hydrocarbons	50	-	-	-	476	-	-	95	134	235.00	96	244.792	107.532	2.237	2.330
Sb	0.12	-	-	-	14.29	0.5	21.19	2.23	4.64	8.570	7.8	109.872	3.921	0.082	1.046
Si	19.7	-	-	-	1372	6008	-	14140	14140	8915	1830	487.158	4079.361	84.874	4.638
V	0.021	-	-	-	6.01	7.24	5.63	4.54	5.49	5.78	1.6	361.375	2.646	0.055	3.440
Zn	0.667	-	-	-	14.77	118.3	44.02	19.16	31.93	45.6	5.9	773.492	20.882	0.434	7.364
Chlorfenapyr	0.005	-	-	-	0.153	0.0025	0.0025	0.0025	0.0025	0.033	0.007	465.714	0.015	0.000	4.434
Fenpropimorph	0.1	-	-	-	1.032	0.05	0.05	0.05	0.05	0.246	0.1	246.400	0.113	0.002	2.346
Avg. Flowrate (m^3/h)		-	-	-	0.83	28	32	32	2.5	**19.066**					

Blue: Priority substances
Purple: River basin specific pollutants
* Upstream water quality of YESIL 69 (which is YESIL 124) Class 4.

Table F. 8. Results of Özmaya (Lesaffre) IWWTP (YESIL 70_IW) Effluents for all Monitoring Periods and related Calculations

YESIL 70_IW (Özmaya IWWTP)	LOD (µg/L)	1.Period (µg/L) Aug-16	2.Period (µg/L) Oct-16	3.Period (µg/L) Feb-17	4.Period (µg/L) Apr-17	5.Period (µg/L) Jun-17	6.Period (µg/L) Aug-17	7.Period (µg/L) Nov-17	8.Period (µg/L) Jan-18	Avg. Conc. (µg/L)	AA-EQS (µg/L)	% EQS Exceedance	Avg. Pollution Load (g/day)	Process Contribution (PC)	% Relative increase
Cd	0.059	-	-	-	0.0295	0.084	0.531	0.0295	0.0295	0.14	0.09*	56.3	0.078	0.0001	0.108
Fluoranthene	0.001	-	-	-	0.807	0.0005	0.0005	0.0005	0.0005	0.16	0.0063	2468.3	0.090	0.0001	1.777
Ni	0.073	-	-	-	3.44	3.74	2.7	6.8	4.01	4.14	4	3.5	2.302	0.003	0.072
Nonylphenols (4-Nonylphenol)	0.001	-	-	-	7.708	0.0005	0.0005	0.0005	0.0005	1.54	0.3	414.0	0.858	0.001	0.356
Pb	0.066	-	-	-	1.31	3.25	14.84	2.33	1.23	4.59	1.2	282.7	2.555	0.003	0.265
4-Chloroaniline	0.005	-	-	-	0.106	0.0025	0.0025	0.0025	0.0025	0.02	0.005	364.0	0.013	0.000	0.321
Al	0.512	-	-	-	102.18	183	230	107.32	142.02	152.90	47.8	219.9	85.078	0.106	0.221
Bromide	30	-	-	-	480	15	265.9	183	159.9	220.76	31	612.1	122.834	0.153	0.493
Co	0.026	-	-	-	0.28	0.5	0.65	0.75	0.57	0.550	0.3	83.3	0.306	0.0004	0.127
Cr	0.2	-	-	-	2.51	2.95	4.73	2.94	2.28	3.08	1.6	92.6	1.715	0.002	0.133
Cu	0.263	-	-	-	14.54	36.6	69.1	15.46	14.2	30	13.2	127.1	16.681	0.021	0.157
Fe	2.172	-	-	-	95.18	219.69	446.1	394.05	632.29	357.46	98.6	262.5	198.898	0.247	0.251
Free CN	1	-	-	-	1.8	0.5	0.5	9.46	0.5	2.552	1.2	112.7	1.420	0.002	0.147
PCB 153	0.001	-	-	-	0.059	0.0005	0.0005	0.0005	0.0005	0.012	0.01	22.0	0.007	0.00001	0.084
Pyrene	0.005	-	-	-	0.699	0.0025	0.0025	0.0025	0.0025	0.142	0.1	41.8	0.079	0.00010	0.098
Si	19.7	-	-	-	2094	5852	3708	6256	8579	5297.8	1830	189.5	2947.781	3.66549	0.200
Tridecane	0.02	-	-	-	16.784	0.01	0.01	0.01	0.01	3.365	0.05	6629.6	1.872	0.002	4.656
Zn	0.667	-	-	-	13.98	161.23	470.16	10.94	50.52	141	5.9	2296.0	78.658	0.098	1.658
Avg. Flowrate (m^3/h)		-	-	-	30	0.92	45	10	30	**23.18**					

Blue: Priority substances
Purple: River basin specific pollutants
* Upstream water quality of YESIL 70 (which is YESIL 19) Class 3.

Table F. 9. Results of Eti Copper Inc. IWWTP (YESIL 71_IW) Effluents for all Monitoring Periods and related Calculations

YESIL 71_IW (Eti Copper IWWTP)	LOD (µg/L)	1.Period (µg/L) Aug-16	2.Period (µg/L) Oct-16	3.Period (µg/L) Feb-17	4.Period (µg/L) Apr-17	5.Period (µg/L) Jun-17	6.Period (µg/L) Aug-17	7.Period (µg/L) Nov-17	8.Period (µg/L) Jan-18	Avg. Conc. (µg/L)	AA-EQS (µg/L)	% EQS Exceedance	Avg. Pollution Load (g/day)	Process Contribution (PC)	% Relative increase
Cd	0.059	-	-	-	-	-	-	0.102	0.061	0.082	0.08*	1.9	0.122	Could not be calculated because there were no upstream and downstream stations data.	
Pb	0.066	-	-	-	-	-	-	3.29	2.35	2.820	1.2	135.0	4.230		
Al	0.512	-	-	-	-	-	-	57.99	119.38	88.69	47.8	85.5	133.028		
Cu	0.263	-	-	-	-	-	-	22.5	25.94	24	13.2	83.5	36.330		
Fe	2.172	-	-	-	-	-	-	101.53	188.44	144.985	98.6	47.0	217.478		
Petroleum hydrocarbons	50	-	-	-	-	-	-	99	138	118.500	96	23.4	177.750		
Si	19.7	-	-	-	-	-	-	1546	3299	2422.5	1830	32.4	3633.750		
Zn	0.667	-	-	-	-	-	-	18.52	32.92	25.720	5.9	335.9	38.580		
Avg. Flowrate (m^3/h)		-	-	-	-	-	-	65	60	**62.50**					

Blue: Priority substances
Purple: River basin specific pollutants
* There is no information about the water quality of the receiving body of Eti Copper IWWTP. An ideal situation was assumed and AA-EQS of Cd was taken as 0.08 (Class 1-2).

Table F. 10. Results of Yemsel Poultry Livestock IWWTP (YESIL 73_IW) Effluents for all Monitoring Periods and related Calculations

YESIL 73_IW (Yemsel Poultry-Livestock IWWTP)	LOD (µg/L)	1.Period (µg/L) Aug-16	2.Period (µg/L) Oct-16	3.Period (µg/L) Feb-17	4.Period (µg/L) Apr-17	5.Period (µg/L) Jun-17	6.Period (µg/L) Aug-17	7.Period (µg/L) Nov-17	8.Period (µg/L) Jan-18	Avg. Conc. (µg/L)	AA-EQS (µg/L)	% EQS Exceedance	Avg. Pollution Load (g/day)	Process Contribution (PC)	% Relative increase
Ni	0.073	-	-	-	-	4.53	2.31	7.19	5.73	4.940	4	23.5	0.179	Could not be calculated because there were no upstream and downstream stations data.	
Pb	0.066	-	-	-	-	1.86	1.3	1.47	0.9	1.38	1.2	15.2	0.050		
Bromide	30	-	-	-	-	15	88	53.1	44.5	50.15	31	61.8	1.820		
Co	0.026	-	-	-	-	0.28	0.26	1.09	1.46	0.773	0.3	157.5	0.028		
Cu	0.263	-	-	-	-	19.5	13.2	18.24	21.05	18.00	13.2	36.3	0.653		
Fe	2.172	-	-	-	-	99.25	165.7	232.94	118.57	154.115	98.6	56.3	5.594		
Petroleum hydrocarbons	50	-	-	-	-	-	-	138	59	98.500	96	2.6	3.576		
Si	19.7	-	-	-	-	6239	-	6683	6004	6308.667	1830	244.7	229.005		
Zn	0.667	-	-	-	-	119.75	23.34	124.09	184.28	112.87	5.9	1813.0	4.097		
Avg. Flowrate (m3/h)		**-**	**-**	**-**	**-**	**0.85**	**1.1**	**1.1**	**3**	**1.51**					

Blue: Priority substances
Purple: River basin specific pollutants

Table F. 11. Results of Yuva Viol and Package IWWTP (YESIL 76_IW) Effluents for all Monitoring Periods and related Calculations

YESIL 76_IW (Yuva Viol IWWTP)	LOD (µg/L)	1.Period (µg/L) Aug-16	2.Period (µg/L) Oct-16	3.Period (µg/L) Feb-17	4.Period (µg/L) Apr-17	5.Period (µg/L) Jun-17	6.Period (µg/L) Aug-17	7.Period (µg/L) Nov-17	8.Period (µg/L) Jan-18	Avg. Conc. (µg/L)	AA-EQS (µg/L)	% EQS Exceedance	Avg. Pollution Load (g/day)	Process Contribution (PC)	% Relative increase
Benzo(a)pyrene	0.0001	-	-	-	-	-	0.00005	0.017	0.00005	0.006	0.00017	3252.9	0.0002	Could not be calculated because there were no upstream and downstream stations data.	
Cd	0.059	-	-	-	-	-	0.084	0.093	0.438	0.21	0.08*	156.3	0.007		
Dichlorvos	0.0005	-	-	-	-	-	0.00025	0.00025	0.012	0.0042	0.0006	594.4	0.00014		
Pb	0.066	-	-	-	-	-	3.54	3.14	3.31	3.330	1.2	177.5	0.112		
Al	0.512	-	-	-	-	-	143	108.74	162.55	138.097	47.8	188.9	4.640		
Bromide	30	-	-	-	-	-	221.4	371.1	381.3	324.6	31	947.1	10.907		
Co	0.026	-	-	-	-	-	0.43	0.49	0.88	0.6	0.3	100.0	0.020		
Fe	2.172	-	-	-	-	-	276.7	428.98	905.75	537.14	98.6	444.8	18.048		
Petroleum hydrocarbons	50	-	-	-	-	-	-	230	106	168	96	75.0	5.645		
Si	19.7	-	-	-	-	-	9837	9806	11140	10261	1830	460.7	344.770		
V	0.034	-	-	-	-	-	6.21	14.93	18.36	13.167	1.6	722.9	0.442		
Zn	0.667	-	-	-	-	-	245.93	19.84	23.56	96.443	5.9	1534.6	3.240		
Avg. Flowrate (m^3/h)		-	-	-	-	-	1.4	-	-	**1.40**					

Blue: Priority substances
Purple: River basin specific pollutants
* There is no information about the water quality of the receiving body of Yuva Viol and Package IWWTP. An ideal situation was assumed and AA-EQS of Cd was taken as 0.08 (Class 1-2).

