WATER QUALITY MANAGEMENT BY HYDRO-INSTITUTIONAL MAPPING APPROACH

by

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July, 2001

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WATER QUALITY MANAGEMENT BY HYDRO-INSTITUTIONAL MAPPING APPROACH

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In recent years, the importance of water has grown because of the great increase in population and industrialization. By this increase, water demand has increased quantitatively whereas water supply has decreased both quantitatively and qualitatively so that existing natural resources have been limited by several factors. Consequently, the use of water resources need an emphasized management approach concerning all water-related problems and "Integrated Water Resources Management" (IWRM) approach has become important. In the stated approach, IWRM, water users, polluters and managers are taken into consideration as well as water quantity and quality.

In the IWRM approach, one of the limiting issues is water quality. Water quality in some basins has gained great importance as in Gediz River Basin in Turkey. Gediz basin with about millions of inhabitants, is currently one of the most highly polluted basins. In the presented study, the stated approach is applied to the case basin using the available data, emphasizing especially the water quality issues. The presented thesis also states the use of mathematical models as an effective tool in IWRM approach by the QUAL2E model application on the Gediz River Basin.

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ABSTRACT

In recent years, the main problem is to provide sufficient amount of water in desired water quantity and quality under conditions of available water resources. The major reason is great increase in population and industrialization that cause an increase in the number and variety of water uses. Consequently, "Integrated Water Resources Management" (IWRM) approach has been developed to improve the existing conditions in terms of water quantity and quality by taking water users, polluters and managers into consideration. Because IWRM has a multi-disciplinary perspective, it is possible to evaluate every detail throughout the basin. In decision-making for development and management for water resources, IWRM approach is currently emphasized for various purposes.

Water quality, one of the limiting issues in IWRM, has gained great importance in more basins. Degrading water quality directly affects water allocation and leads to water scarcity. Gediz River Basin, with about millions of inhabitants, is currently one of the most highly polluted basins. In the presented study, the IWRM approach is applied to the case basin using the available data especially in terms of water quality. The presented study also emphasizes the widespread use of mathematical models in IWRM approach by the use of QUAL2E model in the case basin. Mathematical models are effective tools in management and decision-making stage so that it is possible to identify the natural conditions in mathematical terms. Because the available data on the case basin are limited and not updated, the results do not reflect the current status in terms of water quality.

The stated IWRM approach with its major components and methodology can be a scientific basis for managers and decision-makers of a basin in case of updated and systematic data.

ÖZET

Son yıllarda karşılaşılan temel sorun, mevcut su kaynaklarına göre ihtiyaç duyulan miktar ve kalitede suyun sağlanabilmesidir. Bunun ana nedeni, su kullanımında miktar artışına ve çeşitliliğine sebep olan, hızlı nüfus ve endüstri artışıdır. Dolayısıyla, mevcut durumu iyileştirmeye yönelik, su miktarı ve kalitesi yanında, kullanıcıları, kirleticileri ve yöneticileri de kapsayan "Entegre Su Kaynakları Yönetimi" (ESKY) adı verilen bir yaklaşıma ihtiyaç duyulmuş ve geliştirilmiştir. Çok yönlü perspektifi ile, ESKY, havzayı baştan başa değerlendirme imkanı sağlamaktadır.

ESKY'nin kısıtlayıcı unsurlarından biri olan su kalitesi, havzalarda gün geçtikçe çok daha fazla önem kazanmaktadır. Su kalitesindeki bozulmalar, su tahsisini doğrudan etkilemekte ve su kıtlığına neden olmaktadır. Gediz Nehri Havzası da bu kirliliğe sahip olan havzalardan biridir. Sunulan çalışmada, ESKY yaklaşımı, özellikle su kalitesi dikkate alınarak, mevcut veriler doğrultusunda Gediz Havzası koşullarına uygulanmıştır. Aynı zamanda sunulan çalışmada, QUAL2E modelinin örnek havza koşullarına uygulanması ile, matematiksel modellerin ESKY yaklaşımında etkin kullanımı da vurgulamaktadır. Matematiksel modeller, doğal koşulların matematiksel ifadelerle tanımlanmasını sağlayan, yönetim ve karar verme süreçlerinde kullanılan etkili araçlardır. Mevcut verilerin sınırlı olması, diğer taraftan güncel olmaması, çalışmada elde edilen sonuçların mevcut durumu tam anlamıyla yansıtmamasına neden olmuştur.

Sunulan ESKY yaklaşımı, ana bileşenleri ve yöntemi ile, güncel ve sistemli veri temini koşullarında, gelecek çalışmalara bilimsel bir temel teşkil edebilecektir.

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CHAPTER ONE
INTRODUCTION

Water as the most basic natural resource is necessary in every stage of human life. People need water everywhere; even in a desert, human society centers around the oasis, just as in the rain forest it centers around the rivers. For plants and animals alike, water is essential for life, making up as much as 65% of the human body (90% of an infant's body). An adequate water supply is important in any home, farm or community. Water supply must meet the demands of domestic use, commercial use, industrial needs and agricultural use among other purposes. The percentage of total water withdrawal used for any specific use varies among regions of the world and is a product of socioeconomic conditions, tradition, culture and water availability. Besides its importance, water is a limited source. In contemporary times, one of the main problems is the efficient use of water resources. In our developing world, the efficient use of water resources has not been realized ever since the Water Laws of Hammurabi in Mesopotamia.