Table F. 12. Results of Et-Bir Suluova Slaughterhouse IWWTP (YESIL 77_IW) Effluents for all Monitoring Periods and related Calculations

YESIL 77_IW (Et-Bir Slaughterhouse IWWTP)	LOD (µg/L)	1.Period (µg/L) Aug-16	2.Period (µg/L) Oct-16	3.Period (µg/L) Feb-17	4.Period (µg/L) Apr-17	5.Period (µg/L) Jun-17	6.Period (µg/L) Aug-17	7.Period (µg/L) Nov-17	8.Period (µg/L) Jan-18	Avg. Conc. (µg/L)	AA-EQS (µg/L)	% EQS Exceedance	Avg. Pollution Load (g/day)	Process Contribution (PC)	% Relative increase
Ni	0.073	-	-	-	-	16.33	1.8	0.7	2.52	5.34	4	33.4	0.648	0.020	0.495
Pb	0.066	-	-	-	-	3.69	2.24	1.15	1.01	2.023	1.2	68.5	0.246	0.007	0.625
Al	0.512	-	-	-	-	110	128	26.72	63.13	81.963	47.8	71.5	9.954	0.304	0.636
Bis(2-ethylhexyl) terephthalate	0.001	-	-	-	-	1.089	0.0005	0.0005	0.0005	0.27	0.1	172.6	0.033	0.001	1.011
Bromide	30	-	-	-	-	408.7	161430	227	268	40583	31	130814.3	4928.451	150.426	485.244
Co	0.026	-	-	-	-	2.47	0.47	0.04	0.55	0.883	0.3	194.2	0.107	0.003	1.090
Cu	0.263	-	-	-	-	31.2	27.1	15.05	24.65	24.5	13.2	85.6	2.975	0.091	0.688
Fe	2.172	-	-	-	-	510.3	208.6	57.56	276.59	263.263	98.6	167.0	31.971	0.976	0.990
Free CN	1	-	-	-	-	0.5	4.6	0.5	0.5	1.53	1.2	27.1	0.185	0.006	0.471
Petroleum hydrocarbons	50	-	-	-	-	-	-	25	231	128	96	33.3	15.544	0.474	0.494
Si	19.7	-	-	-	-	11420	6215	3323	8574	7383	1830	303.4	896.592	27.366	1.495
V	0.021	-	-	-	-	1.5	3.34	0.32	1.45	1.653	1.6	3.3	0.201	0.006	0.383
Zn	0.667	-	-	-	-	197.96	114.33	3.11	46.59	90.50	5.9	1433.9	10.990	0.335	5.685
Avg. Flowrate (m^3/h)		-	-	-	-	2.5	2.68	-	10	**5.06**					

Blue: Priority substances
Purple: River basin specific pollutants

Table F. 13. Results of Kozlu Food (Feed) IWWTP (YESIL 78_IW) Effluents for all Monitoring Periods and related Calculations

YESIL 78_IW (Kozlu Food IWWTP)	LOD (µg/L)	1.Period (µg/L) Aug-16	2.Period (µg/L) Oct-16	3.Period (µg/L) Feb-17	4.Period (µg/L) Apr-17	5.Period (µg/L) Jun-17	6.Period (µg/L) Aug-17	7.Period (µg/L) Nov-17	8.Period (µg/L) Jan-18	Avg. Conc. (µg/L)	AA-EQS (µg/L)	% EQS Exceedance	Avg. Pollution Load (g/day)	Process Contribution (PC)	% Relative increase
Ni	0.073	-	-	-	-	3.28	1.57	7.05	5.22	4.280	4	7.0	0.114	0.002	0.05
Pb	0.066	-	-	-	-	2.67	1.58	7.33	1.66	3.310	1.2	175.8	0.088	0.002	0.14
Al	0.512	-	-	-	-	235	21	1127.92	287.57	417.87	47.8	774.2	11.157	0.208	0.44
Bis(2-ethylhexyl) terephthalate	0.001	-	-	-	-	0.0005	0.0005	1.739	0.0005	0.435	0.1	335.1	0.012	0.000	0.22
Bromide	30	-	-	-	-	15	259.8	133.5	132.8	135.28	31	336.4	3.612	0.067	0.22
Co	0.026	-	-	-	-	0.22	0.12	1.49	0.76	0.648	0.3	115.8	0.017	0.000	0.11
Cr	0.2	-	-	-	-	4.95	3.02	21.93	4.54	8.610	1.6	438.1	0.230	0.004	0.27
Cu	0.263	-	-	-	-	17.7	18.5	20.73	28.78	21.43	13.2	62.3	0.572	0.011	0.08
Fe	2.172	-	-	-	-	252.49	69.3	1194.73	780.24	574.190	98.6	482.3	15.331	0.286	0.29
Petroleum hydrocarbons	50	-	-	-	-	-	-	366	104	235.00	96	144.8	6.275	0.117	0.12
Si	19.7	-	-	-	-	12900	11350	17830	13380	13865	1830	657.7	370.196	6.902	0.38
V	0.021	-	-	-	-	18.09	10.31	33.5	15.96	19.47	1.6	1116.6	0.520	0.010	0.61
Zn	0.667	-	-	-	-	541.41	205.51	52.54	129.8	232.315	5.9	3837.5	6.203	0.116	1.96
Avg. Flowrate (m^3/h)		-	-	-	-	0.75	0.85	0.85	2	**1.11**					

Blue: Priority substances
Purple: River basin specific pollutants

Table F. 14. Results of Bakraç Dairy IWWTP (YESIL 79_IW) Effluents for all Monitoring Periods and related Calculations

YESIL 79_IW (Bakraç Dairy IWWTP)	LOD (µg/L)	1.Period (µg/L) Aug-16	2.Period (µg/L) Oct-16	3.Period (µg/L) Feb-17	4.Period (µg/L) Apr-17	5.Period (µg/L) Jun-17	6.Period (µg/L) Aug-17	7.Period (µg/L) Nov-17	8.Period (µg/L) Jan-18	Avg. Conc. (µg/L)	AA-EQS (µg/L)	% EQS Exceedance	Avg. Pollution Load (g/day)	Process Contribution (PC)	% Relative increase
Hg	0.13	-	-	-	-	0.065	0.065	-	0.18	0.103	0.07*	47.6	0.021	0.0004	0.561
Ni	0.073	-	-	-	-	8.54	34.56	9.82	11.27	16.048	4	301.2	3.289	0.061	1.524
Pb	0.066	-	-	-	-	2.78	2.01	2.14	1.19	2.030	1.2	69.2	0.416	0.008	0.643
Al	0.512	-	-	-	-	92	42	106.3	27.55	66.963	47.8	40.1	13.725	0.254	0.532
Bromide	30	-	-	-	-	15	418.6	67.5	55	139.025	31	348.5	28.495	0.528	1.704
Co	0.026	-	-	-	-	0.59	9.53	0.3	0.34	2.690	0.3	796.7	0.551	0.010	3.407
Cu	0.263	-	-	-	-	20.9	21	15.92	13.48	17.825	13.2	35.0	3.653	0.068	0.513
Fe	2.172	-	-	-	-	3247.397	3443.4	1392.98	1853.06	2484.209	98.6	2419.5	509.164	9.438	9.572
Si	19.7	-	-	-	-	4149	4785	2417	3473	3706	1830	102.5	759.582	14.080	0.769
Zn	0.667	-	-	-	-	709.09	299.34	410.96	807.21	556.650	5.9	9334.7	114.091	2.115	35.846
Avg. Flowrate (m^3/h)		-	-	-	-	2.5	8.33	8.33	15	8.54					

Blue: Priority substances
Purple: River basin specific pollutants
* MAC-EQS of Hg

G. Results of Surface Water (Receiving Body) Stations for all Monitoring Periods

Table G. 1. Results of Upstream Station of the Tokat UWWTP (YESIL 11) for all Monitoring Periods

YESIL 11 (Upstream of Tokat UWWTP)	LOD (µg/L)	1.Period (µg/L) Aug-16	2.Period (µg/L) Oct-16	3.Period (µg/L) Feb-17	4.Period (µg/L) Apr-17	5.Period (µg/L) Jun-17	6.Period (µg/L) Aug-17	7.Period (µg/L) Nov-17	8.Period (µg/L) Jan-18	Avg. Conc. (µg/L)	AA-EQS (µg/L)	% EQS Exceedance	Avg. Pollution Load (g/day)
Pb	0.066	0.81	1.17	0.72	1.2	4.46	0.88	4.393	0.89	1.815	1.2	151.3	479.071
Al	0.512	144	256	181	300	264	82	278.1	256.99	220.261	47.8	460.8	58126.107
Co	0.026	0.24	0.63	0.36	0.51	0.2	0.17	0.43	0.4	0.368	0.3	122.5	96.982
Cr	0.2	2.11	4	1.38	3.63	9.9	1.59	4.83	4.89	4.041	1.6	252.6	1066.471
Cu	0.263	12.2	18.6	12.4	20.8	19.4	14.5	18.12	15.67	16.461	13.2	124.7	4344.061
Fe	2.172	219	471	231	424	429	128.7	385.73	383.14	333.946	98.6	338.7	88127.146
Petroleum hydrocarbons	50	-	281	376	387	-	-	117	158	263.800	96	274.8	69615.818
Si	19.7	4140	6507	2783	5503	4962	3417	7093	6320	5090.625	1830	278.2	1343396.593
V	0.021	1.83	2.76	1.97	2.78	2.93	1.75	3.03	2.76	2.476	1.6	154.8	653.473
Zn	0.667	4.53	4.79	5.09	6.97	-	10.29	4.15	9.81	6.519	5.9	110.5	1720.226
Avg. Flowrate (m^3/h)		23399.71	11270.21	32027.76	1617.12	2415.6	14328	1555.2	1351.8	**10995.68**			

Blue: Priority substances
Purple: River basin specific pollutants

Table G. 2. Results of Upstream Station of Özdemir Antimony Mine IWWTP and downstream of Turhal Sugar Factory (YESIL 18) for all Monitoring Periods

YESIL 18 (Upstream of Özdemir Antimony & Downstream of Turhal Sugar IWWTP)	LOD (µg/L)	1.Period (µg/L) Aug-16	2.Period (µg/L) Oct-16	3.Period (µg/L) Feb-17	4.Period (µg/L) Apr-17	5.Period (µg/L) Jun-17	6.Period (µg/L) Aug-17	7.Period (µg/L) Nov-17	8.Period (µg/L) Jan-18	Avg. Conc. (µg/L)	AA-EQS (µg/L)	% EQS Exceedance	Avg. Pollution Load (g/day)
Cd	0.059	0.28	0.0295	0.0295	0.0295	0.081	0.0295	0.0295	0.0295	0.067	0.09*	74.722	57.917
Dichlorvos	0.0005	0.08	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025	0.010	0.0006	1703.125	8.801
Ni	0.073	6.26	3.05	9.48	4.28	7.38	5.86	4.52	3.38	5.526	4	138.156	4759.301
Pb	0.066	4.18	1.1	1.41	1.32	5.36	1.88	1.57	1.11	2.241	1.2	186.771	1930.203
Al	0.512	447	99	907	290	598	411	298	186.65	404.581	47.8	846.404	348432.295
Co	0.026	0.83	0.36	1.75	0.69	1.43	1.03	0.63	0.45	0.896	0.3	298.750	771.866
Cr	0.2	4.17	3.14	6.29	3.37	4.38	3.57	3.96	3.46	4.043	1.6	252.656	3481.470
Cu	0.263	18.5	19.2	17.4	16.6	28.1	15.3	13.54	18.11	18.344	13.2	138.968	15797.951
Fe	2.172	795	194	1423	529	912	742.6	516.38	327.82	679.975	98.6	689.630	585606.104
Petroleum hydrocarbons	50	-	63	687	422	-	-	77	219	293.6	96	305.833	252853.343
Si	19.7	5698	7346	4946	4915	5994	5507	7897	7958	6282.625	1830	343.313	5410704.146
V	0.021	4	3.45	4.6	4.16	5.43	4.48	3.58	3.69	4.174	1.6	260.859	3594.505
Zn	0.667	52.2	10.3	16.6	12.1	152.9	12.71	7.82	16.55	35.148	5.9	595.720	30269.628
Prothiofos	0.05	0.025	0.631	0.025	0.025	0.025	0.025	0.025	0.025	0.101	0.1	100.750	86.768
Avg. Flowrate (m^3/h)		44820	41650.29	98815.68	20430	17373.6	31140	18838.8	14004	**35884.05**			

Blue: Priority substances
Purple: River basin specific pollutants
* The water quality where YESIL 18 station located is Class 3

Table G. 3. Results of Upstream Station of Amasya UWWTP and Özmaya (Lesaffre) IWWTP (YESIL 19) for all Monitoring Periods

YESIL 19 (Upstream of Amasya UWWTP & Özmaya IWWTP)	LOD (µg/L)	1.Period (µg/L) Aug-16	2.Period (µg/L) Oct-16	3.Period (µg/L) Feb-17	4.Period (µg/L) Apr-17	5.Period (µg/L) Jun-17	6.Period (µg/L) Aug-17	7.Period (µg/L) Nov-17	8.Period (µg/L) Jan-18	Avg. Conc. (µg/L)	AA-EQS (µg/L)	% EQS Exceedance	Avg. Pollution Load (g/day)
Cd	0.059	0.07	0.0295	0.331	1.052	0.802	0.116	0.0295	0.0295	0.307	0.09*	241.6	247.069
Hexachlorobenzene	0.001	1.379	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.173	0.05**	245.6	138.879
Hg	0.13	0.065	0.18	0.065	0.065	0.065	0.065	0.065	0.065	0.079	0.07**	13.4	63.789
Ni	0.073	9.46	3.86	5.5	7.87	31.21	8.05	6.85	6.83	9.95	4	148.8	7999.243
Pb	0.066	5.37	2.64	6.4	4.45	8.74	4.86	8.38	8.39	6.154	1.2	412.8	4945.407
Al	0.512	696	95	265	565	764	453	188.65	273.16	412.476	47.8	762.9	331482.896
Bromide	30	50	50	50	40.5	48.8	45.4	38.6	91.2	51.8	31	67.1	41628.613
Co	0.026	1.24	0.38	0.84	1.19	2.08	1.38	0.75	0.94	1.1	0.3	266.7	884.005
Cr	0.2	4.4	1.87	3.02	3.67	3.87	2.94	3.17	3.05	3.249	1.6	103.0	2610.829
Cu	0.263	20.2	16.6	13.3	15.8	97.7	15.8	15.65	15.65	26.338	13.2	99.5	21165.899
Fe	2.172	1228	225	786	1072	1212	866.8	518.55	760.65	833.63	98.6	745.5	669935.370
Petroleum hydrocarbons	50	-	97	415	473	-	-	102	25	222.40	96	131.7	178729.796
Sb	0.12	19.8	22.3	38.7	16.8	14.89	32.73	40.09	68.75	32	7.8	307.1	25521.634
Si	19.7	6768	6537	4960	5358	6255	6930	7577	7517	6488	1830	254.5	5213823.001
V	0.021	6.09	4.51	3.51	5.6	8.11	6.51	4.37	4.59	5.411	1.6	238.2	4348.703
Zn	0.667	23.6	10.3	13.5	24.9	267.2	15.11	7.27	13.97	46.98	5.9	696.3	37756.067
Prothiofos	0.05	0.025	1.013	0.025	0.025	0.025	0.025	0.025	0.025	0.149	0.1	48.5	119.341
Avg. Flowrate (m^3/h)		17756.1	15655.41	22426.2	44640	48318.28	39855.6	35272.8	43956	**33485.05**			

Blue: Priority substances

Purple: River basin specific pollutants

* The water quality where YESIL 19 station located is Class 3.

** MAC-EQS

Table G. 4. Results of Downstream Station of Bakraç Dairy IWWTP (YESIL 20) for all Monitoring Periods

YESIL 20 (Downstream of Bakraç IWWTP)	LOD (µg/L)	1.Period (µg/L) Aug-16	2.Period (µg/L) Oct-16	3.Period (µg/L) Feb-17	4.Period (µg/L) Apr-17	5.Period (µg/L) Jun-17	6.Period (µg/L) Aug-17	7.Period (µg/L) Nov-17	8.Period (µg/L) Jan-18	Avg. Conc. (µg/L)	AA-EQS (µg/L)	% EQS Exceedance	Avg. Pollution Load (g/day)
Bifenox	0.005	0.0025	0.0025	0.0025	0.0025	0.0025	0.111	0.0025	0.0025	0.016	0.012	33.9	2.801
Cd	0.059	0.14	0.25	0.182	0.0295	0.295	0.068	0.32	0.121	0.176	0.15*	17.1	30.639
Dichlorvos	0.0005	0.075	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025	0.027	0.01	0.0006	2056.3	2.256
Hg	0.13	0.065	0.065	0.16	0.065	0.065	0.065	0.065	0.065	0.077	0.07**	9.8	13.407
Ni	0.073	13.1	6.6	6.2	6.2	23.4	5.49	21.93	11.2	11.77	4	194.1	2051.775
Pb	0.066	5.38	5.73	2.93	2.06	20.47	2.34	22.32	5.43	8.333	1.2	594.4	1453.159
Al	0.512	3067	1089	475	485	4880	785	6196.31	2672.15	2456.183	47.8	5038.5	428349.730
Bromide	30	180	240	366.9	212.8	173.1	220.6	268.5	381.6	255.438	31	724.0	44547.416
Co	0.026	3.42	2.02	1.41	1.39	8.53	1.68	5.72	2.79	3.370	0.3	1023.3	587.716
Cr	0.2	6.16	3.95	3.12	2.09	7.28	2.19	16.73	7.93	6.181	1.6	286.3	1077.989
Cu	0.263	30.5	17	68.2	29	164.6	18	54.95	35.41	52.208	13.2	295.5	9104.807
Fe	2.172	3955	1587	917	699	4418	1070.5	7132.6	3192.07	2871.396	98.6	2812.2	500761.571
Petroleum hydrocarbons	50	-	25	997	418	-	-	339	55	366.800	96	282.1	63968.651
Si	19.7	11930	8413	8343	7608	15450	8416	20830	13760	11843.75	1830	547.2	2065509.021
V	0.021	16.5	9.4	5.2	6.5	31.5	9.07	23.12	11.82	14.139	1.6	783.7	2465.749
Zn	0.667	59.9	42.7	142	43.9	210.4	32.62	136.39	60.76	91.084	5.9	1443.8	15884.691
Prothiofos	0.05	0.08	4.161	0.025	0.025	0.025	0.025	0.025	0.025	0.549	0.1	448.9	95.722
Avg. Flowrate (m^3/h)		11170.1	10278.66	3628.22	10249.2	6206.4	9324	4680	2595.6	**7266.52**			

Blue: Priority substances
Purple: River basin specific pollutants
* The water quality where YESIL 20 station located is Class 4.
** MAC-EQS

Table G. 5. Results of Downstream Station of Çorum UWWTP and Olmuksan International Paper IWWTP (YESIL 25) for all Monitoring Periods

YESIL 25 (Downstream of Çorum UWWTP & Olmuksan Int. Paper IWWTP)	LOD (µg/L)	1.Period (µg/L) Aug-16	2.Period (µg/L) Oct-16	3.Period (µg/L) Feb-17	4.Period (µg/L) Apr-17	5.Period (µg/L) Jun-17	6.Period (µg/L) Aug-17	7.Period (µg/L) Nov-17	8.Period (µg/L) Jan-18	Avg. Conc. (µg/L)	AA-EQS (µg/L)	% EQS Exceedance	Avg. Pollution Load (g/day)
Cd	0.059	0.63	5.14	45.591	13.213	2.054	0.364	2.739	1.825	8.945	0.15*	5863.0	755.053
Dichlorvos	0.0005	0.108	0.26	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025	0.046	0.0006	7597.9	3.899
Hg	0.13	0.065	0.065	0.065	0.065	0.065	-	-	0.15	0.079	0.07**	13.1	6.683
Ni	0.073	6.3	6.87	6.32	21.07	7.63	7.98	13.71	9.95	9.979	4	149.5	842.360
Pb	0.066	3.06	20.58	14.06	25.56	10.65	2.25	95.63	12.45	23.030	1.2	1819.2	1944.086
Al	0.512	176	280	303	2316	530	149	1011.23	324.35	636.198	47.8	1231.0	53704.835
Bromide	30	220	590	706.5	313.7	140	239.4	141.6	541.3	361.563	31	1066.3	30521.425
Co	0.026	0.63	0.85	0.83	3.65	1.36	1.52	2.11	35.03	5.748	0.3	1815.8	485.177
Cr	0.2	1.74	2.68	2.78	10.78	2.9	1.7	6.88	2.59	4.006	1.6	150.4	338.189
Cu	0.263	15.5	18	30.1	35	24.2	20.5	49.05	31.83	28.023	13.2	112.3	2365.529
Fe	2.172	378	483	298	3225	729	390.4	3426.61	1970.81	1362.603	98.6	1281.9	115024.567
Petroleum hydrocarbons	50	-	191	483	414	-	-	408	106	320.4	96	233.8	27046.678
Si	19.7	6383	6922	6616	1035	7436	-	8645	7283	6331.429	1830	246.0	534469.759
V	0.021	4.63	4.03	3.72	12.98	7.56	5.92	6.69	3.74	6.159	1.6	284.9	519.893
Zn	0.667	29.4	220.8	423.5	228.1	256.6	31.05	317.47	347.8	231.840	5.9	3829.5	19570.855
Fenpropimorph	0.1	0.05	0.05	0.05	1.82	0.05	0.05	0.05	0.05	0.271	0.1	171.3	22.898
Imidacloprid	0.02	0.671	0.12	0.03	0.32	0.01	0.042	0.01	0.01	0.152	0.14	8.3	12.799
Avg. Flowrate (m^3/h)		1488.97	1753.18	9788.9	5596.2	3056.4	457.2	2862	3135.6	**3517.31**			

Blue: Priority substances
Purple: River basin specific pollutants
* The water quality where YESIL 25 station located is Class 4.
** MAC-EQS

Table G. 6. Results of Downstream Station of Merzifon OIZ IWWTP (YESIL 31) for all Monitoring Periods

YESIL 31 (Downstream of Merzifon OIZ IWWTP)	LOD (µg/L)	1.Period (µg/L) Aug-16	2.Period (µg/L) Oct-16	3.Period (µg/L) Feb-17	4.Period (µg/L) Apr-17	5.Period (µg/L) Jun-17	6.Period (µg/L) Aug-17	7.Period (µg/L) Nov-17	8.Period (µg/L) Jan-18	Avg. Conc. (µg/L)	AA-EQS (µg/L)	% EQS Exceedance	Avg. Pollution Load (g/day)
Cd	0.059	0.12	0.13	0.077	0.06	0.488	0.083	0.1	0.191	0.156	0.15*	4.1	1.092
Dichlorvos	0.0005	0.252	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025	0.032	0.0006	5186.5	0.222
Ni	0.073	15.6	16.7	13.6	114.3	17.6	17.83	76.14	19.26	36.379	4	809.5	254.423
Pb	0.066	7.25	1.46	1.33	2.25	3.91	1.93	1.69	1.29	2.639	1.2	119.9	18.455
Al	0.512	2767	118	188	756	603	519	137.48	420.72	688.650	47.8	1340.7	4816.225
Bromide	30	480	540	589.2	407.8	771.4	804.6	285.8	721.4	575.025	31	1754.9	4021.564
Co	0.026	7.75	10.39	8.33	4.73	65.5	11.7	34.69	21.72	20.601	0.3	6767.1	144.079
Cr	0.2	23.9	12.2	24.7	27.4	102.23	17.95	14.44	43.98	33.350	1.6	1984.4	233.241
Cu	0.263	306	572	587	318	196.5	231.6	458.98	677.3	418.423	13.2	3069.9	2926.330
Fe	2.172	3145	239	572	1467	646	764.4	319.33	1285.02	1054.719	98.6	969.7	7376.408
Free CN	1	-	0.5	10.63	0.5	0.5	0.5	0.5	38.2	7.333	1.2	511.1	51.284
Petroleum hydrocarbons	50	-	270	314	503	-	-	94	25	241.200	96	151.3	1686.885
Si	19.7	12430	7848	7326	8906	8593	9249	8132	7782	8783.250	1830	380.0	61427.591
Sn	10	5	5	19.23	15.06	5	5	5	46.95	13.280	13	2.2	92.877
V	0.021	23.5	9.2	7	11.1	10.9	14.62	5.98	6.18	11.060	1.6	591.3	77.351
Zn	0.667	219	377	412	192	314	171.87	737.14	416.29	354.913	5.9	5915.5	2482.159
Avg. Flowrate (m^3/h)		421.56	-	161.25	-	-	-	-	-	**291.41**			

Blue: Priority substances
Purple: River basin specific pollutants
* The water quality where YESIL 31 station located is Class 4.

Table G. 7. Results of Downstream Station of Et-Bir Suluova Slaughterhouse IWWTP (YESIL 32) for all Monitoring Periods

YESIL 32 (Downstream of Et-Bir Slaughterhouse IWWTP)	LOD (µg/L)	1.Period (µg/L) Aug-16	2.Period (µg/L) Oct-16	3.Period (µg/L) Feb-17	4.Period (µg/L) Apr-17	5.Period (µg/L) Jun-17	6.Period (µg/L) Aug-17	7.Period (µg/L) Nov-17	8.Period (µg/L) Jan-18	Avg. Conc. (µg/L)	AA-EQS (µg/L)	% EQS Exceedance	Avg. Pollution Load (g/day)
Bifenox	0.005	0.0025	0.0025	-	0.0025	0.0025	0.225	0.0025	0.0025	0.034286	0.012	185.7	2.031
Dichlorvos	0.0005	0.152	0.427	-	0.00025	0.00025	0.00025	0.00025	0.00025	0.083	0.0006	13715.5	4.909
Ni	0.073	6.99	7.21	3.23	5.46	3.45	2.03	27.62	8.38	8.046	2	302.3	476.539
Nonylphenols	0.001	1.692	0.055	-	0.453	0.0005	0.0005	0.0005	0.0005	0.315	0.3	4.9	18.630
Pb	0.066	5.3	5.6	1.76	1.8	4.64	1.54	28.71	3.5	6.606	1.2	450.5	391.255
4-Chloroaniline	0.005	0.014	0.0025	-	0.016	0.0025	0.0025	0.0025	0.0025	0.006	0.005	21.4	0.360
Al	0.512	1327	1164	328	563	412	75	6689.32	1223.12	1472.680	47.8	2980.9	87219.399
Bromide	30	50	50	128.8	104.8	106.8	143.9	15	164.8	95.513	31	208.1	5656.723
Co	0.026	1.7	1.94	0.72	1.15	0.65	0.57	6.11	2.25	1.89	0.3	528.8	111.713
Cr	0.2	4.64	3.1	1.31	1.96	1.6	0.45	16.91	3.77	4.218	1.6	163.6	249.781
Cu	0.263	25.2	32.9	29.9	36.8	20.9	17.9	83.67	29.22	34.561	13.2	161.8	2046.888
Fe	2.172	1813	1186	454	893	481	220.8	7498.42	1861.28	1800.938	98.6	1726.5	106660.433
Fenthion	0.05	0.025	0.21	-	0.025	0.025	0.025	0.025	0.025	0.051	0.05	2.9	3.046
Free CN	1	-	0.5	-	0.5	0.5	0.5	15.95	0.5	3.075	1.2	156.3	182.117
Petroleum hydrocarbons	50	-	350	25	515	-	-	192	108	238	96	147.9	14095.538
Si	19.7	9440	6699	6583	8712	7812	9444	21660	8998	9918.5	1830	442.0	587422.667
V	0.021	6.9	10.66	2.86	3.56	5.1	2.55	24.34	7.45	7.928	1.6	395.5	469.506
Zn	0.667	69.5	33.2	72.3	103	191	22	251.24	57.69	99.991	5.9	1594.8	5921.977
Diflubenzuron	0.05	0.025	2.43	-	0.025	0.025	0.025	0.025	0.025	0.369	0.13	183.5	21.829
Fenpropimorph	0.1	0.05	0.05	-	0.731	0.05	0.05	0.05	0.05	0.147	0.1	47.3	8.723
Avg. Flowrate (m^3/h)		3864.24	2762.25	1128.96	1197	4989.6	3110.4	1717.2	972	**2467.71**			

Blue: Priority substances
Purple: River basin specific pollutants

Table G. 8. Results of Downstream Station of Amasya UWWTP and Özmaya (Lesaffre) IWWTP (YESIL 33) for all Monitoring Periods

YESIL 33 (Downstream of Amasya UWWTP & Özmaya IWWTP)	LOD (µg/L)	1.Period (µg/L) Aug-16	2.Period (µg/L) Oct-16	3.Period (µg/L) Feb-17	4.Period (µg/L) Apr-17	5.Period (µg/L) Jun-17	6.Period (µg/L) Aug-17	7.Period (µg/L) Nov-17	8.Period (µg/L) Jan-18	Avg. Conc. (µg/L)	AA-EQS (µg/L)	% EQS Exceedance	Avg. Pollution Load (g/day)
Bifenox	0.005	0.0025	0.0025	0.0025	0.0025	0.0025	0.228	0.0025	0.0025	0.031	0.012	155.7	46.948
Cd	0.059	0.12	0.0295	0.333	0.764	0.527	0.071	0.0295	0.068	0.243	0.15*	61.8	371.375
Dichlorvos	0.0005	0.1627	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025	0.020556	0.0006	3326.0	31.448
Hg	0.13	0.065	0.17	0.18	0.065	0.065	0.065	-	0.065	0.096	0.07**	37.8	147.523
Ni	0.073	10.1	3.3	8.5	10.8	8.4	5.51	3.56	7.5	7.209	4	80.2	11028.412
Pb	0.066	5.1	1.74	6.15	4.19	6.33	2.35	3.35	6.11	4.415	1.2	267.9	6754.353
Al	0.512	1124	99	652	1239	703	381	56.07	777.54	628.951	47.8	1215.8	962210.334
Bromide	30	50	50	50	36.6	42.9	89.6	55.1	108.3	60.313	31	94.6	92269.967
Co	0.026	1.57	0.48	1.42	1.76	1.75	1.05	0.64	1.91	1.323	0.3	340.8	2023.246
Cr	0.2	5.28	1.5	4.35	5.74	2.84	1.94	1.02	4.1	3.346250	1.6	109.1	5119.310
Cu	0.263	17.9	19.1	20.3	20.9	24.2	15.2	13.6	22.89	19.261250	13.2	45.9	29467.107
Fe	2.172	1695	208	1259	2001	1028	679	277.71	1187.13	1041.855	98.6	956.6	1593897.218
Fenthion	0.05	0.025	0.25	0.025	0.025	0.025	0.025	0.025	0.025	0.053	0.05	6.3	81.274
Petroleum hydrocarbons	50	-	295	207	338	-	-	58	163	212.200000	96	121.0	324637.296
Sb	0.12	19	23.4	33.2	15	13.72	26.43	32.16	37.84	25.094	7.8	221.7	38390.043
Si	19.7	7845	6706	5202	7324	6539	7077	7491	8207	7048.875	1830	285.2	10783825.249
V	0.021	7.19	4.39	4.81	7.27	8.2	7.51	2.68	6.3	6.044	1.6	277.7	9246.120
Zn	0.667	62.8	9	20.7	39.2	0.3335	14.62	7.13	36.67	23.807	5.9	303.5	36421.012
Avg. Flowrate (m^3/h)		54746.64	58966.21	97804.94	128653.92	67114.8	40824	3038.4	58806	**63744.36**			

Blue: Priority substances
Purple: River basin specific pollutants
* The water quality where YESIL 33 station located is Class 4.
** MAC-EQS

Table G. 9. Results of Downstream Station of Erbaa UWWTP (YESIL 36) for all Monitoring Periods

YESIL 36 (Downstream of Erbaa UWWTP)	LOD (µg/L)	1.Period (µg/L) Aug-16	2.Period (µg/L) Oct-16	3.Period (µg/L) Feb-17	4.Period (µg/L) Apr-17	5.Period (µg/L) Jun-17	6.Period (µg/L) Aug-17	7.Period (µg/L) Nov-17	8.Period (µg/L) Jan-18	Avg. Conc. (µg/L)	AA-EQS (µg/L)	% EQS Exceedance	Avg. Pollution Load (g/day)
Cd	0.059	0.14	0.0295	0.0295	0.092	0.161	0.131	0.0295	0.0295	0.0803	0.08*	100.313	60.253
Dichlorvos	0.0005	0.068	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025	0.009	0.0006	1453.125	6.546
Ni	0.073	4.56	3.86	4.7	6.64	5.4	2.78	3.01	4.22	4.396	4	109.906	3300.775
Pb	0.066	3.34	1.41	0.83	2	5.2	2.61	4.66	1.12	2.646	1.2	220.521	1986.847
Al	0.512	372	244	299	797	492	169	126.43	279.03	347.308	47.8	726.585	260764.028
Co	0.026	0.57	0.48	0.49	1.24	0.65	0.33	0.18	0.44	0.548	0.3	182.500	411.072
Cr	0.2	1.77	1.29	1.37	3.38	2.47	0.91	1.31	1.48	1.748	1.6	109.219	1312.051
Cu	0.263	16.6	21.2	16.7	18.1	20.5	11.8	12.77	19.36	17.129	13.2	129.763	12860.540
Fe	2.172	557	322	392	1350	435	240.9	186.41	418.74	487.756	98.6	494.682	366215.197
Petroleum hydrocarbons	50	-	298	639	479	-	-	25	119	312.000	96	325.000	234254.592
Si	19.7	5870	5907	4408	7110	5527	4690	3813	4119	5180.5	1830	283.087	3889602.288
V	0.021	4.06	3.92	3.2	5.18	4.8	2.63	2.17	2.96	3.615	1.6	225.938	2714.200
Zn	0.667	30.8	12.4	5.1	10.9	338.5	18.31	2.73	9.01	53.469	5.9	906.250	40145.193
Avg. Flowrate (m^3/h)		-	-	-	31284	-	-	-	-	**31284**			

Blue: Priority substances
Purple: River basin specific pollutants
* The water quality where YESIL 36 station located is Class 2.

Table G. 10. Results of Upstream Station of Erbaa UWWTP (YESIL 37) for all Monitoring Periods

YESIL 37 (Upstream of Erbaa UWWTP)	LOD (µg/L)	1.Period (µg/L) Aug-16	2.Period (µg/L) Oct-16	3.Period (µg/L) Feb-17	4.Period (µg/L) Apr-17	5.Period (µg/L) Jun-17	6.Period (µg/L) Aug-17	7.Period (µg/L) Nov-17	8.Period (µg/L) Jan-18	Avg. Conc. (µg/L)	AA-EQS (µg/L)	% EQS Exceedance	Avg. Pollution Load (g/day)
Bifenox	0.005	0.0025	0.0025	0.0025	0.0025	0.0025	0.349	0.0025	0.0025	0.046	0.012	381.771	68.428
Dichlorvos	0.0005	0.062	0.218	0.00025	0.00025	0.00025	0.00025	0.00025	0.027	0.039	0.0006	6421.875	57.552
Pb	0.066	2.75	0.9	0.64	1.13	2.56	1.37	1.19	0.69	1.404	1.2	116.979	2096.714
Al	0.512	198	66	100	91	154	64	111.16	125.39	113.694	47.8	237.853	169818.893
Cu	0.263	11.2	16.8	11.6	17.8	17.2	16.1	18.21	14.05	15.370	13.2	116.439	22957.431
Fe	2.172	248	92	146	112	202	93.8	181.45	192.26	158.439	98.6	160.688	236652.350
Petroleum hydrocarbons	50	-	595	144	369	-	-	25	131	252.800	96	263.333	377595.217
Si	19.7	5342	5321	4041	6467	5464	-	4486	3922	5006.143	1830	273.560	7477435.119
Tridecane	0.02	0.01	0.01	0.01	4.343	0.01	0.01	0.01	0.01	0.552	0.05	1103.250	823.936
V	0.021	2.69	2.62	2.46	2.91	3.2	2.36	2.22	2.55	2.626	1.6	164.141	3922.703
Zn	0.667	18.8	5.9	12.7	7.6	146.4	20.41	37.01	7.06	31.985	5.9	542.119	47774.458
Avg. Flowrate (m^3/h)		62241.48	65431.11	6609.33	87480	74318.17	-	41767.2	97801.2	**62235.50**			

Blue: Priority substances
Purple: River basin specific pollutants

Table G. 11. Results of Upstream Station of Dimes Food IWWTP and downstream station of the Tokat UWWTP (YESIL 95) for all Monitoring Periods

YESIL 95 (Upstream of Dimes IWWTP & Downstream of the Tokat UWWTP)	LOD (µg/L)	1.Period (µg/L) Aug-16	2.Period (µg/L) Oct-16	3.Period (µg/L) Feb-17	4.Period (µg/L) Apr-17	5.Period (µg/L) Jun-17	6.Period (µg/L) Aug-17	7.Period (µg/L) Nov-17	8.Period (µg/L) Jan-18	Avg. Conc. (µg/L)	AA-EQS (µg/L)	% EQS Exceedance	Avg. Pollution Load (g/day)
Pb	0.066	-	-	-	-	-	0.24	3.26	1.99	1.830	1.2	152.5	660.181
Al	0.512	-	-	-	-	-	43	132.37	409.98	195.117	47.8	408.2	70389.227
Co	0.026	-	-	-	-	-	0.1	0.26	0.68	0.347	0.3	115.6	125.062
Cr	0.2	-	-	-	-	-	0.51	3.08	5.51	3.033	1.6	189.6	1094.289
Cu	0.263	-	-	-	-	-	4.1	16.33	22.55	14.327	13.2	108.5	5168.410
Fe	2.172	-	-	-	-	-	70.1	224.15	600.31	298.187	98.6	302.4	107572.200
Petroleum Hydrocarbons	50	-	-	-	-	-	-	187	104	145.500	96	151.6	52489.788
Si	19.7	-	-	-	-	-	-	5986	6582	6284	1830	343.4	2266981.655
V	0.021	-	-	-	-	-	0..58	2.04	3.46	2.750	1.6	171.9	992.075
Zn	0.667	-	-	-	-	-	1.49	19	42.58	21.023	5.9	356.3	7584.263
Avg. Flowrate (m^3/h)		-	-	-	-	-	29181.6	-	881.28	**15031.44**			

Blue: Priority substances
Purple: River basin specific pollutants

Table G. 12. Results of Upstream Station of Merzifon OIZ IWWTP and downstream station of Meray Oil IWWTP (YESIL 97) for all Monitoring Periods

YESIL 97 (Upstream of Merzifon OIZ IWWTP & Downstream of Meray Oil IWWTP)	LOD (µg/L)	1.Period (µg/L) Aug-16	2.Period (µg/L) Oct-16	3.Period (µg/L) Feb-17	4.Period (µg/L) Apr-17	5.Period (µg/L) Jun-17	6.Period (µg/L) Aug-17	7.Period (µg/L) Nov-17	8.Period (µg/L) Jan-18	Avg. Conc. (µg/L)	AA-EQS (µg/L)	% EQS Exceedance	Avg. Pollution Load (g/day)
Pb	0.066	-	-	-	-	-	0.81	2.35	1.18	1.447	1.2	20.6	5.681
Al	0.512	-	-	-	-	-	183	464.31	502.57	383.293	47.8	701.9	1505.147
Bromide	30	-	-	-	-	-	171.6	107.9	116.2	131.900	31	325.5	517.955
Co	0.026	-	-	-	-	-	0.31	0.41	0.5	0.407	0.3	35.6	1.597
Cr	0.2	-	-	-	-	-	2.05	4.1	4.58	3.577	1.6	123.5	14.045
Cu	0.263	-	-	-	-	-	15.7	12.64	12.76	13.700	13.2	3.8	53.798
Fe	2.172	-	-	-	-	-	186.2	511.28	602.81	433.430	98.6	339.6	1702.028
Petroleum hydrocarbons	50	-	-	-	-	-	-	84	161	122.500	96	27.6	481.043
Si	19.7	-	-	-	-	-	9531	10680	9686	9965.667	1830	444.6	39133.977
V	0.034	-	-	-	-	-	9.65	7.26	8.92	8.610	1.6	438.1	33.810
Zn	0.667	-	-	-	-	-	9.29	8.9	12.2	10.130	5.9	71.7	39.779
Avg. Flowrate (m^3/h)		-	-	-	-	-	-	52.2	275.04	**163.62**			

Blue: Priority substances
Purple: River basin specific pollutants

Table G. 13. Results of Downstream Station of Özdemir Antimony Mine IWWTP (YESIL 99) for all Monitoring Periods

YESIL 99 (Downstream of Özdemir Antimony IWWTP)	LOD (µg/L)	1.Period (µg/L) Aug-16	2.Period (µg/L) Oct-16	3.Period (µg/L) Feb-17	4.Period (µg/L) Apr-17	5.Period (µg/L) Jun-17	6.Period (µg/L) Aug-17	7.Period (µg/L) Nov-17	8.Period (µg/L) Jan-18	Avg. Conc. (µg/L)	AA-EQS (µg/L)	% EQS Exceedance	Avg. Pollution Load (g/day)
Ni	0.073	-	-	-	-	-	77.15	33.74	4.53	38.473	4	961.833	10454.697
Pb	0.066	-	-	-	-	-	48.71	50.5	2.43	33.88	1.2	2823.333	9206.511
Al	0.512	-	-	-	-	-	68	1631.52	181.15	626.89	47.8	1311.485	170350.336
As	0.209	-	-	-	-	-	188.23	520.11	19.56	242.633	53	457.799	65932.891
Bromide	30	-	-	-	-	-	54	15	32.8	33.933	31	109.462	9221.003
Co	0.026	-	-	-	-	-	1.22	5.1	0.6	2.307	0.3	768.889	626.811
Cr	0.2	-	-	-	-	-	0.86	13.49	3.84	6.063	1.6	378.958	1647.643
Cu	0.263	-	-	-	-	-	17.5	22.42	22.31	20.743	13.2	157.146	5636.769
Fe	2.172	-	-	-	-	-	735.3	7109.81	591.87	2812.327	98.6	2852.258	764218.274
Sb	0.12	-	-	-	-	-	1411.93	196.06	21.18	543.057	7.8	6962.265	147569.567
Si	19.7	-	-	-	-	-	6559	10820	7598	8325.667	1830	454.954	2262406.669
V	0.034	-	-	-	-	-	0.6	8.95	3.62	4.39	1.6	274.375	1192.933
Zn	0.667	-	-	-	-	-	20.34	24.86	15.57	20.257	5.9	343.333	5504.522
Avg. Flowrate (m^3/h)		-	-	-	-	-	1.75	19338.8	14626.8	**11322.45**			

Blue: Priority substances
Purple: River basin specific pollutants

Table G. 14. Results of Upstream Station of the Havza UWWTP (YESIL 109) for all Monitoring Periods

YESIL 109 (Upstream of the Havza UWWTP)	LOD (µg/L)	1.Period (µg/L) Aug-16	2.Period (µg/L) Oct-16	3.Period (µg/L) Feb-17	4.Period (µg/L) Apr-17	5.Period (µg/L) Jun-17	6.Period (µg/L) Aug-17	7.Period (µg/L) Nov-17	8.Period (µg/L) Jan-18	Avg. Conc. (µg/L)	AA-EQS (µg/L)	% EQS Exceedance	Avg. Pollution Load (g/day)
Pb	0.066	-	-	-	-	-	0.23	2.79	1.33	1.450	1.2	120.833	158.291
Al	0.512	-	-	-	-	-	58	279.86	250.06	195.973	47.8	409.986	21393.703
Bromide	30	-	-	-	-	-	69	15	15	33.000	31	106.452	3602.491
Co	0.026	-	-	-	-	-	0.08	0.48	0.41	0.323	0.3	107.778	35.297
Fe	2.172	-	-	-	-	-	94.4	416.88	351.05	287.443	98.6	291.525	31379.154
Petroleum hydrocarbons	50	-	-	-	-	-	-	207	25	116	96	120.833	12663.302
Si	19.7	-	-	-	-	-	-	3635	5778	4706.50	1830	257.186	513791.662
V	0.034	-	-	-	-	-	0.59	2.44	1.99	1.673	1.6	104.583	182.672
Zn	0.667	-	-	-	-	-	1.58	17.41	10.13	9.707	5.9	164.520	1059.642
Avg. Flowrate (m^3/h)		-	-	-	-	-	4143.6	3274.2	6228	**4548.60**			

Blue: Priority substances
Purple: River basin specific pollutants

Table G. 15. Results of Downstream Station of Dimes Food IWWTP (YESIL 120) for all Monitoring Periods

YESIL 120 (Downstream of Dimes IWWTP)	LOD (µg/L)	1.Period (µg/L) Aug-16	2.Period (µg/L) Oct-16	3.Period (µg/L) Feb-17	4.Period (µg/L) Apr-17	5.Period (µg/L) Jun-17	6.Period (µg/L) Aug-17	7.Period (µg/L) Nov-17	8.Period (µg/L) Jan-18	Avg. Conc. (µg/L)	AA-EQS (µg/L)	% EQS Exceedance	Avg. Pollution Load (g/day)
Dichlorvos	0.0005	-	-	-	-	-	0.00025	0.00025	0.013	0.005	0.0006	650.0	1.633
Ni	0.073	-	-	-	-	-	5.09	16.59	6.73	9.470	4	136.8	3435.655
Pb	0.066	-	-	-	-	-	2.03	3.17	1.5	2.233	1.2	86.1	810.239
Al	0.512	-	-	-	-	-	403	1665.58	483.27	850.617	47.8	1679.5	308598.283
Co	0.026	-	-	-	-	-	0.94	2.64	1.13	1.570	0.3	423.3	569.586
Cr	0.2	-	-	-	-	-	3.93	11.47	5.3	6.900	1.6	331.3	2503.276
Cu	0.263	-	-	-	-	-	26.3	23.29	23.36	24.317	13.2	84.2	8821.931
Fe	2.172	-	-	-	-	-	624.5	2878.97	1009.52	1504.330	98.6	1425.7	545761.296
Petroleum hydrocarbons	50	-	-	-	-	-	-	164	61	112.500	96	17.2	40814.280
Si	19.7	-	-	-	-	-	6138	9224	7331	7564.333	1830	313.4	2744291.722
V	0.021	-	-	-	-	-	3.23	6.19	3.36	4.260	1.6	166.3	1545.501
Zn	0.667	-	-	-	-	-	-	17.65	23.12	20.385	5.9	245.5	7395.548
Avg. Flowrate (m^3/h)		-	-	-	-	-	29181.6	-	1051.2	**15116.4**			

Blue: Priority substances
Purple: River basin specific pollutants

Table G. 16. Results of Upstream Station of Kozlu Food (Feed) IWWTP (YESIL 122) for all Monitoring Periods

YESIL 122 (Upstream of Kozlu Food IWWTP)	LOD (µg/L)	1.Period (µg/L) Aug-16	2.Period (µg/L) Oct-16	3.Period (µg/L) Feb-17	4.Period (µg/L) Apr-17	5.Period (µg/L) Jun-17	6.Period (µg/L) Aug-17	7.Period (µg/L) Nov-17	8.Period (µg/L) Jan-18	Avg. Conc. (µg/L)	AA-EQS (µg/L)	% EQS Exceedance	Avg. Pollution Load (g/day)
Dichlorvos	0.0005	-	-	-	-	-	0.00025	0.00025	0.017	0.006	0.0006	872.2	0.313
Ni	0.073	-	-	-	-	-	3.53	6.85	9.98	6.787	4	69.7	363.813
Pb	0.066	-	-	-	-	-	2.98	4.48	3.04	3.5	1.2	191.7	187.625
Al	0.512	-	-	-	-	-	601	580.64	1168.55	783.40	47.8	1538.9	41995.576
Co	0.026	-	-	-	-	-	1.41	1.54	2.02	1.657	0.3	452.2	88.809
Cr	0.2	-	-	-	-	-	0.88	3.93	3.39	2.733	1.6	70.8	146.526
Cu	0.263	-	-	-	-	-	22	43.6	61.67	42.423	13.2	221.4	2274.189
Fe	2.172	-	-	-	-	-	992.4	1014.93	1787.11	1264.813	98.6	1182.8	67802.899
Free CN	1	-	-	-	-	-	1.93	7.64	7.35	5.640	1.2	370.0	302.344
Petroleum hydrocarbons	50	-	-	-	-	-	-	212	108	160	96	66.7	8577.126
Si	19.7	-	-	-	-	-	5597	10970	10420	8995.667	1830	391.6	482231.063
V	0.034	-	-	-	-	-	4.85	3.74	5.25	4.613	1.6	188.3	247.307
Zn	0.667	-	-	-	-	-	223.87	119.95	270.68	204.8	5.9	3371.8	10980.509
Avg. Flowrate (m^3/h)		-	-	-	-	-	6163.2	2	535.68	**2233.63**			

Blue: Priority substances
Purple: River basin specific pollutants

Table G. 17. Results of Upstream Station of Et-Bir Suluova Slaughterhouse IWWTP and Downstream Station of the Havza UWWTP (YESIL 123) for all Monitoring Periods

YESIL 123 (Upstream of Et-Bir IWWTP & Downstream of the Havza UWWTP)	LOD (µg/L)	1.Period (µg/L) Aug-16	2.Period (µg/L) Oct-16	3.Period (µg/L) Feb-17	4.Period (µg/L) Apr-17	5.Period (µg/L) Jun-17	6.Period (µg/L) Aug-17	7.Period (µg/L) Nov-17	8.Period (µg/L) Jan-18	Avg. Conc. (µg/L)	AA-EQS (µg/L)	% EQS Exceedance	Avg. Pollution Load (g/day)
Cd	0.059	-	-	-	-	-	0.967	0.513	2.029	1.17	0.15*	679.8	38.180
Hg	0.13	-	-	-	-	-	-	-	0.15	0.15	0.07**	114.3	4.896
Ni	0.073	-	-	-	-	-	10.63	37.3	210.91	86.28	4	2057.0	2816.345
Pb	0.066	-	-	-	-	-	10.41	32.31	109.97	50.9	1.2	4141.4	1661.365
Al	0.512	-	-	-	-	-	607	8950.91	61485.75	23681.22	47.8	49442.3	773000.489
As	0.209	-	-	-	-	-	11.39	15.42	167.24	64.683	53	22.0	2111.388
Bis(2-ethylhexyl) terephthalate	0.001	-	-	-	-	-	0.0005	1.221	0.0005	0.407	0.1	307.3	13.296
Bromide	30	-	-	-	-	-	122.6	333.5	15	157.033	31	406.6	5125.870
Co	0.026	-	-	-	-	-	1.33	8.2	60.75	23.427	0.3	7708.9	764.691
Cr	0.2	-	-	-	-	-	2.4	23.13	135.6	53.71	1.6	3256.9	1753.198
Cu	0.263	-	-	-	-	-	39	92.2	247.19	126.13	13.2	855.5	4117.125
Fe	2.172	-	-	-	-	-	974.7	10163.45	93282.63	34806.927	98.6	35201.1	1136164.916
Free CN	1	-	-	-	-	-	0.5	22.42	2.01	8.31	1.2	592.5	271.254
Petroleum hydrocarbons	50	-	-	-	-	-	-	72	549	310.5	96	223.4	10135.316
Si	19.7	-	-	-	-	-	10130	30180	55650	31986.667	1830	1647.9	1044106.214
Ti	7.67	-	-	-	-	-	3.835	121.96	886.85	337.5	26	1198.3	11018.226
V	0.034	-	-	-	-	-	5.49	30.12	206.15	80.587	1.6	4936.7	2630.504
Zn	305.59	-	-	-	-	-	0.667	274.81	618.38	297.952	5.9	4950.0	9725.736
Avg. Flowrate (m^3/h)		-	-	-	-	-	329.04	2196	1555.2	**1360.08**			

Blue: Priority substances
Purple: River basin specific pollutants
* The water quality where YESIL 123 station located is Class 4.
** MAC-EQS

Table G. 18. Results of Upstream Station of the Çorum UWWTP and the Olmuksan International Paper IWWTP (YESIL 124) for all Monitoring Periods

YESIL 124 (Upstream of Çorum UWWTP & Olmuksan Int. Paper IWWTP)	LOD (µg/L)	1.Period (µg/L) Aug-16	2.Period (µg/L) Oct-16	3.Period (µg/L) Feb-17	4.Period (µg/L) Apr-17	5.Period (µg/L) Jun-17	6.Period (µg/L) Aug-17	7.Period (µg/L) Nov-17	8.Period (µg/L) Jan-18	Avg. Conc. (µg/L)	AA-EQS (µg/L)	% EQS Exceedance	Avg. Pollution Load (g/day)
Cd	0.059	-	-	-	-	-	-	0.0295	1.925	0.977	0.15*	651.500	46.523
Ni	0.073	-	-	-	-	-	-	5.12	136.23	70.675	4	1766.875	3364.582
Pb	0.066	-	-	-	-	-	-	2.03	80.06	41.045	1.2	3420.417	1954.005
Trichloromethane	0.1	-	-	-	-	-	-	0.05	5.6	2.825	2.5	113.000	134.488
Al	0.512	-	-	-	-	-	-	293.13	25982.86	13137.995	47.8	27485.345	625452.645
Bromide	30	-	-	-	-	-	-	86.4	51	68.700	31	221.613	3270.560
Co	0.026	-	-	-	-	-	-	0.63	27.72	14.18	0.3	4725.000	674.821
Cr	0.2	-	-	-	-	-	-	2.71	116.26	59.485	1.6	3717.813	2831.867
Cu	0.263	-	-	-	-	-	-	13.79	151.24	82.515	13.2	625.114	3928.242
Fe	2.172	-	-	-	-	-	-	439.11	34656.05	17547.58	98.6	17796.734	835377.113
Petroleum hydrocarbons	50	-	-	-	-	-	-	125	401	263	96	273.958	12520.483
Si	19.7	-	-	-	-	-	-	7198	26430	16814	1830	918.798	800454.010
Ti	7.67	-	-	-	-	-	-	3.835	520.73	262.3	26	1008.779	12486.326
V	0.021	-	-	-	-	-	-	4.34	81.12	42.73	1.6	2670.625	2034.221
Zn	0.667	-	-	-	-	-	-	7.81	640.81	324.31	5.9	5496.780	15439.232
Avg. Flowrate (m^3/h)		-	-	-	-	-	-	853.2	3114	**1983.60**			

Blue: Priority substances
Purple: River basin specific pollutants
* The water quality where YESIL 124 station located is Class 4.

Table G. 19. Results of Upstream Station of Bakraç Dairy IWWTP and Downstream Station of Kozlu Food (Feed) IWWTP (YESIL 125) for all Monitoring Periods

YESIL 125 (Upstream of Bakraç Dairy IWWTP & Downstream of Kozlu Food IWWTP)	LOD (µg/L)	1.Period (µg/L) Aug-16	2.Period (µg/L) Oct-16	3.Period (µg/L) Feb-17	4.Period (µg/L) Apr-17	5.Period (µg/L) Jun-17	6.Period (µg/L) Aug-17	7.Period (µg/L) Nov-17	8.Period (µg/L) Jan-18	Avg. Conc. (µg/L)	AA-EQS (µg/L)	% EQS Exceedance	Avg. Pollution Load (g/day)
Cd	0.059	-	-	-	-	-	-	0.253	0.185	0.219	0.15*	46.0	11.769
Ni	0.073	-	-	-	-	-	-	17.63	19.7	18.665	4	366.6	1003.072
Pb	0.066	-	-	-	-	-	-	15.63	7.79	11.71	1.2	875.8	629.305
Al	0.512	-	-	-	-	-	-	4150.27	4684.27	4417.27	47.8	9141.2	237387.624
Bromide	30	-	-	-	-	-	-	260.8	380	320.4	31	933.5	17218.552
Co	0.026	-	-	-	-	-	-	5.4	5.45	5.425	0.3	1708.3	291.544
Cr	0.2	-	-	-	-	-	-	12.31	11.97	12.14	1.6	658.8	652.413
Cu	0.263	-	-	-	-	-	-	35.88	52.75	44.315	13.2	235.7	2381.524
Fe	2.172	-	-	-	-	-	-	5804.46	6508.11	6156.285	98.6	6143.7	330843.681
Free CN	1	-	-	-	-	-	-	1.79	2.01	1.9	1.2	58.3	102.108
Si	19.7	-	-	-	-	-	-	18970	16610	17790	1830	872.1	956048.832
Ti	7.67	-	-	-	-	-	-	62.36	62.5	62.43	26	140.1	3355.038
V	0.021	-	-	-	-	-	-	20.21	19.79	20	1.6	1150.0	1074.816
Zn	0.667	-	-	-	-	-	-	57.58	140.07	98.825	5.9	1575.0	5310.935
Avg. Flowrate (m^3/h)		-	-	-	-	-	-	3492	986.4	**2239.20**			

Blue: Priority substances

Purple: River basin specific pollutants

* The water quality where YESIL 124 station located is Class 4.

Table G. 20. Results of Upstream Station of Turhal Sugar Factory IWWTP (YESIL 126) for all Monitoring Periods

YESIL 126 (Upstream of Turhal Sugar IWWTP)	LOD (µg/L)	1.Period (µg/L) Aug-16	2.Period (µg/L) Oct-16	3.Period (µg/L) Feb-17	4.Period (µg/L) Apr-17	5.Period (µg/L) Jun-17	6.Period (µg/L) Aug-17	7.Period (µg/L) Nov-17	8.Period (µg/L) Jan-18	Avg. Conc. (µg/L)	AA-EQS (µg/L)	% EQS Exceedance	Avg. Pollution Load (g/day)
Ni	0.073	-	-	-	-	-	-	4.95	6.17	5.56	4	139.000	1836.268
Pb	0.066	-	-	-	-	-	-	6.64	1.34	3.99	1.2	332.500	1317.753
Al	0.512	-	-	-	-	-	-	276.61	585.46	431.035	47.8	901.747	142355.343
Co	0.026	-	-	-	-	-	-	0.61	0.96	0.785	0.3	261.667	259.257
Cr	0.2	-	-	-	-	-	-	4.82	6.04	5.430	1.6	339.375	1793.334
Cu	0.263	-	-	-	-	-	-	18.97	21.09	20.030	13.2	151.742	6615.188
Fe	2.172	-	-	-	-	-	-	667.66	1026.41	847.035	98.6	859.062	279745.167
Si	19.7	-	-	-	-	-	-	7612	8451	8031.500	1830	438.880	2652515.316
V	0.021	-	-	-	-	-	-	3.22	4.79	4.005	1.6	250.313	1322.707
Zn	0.667	-	-	-	-	-	-	8.47	25.71	17.09	5.9	289.661	5644.212
Avg. Flowrate (m^3/h)		-	-	-	-	-	-	22122	5400	**13761**			

Blue: Priority substances
Purple: River basin specific pollutants

H. Results of Some WWTPs Influents for all Monitoring Periods

Table H. 1. Results of Meray Oil IWWTP Influents (YESIL 102_INF) for all Monitoring Periods

YESIL 102_INF (Influent of Meray Oil IWWTP)	LOD (µg/L)	1.Period (µg/L) Aug-16	2.Period (µg/L) Oct-16	3.Period (µg/L) Feb-17	4.Period (µg/L) Apr-17	5.Period (µg/L) Jun-17	6.Period (µg/L) Aug-17	7.Period (µg/L) Nov-17	8.Period (µg/L) Jan-18	Avg. Conc. (µg/L)	AA-EQS (µg/L)	% EQS Exceedance	Avg. Pollution Load (g/day)
Cd	0.059	-	-	-	-	-	-	0.682	0.133	0.408	0.25*	63.0	0.155
Dichlorvos	0.0005	-	-	-	-	-	-	0.00025	0.047	0.024	0.0006	3837.5	0.009
Ni	0.073	-	-	-	-	-	-	55.78	54.24	55.010	4	1275.3	20.906
Pb	0.066	-	-	-	-	-	-	24.37	10.74	17.555	1.2	1362.9	6.672
Trichloromethane	0.1	-	-	-	-	-	-	1.54	7.82	4.680	2.5	87.2	1.779
Al	0.512	-	-	-	-	-	-	5997.98	4436.39	5217.185	47.8	10814.6	1982.739
Bromide	30	-	-	-	-	-	-	26462	0.0025	13231.001	31	42580.6	5028.310
Co	0.026	-	-	-	-	-	-	5.08	4.57	4.825	0.3	1508.3	1.834
Cr	0.2	-	-	-	-	-	-	87.67	57.88	72.775	1.6	4448.4	27.657
Cu	0.263	-	-	-	-	-	-	55.89	20.37	38.130	13.2	188.9	14.491
Fe	2.172	-	-	-	-	-	-	12165.07	16134.32	14149.695	98.6	14250.6	5377.450
Free CN	1	-	-	-	-	-	-	46.34	2.17	24.255	1.2	1921.3	9.218
o,p'-DDT	0.005	-	-	-	-	-	-	0.0025	0.054	0.028	0.01**	182.5	0.011
Petroleum hydrocarbons	50	-	-	-	-	-	-	6603	1788	4195.500	96	4270.3	1594.458
Sb	0.12	-	-	-	-	-	-	11.8	4.21	8.005	7.8	2.6	3.042
Si	19.7	-	-	-	-	-	-	31910	524	16217.000	1830	786.2	6163.109
Ti	7.67	-	-	-	-	-	-	203.17	215.13	209.150	26	704.4	79.485
V	0.021	-	-	-	-	-	-	16.22	8.77	12.495	1.6	680.9	4.749
Zn	0.667	-	-	-	-	-	-	297.07	248.61	272.840	5.9	4524.4	103.690
Avg. Flowrate (m^3/h)		-	-	-	-	-	-	1.67	30	**15.84**			

Blue: Priority substances
Purple: River basin specific pollutants
* The water quality was assumed as Class 5.
** EQS of Total DDT

Table H. 2. Results of Merzifon OIZ IWWTP Influents (YESIL 103_INF) for all Monitoring Periods

YESIL 103_INF (Influent of Merzifon OIZ IWWTP)	LOD (µg/L)	1.Period (µg/L) Aug-16	2.Period (µg/L) Oct-16	3.Period (µg/L) Feb-17	4.Period (µg/L) Apr-17	5.Period (µg/L) Jun-17	6.Period (µg/L) Aug-17	7.Period (µg/L) Nov-17	8.Period (µg/L) Jan-18	Avg. Conc. (µg/L)	AA-EQS (µg/L)	% EQS Exceedance	Avg. Pollution Load (g/day)
Bifenox	0.005	-	-	-	-	-	0.424	0.0025	0.0025	0.143	0.012	1091.7	0.069
Cd	0.059	-	-	-	-	-	0.157	0.632	0.226	0.338	0.25*	35.3	0.162
Dichloromethane	2	-	-	-	-	-	1	1	83.87	28.623	20	43.1	13.739
Hg	0.13	-	-	-	-	-	-	-	0.17	0.170	0.07*	142.9	0.082
Ni	0.073	-	-	-	-	-	15.27	76.88	33.05	41.733	4	943.3	20.032
Pb	0.066	-	-	-	-	-	4.22	15.69	12.51	10.807	1.2	800.6	5.187
Trichloromethane	0.1	-	-	-	-	-	0.05	0.05	9.41	3.170	2.5	26.8	1.522
Al	0.512	-	-	-	-	-	872	2947.14	742.95	1520.697	47.8	3081.4	729.934
B	0.067	-	-	-	-	-	761	3284.11	1592.91	1879.340	707	165.8	902.083
Bis(2-ethylhexyl) terephthalate	0.001	-	-	-	-	-	0.0005	1.02	0.0005	0.340	0.1	240.3	0.163
Bromide	30	-	-	-	-	-	58.3	118.5	15	63.933	31	106.2	30.688
Co	0.026	-	-	-	-	-	4.91	5.5	8.18	6.197	0.3	1965.6	2.974
Cr	0.2	-	-	-	-	-	19.23	10.21	7.55	12.330	1.6	670.6	5.918
Cu	0.263	-	-	-	-	-	29.9	263.93	133.09	142.307	13.2	978.1	68.307
Fe	2.172	-	-	-	-	-	1275.1	1886.82	851.52	1337.813	98.6	1256.8	642.150
Free CN	1	-	-	-	-	-	4.24	15.83	0.5	6.857	1.2	471.4	3.291
Petroleum hydrocarbons	50	-	-	-	-	-	-	324	2441	1382.500	96	1340.1	663.600
Si	19.7	-	-	-	-	-	13240	18820	10760	14273.333	1830	680.0	6851.200
Ti	7.67	-	-	-	-	-	3.835	624.2	36.2	221.412	26	751.6	106.278
V	0.034	-	-	-	-	-	5.48	5.99	5.4	5.623	1.6	251.5	2.699
Zn	0.667	-	-	-	-	-	4833.35	12632.12	3868.77	7111.413	5.9	120432.4	3413.478
Avg. Flowrate (m^3/h)		-	-	-	-	-	20	20	20	**20.00**			

Blue: Priority substances
Purple: River basin specific pollutants
* The water quality was assumed as Class 5.
** MAC-EQS

Table H. 3. Results of the Tokat UWWTP Influents (YESIL 104_INF) for all Monitoring Periods

YESIL 104_INF (Influent of Tokat UWWTP)	LOD (µg/L)	1.Period (µg/L) Aug-16	2.Period (µg/L) Oct-16	3.Period (µg/L) Feb-17	4.Period (µg/L) Apr-17	5.Period (µg/L) Jun-17	6.Period (µg/L) Aug-17	7.Period (µg/L) Nov-17	8.Period (µg/L) Jan-18	Avg. Conc. (µg/L)	AA-EQS (µg/L)	% EQS Exceedance	Avg. Pollution Load (g/day)
Dichlorvos	0.0005	-	-	-	-	-	0.00025	0.00025	0.04	0.014	0.0006	2150.0	0.269
Ni	0.073	-	-	-	-	-	2.57	50.47	6.14	19.727	4	393.2	393.113
Pb	0.066	-	-	-	-	-	1.29	5.49	2.46	3.080	1.2	156.7	61.378
Al	0.512	-	-	-	-	-	94	159.05	314.77	189.273	47.8	296.0	3771.839
Co	0.026	-	-	-	-	-	0.28	0.32	0.53	0.377	0.3	25.6	7.506
Cr	0.2	-	-	-	-	-	3.66	4.01	7.81	5.160	1.6	222.5	102.828
Cu	0.263	-	-	-	-	-	14.9	17.5	34.46	22.287	13.2	68.8	444.129
Fe	2.172	-	-	-	-	-	169.5	369.15	519.93	352.860	98.6	257.9	7031.794
Free CN	1	-	-	-	-	-	0.5	6.05	0.5	2.350	1.2	95.8	46.831
Petroleum hydrocarbons	50	-	-	-	-	-	-	230	356	293.000	96	205.2	5838.904
Si	19.7	-	-	-	-	-	8217	8166	5530	7304.333	1830	299.1	145560.755
V	0.021	-	-	-	-	-	2.48	1.98	3.52	2.660	1.6	66.3	53.008
Zn	0.667	-	-	-	-	-	84.57	60.44	101.06	82.023	5.9	1290.2	1634.561
Avg. Flowrate (m^3/h)		-	-	-	-	-	543	680	1268	**830.333**			

Blue: Priority substances
Purple: River basin specific pollutants

Table H. 4. Results of the Çorum UWWTP Influents (YESIL 105_INF) for all Monitoring Periods

YESIL 105_INF (Influent of the Çorum UWWTP)	LOD (µg/L)	1.Period (µg/L) Aug-16	2.Period (µg/L) Oct-16	3.Period (µg/L) Feb-17	4.Period (µg/L) Apr-17	5.Period (µg/L) Jun-17	6.Period (µg/L) Aug-17	7.Period (µg/L) Nov-17	8.Period (µg/L) Jan-18	Avg. Conc. (µg/L)	AA-EQS (µg/L)	% EQS Exceedance	Avg. Pollution Load (g/day)
Cd	0.059	-	-	-	-	-	0.081	0.179	2.105	0.788	0.25*	215.3	41.624
Ni	0.073	-	-	-	-	-	5.09	6.12	37	16.07	4	301.8	848.496
Pb	0.066	-	-	-	-	-	1.66	13.97	66.99	27.54	1.2	2195.0	1454.112
Trichloromethane	0.1	-	-	-	-	-	0.05	1.19	6.37	2.537	2.5	1.5	133.936
Al	0.512	-	-	-	-	-	277	434.02	6253.44	2321.487	47.8	4756.7	122574.496
Bromide	30	-	-	-	-	-	81.2	250.7	1409.7	580.533	31	1772.7	30652.160
Co	0.026	-	-	-	-	-	0.69	0.66	7.12	2.823	0.3	841.1	149.072
Cr	0.2	-	-	-	-	-	2.42	2.86	31.09	12.123	1.6	657.7	640.112
Cu	0.263	-	-	-	-	-	21.7	45.02	104.57	57.097	13.2	332.6	3014.704
Fe	2.172	-	-	-	-	-	437.5	579.3	7840.05	2952.283	98.6	2894.2	155880.560
Free CN	1	-	-	-	-	-	0.5	8.57	0.5	3.190	1.2	165.8	168.432
Petroleum hydrocarbons	50	-	-	-	-	-	-	157	1341	749	96	680.2	39547.200
Si	19.7	-	-	-	-	-	5616	6043	13660	8439.667	1830	361.2	445614.4
Ti	7.67	-	-	-	-	-	3.835	3.835	72.33	26.667	26	2.6	1408.000
V	0.034	-	-	-	-	-	3.78	3.86	23.99	10.543	1.6	559.0	556.688
Zn	0.667	-	-	-	-	-	83.38	170.35	777.02	343.583	5.9	5723.4	18141.200
Avg. Flowrate (m^3/h)		-	-	-	-	-	2250	2250	2100	**2200**			

Blue: Priority substances
Purple: River basin specific pollutants
* The water quality was assumed as Class 5.

Table H. 5. Results of the Amasya UWWTP Influents (YESIL 106_INF) for all Monitoring Periods

YESIL 106_INF (Influent of the Amasya UWWTP)	LOD (µg/L)	1.Period (µg/L) Aug-16	2.Period (µg/L) Oct-16	3.Period (µg/L) Feb-17	4.Period (µg/L) Apr-17	5.Period (µg/L) Jun-17	6.Period (µg/L) Aug-17	7.Period (µg/L) Nov-17	8.Period (µg/L) Jan-18	Avg. Conc. (µg/L)	AA-EQS (µg/L)	% EQS Exceedance	Avg. Pollution Load (g/day)
Cd	0.059	-	-	-	-	-	0.418	0.359	0.118	0.298	0.25*	19.3	4.893
Dichlorvos	0.0005	-	-	-	-	-	0.00025	0.00025	0.035	0.012	0.0006	1872.2	0.194
Ni	0.073	-	-	-	-	-	2.89	18.6	7	9.497	4	137.4	155.747
Pb	0.066	-	-	-	-	-	4.28	13.74	4.79	7.603	1.2	533.6	124.696
Trichloromethane	0.1	-	-	-	-	-	0.05	1.72	15.01	5.593	2.5	123.7	91.732
Al	0.512	-	-	-	-	-	306	2493.11	1028.46	1275.857	47.8	2569.2	20924.253
Bis(2-ethylhexyl) terephthalate	0.001	-	-	-	-	-	0.0005	1.239	0.0005	0.413	0.1	313.3	6.779
Co	0.026	-	-	-	-	-	0.4	2.37	0.83	1.200	0.3	300.0	19.680
Cr	0.2	-	-	-	-	-	2.74	18.72	7.35	9.603	1.6	500.2	157.496
Cu	0.263	-	-	-	-	-	18.1	96.06	45.12	53.093	13.2	302.2	870.739
Fe	2.172	-	-	-	-	-	275.8	5664.37	985.55	2308.573	98.6	2241.4	37860.972
Free CN	1	-	-	-	-	-	0.5	7.93	0.5	2.977	1.2	148.1	48.818
Petroleum hydrocarbons	50	-	-	-	-	-	-	136	480	308.000	96	220.8	5051.249
Propylbenzene	0.1	-	-	-	-	-	0.05	0.05	2.79	0.963	0.2	381.7	15.799
Si	19.7	-	-	-	-	-	7195	12280	9257	9577	1830	423.4	157069.799
V	0.034	-	-	-	-	-	2.53	13.69	5.1	7.107	1.6	344.2	116.550
Zn	0.667	-	-	-	-	-	122.42	711.39	167.6	333.803	5.9	5557.7	5474.428
Avg. Flowrate (m^3/h)		-	-	-	-	-	620.02	670	760	**683.34**			

Blue: Priority substances
Purple: River basin specific pollutants
* The water quality was assumed as Class 5.