In recent years, the importance of water has grown because of the great increase in population and industrialization. By this increase, water demand has increased quantitatively, whereas water supply has decreased both quantitatively and qualitatively. The existing resources – groundwater and surface waters – are not sufficient due to growing population. If there is infinite water, there will be no problem. Water is not infinite so that there are significant problems in water allocation. Water is used in the home for a variety of purposes such as cleaning, bathing, drinking, etc. On the other hand, industries have varying water demands. In addition, industries may use water for production, cleaning or cooling. Besides domestic and industrial use, agriculture also depends on water. A certain amount of water is needed to irrigate plants. For all these purposes, water is essential but is limited due to increasing water demand and use. Several problems associated with water resources, the most significant ones being water scarcity and deterioration of water quality, have led to the concept of environmental management.

Environmental management is considered in three main components: (a) water resources, (b) solid waste and (c) air quality management. Among these components, the major part that is affected by the great increase in population and industrialization is water resources. The main problem is to provide sufficient amount of water in desired quantity and quality. Increasing number and variety of water users has led to serious water resources problems, so that there is a great need for an approach concerning all water-related problems. Thus, "Integrated Water Resources Management" (IWRM) approach has become important and recently developed. As a component of environmental management, water resources management has also its own components such as; (a) water use and (b) water allocation. Mainly, water resources management concerns water quantity and quality but it also concerns water users, polluters and managers. Thus, "integrated management" concept has become important and a new approach called "Integrated Water Resources Management" is developed to include not only the physical natural system but also social, economic, legal and institutional issues. "Integrated Water Resources Management" concept, in other words, the ideal management paradigm, recognizes the linkages of biophysical resources within a hydrologic unit and acknowledges that attempts to achieve goals within a single hydrologic unit require attention to those linkages. Consequently this concept has taken place in researches and studies in order to evaluate every issue throughout the basin.

The management concept ensures that the chemical, physical and biological integrity of a water resource is maintained within the bounds required for a suite of human values. IWRM is necessary for sustainable resource use for all the sub-sectors and to protect the environment, in other words, to achieve environmental management goals. IWRM has a multi-disciplinary perspective including following issues:

a. physical aspects; water allocation, distribution, water quality
b. institutional aspects
c. legal aspects
d. social aspects
e. economic aspects

In the IWRM approach, mainly water users, water polluters, water managers, water policy and law makers and the society are taken into consideration. This concept depends on the socio-economic and the political situation as to whether all interests are represented. IWRM is the main step in decision-making for development and management of water resources for various uses. In other words, IWRM occurs at the intersection of the social goals of multiple-use management and the scientific understandings of biophysical and ecological patterns at different scales. Thirty years ago, the practice of water resource management consisted of attempts to achieve a series of population-level goals. The general trend is to apply this concept in a management model, but there is no complete example. There are a few number of examples of this approach but each has its own characteristics.

IWRM has originated from technical, institutional and legal constraints in management of water resources. The major technical constraint is the competition between water users when water of a desired quality is to be allocated. Increasing water demands are not met by the available natural resources and consequently, water scarcity occurs as a major problem in water allocation practices. Institutional constraints include the increase in the number and the variety of water users. Previously, few numbers of institutions were dealing with water resources and "planning" was enough to develop water resources and its use. In recent years, increasing number of institutions and types of water use have led to "management" activities in water resources. IWRM is an emerging issue, and there is no systematic approach that can be applied. Designers, planners and decision makers from different disciplines are handling the issue from different perspectives and are trying to converge everybody's idea to a systematic management approach. Besides the technical and institutional problems, there is the lack of rules and regulations in many countries. In other words, there is no legal basis to solve the allocation of desired amount of water in desired quality. Some countries have suitable laws that ensure better management of water quality whereas the others do not have sufficient legal background. There are also countries like Turkey who have the lack as well as the surplus of laws that interface each other and their applications are poor.

There are some successful management approaches in some developed countries, whereas, most of the developing countries have been suffering as to how to cope with water resources management. There are many governmental and non-governmental (NGO) institutions that are deeply involved with water resources management. However, when a problem takes place anywhere, it is very difficult to determine the major responsible institution or to decide who will take the responsibility. From the problems stated above the objective of this thesis is to define such problems clearly and to propose general and specific solutions. The results of the presented thesis reveals that a successful water resources management can be achieved by the constitution of a basin-wide responsible institution.

IWRM has three major components in terms of technical aspects; (a) water allocation, (b) water distribution, and (c) water quality. The first two components are related to each other. Water distribution can be assessed together with allocation. In addition, these three main components contain several sub-components especially water quality such as assessment of pollution loads. The water quality sub-component also includes components such as point sources containing domestic and industrial discharges and non-point sources containing agriculture, storm water-runoff, etc.

Technical planning, investigated in terms of major components of IWRM, is still an unsolved problem because each basin has its own special characteristics. However, in such an approach, the following conditions has to be fulfilled. Basin should be defined properly. Monitoring should be carried out for both water quality and land use. All the data should be collected, stored and processed by the related authority. By defining the basin properly, the physical system is identified in terms of technical aspects. In scope of the IWRM approach, for the next step, institutions and legal basis should be examined briefly in order to determine the authorities who have the right to comment on mentioned IWRM components; water allocation, distribution and quality.

Among various constraints in an IWRM approach, one of the limiting issues is water quality. Water quality in some basins has gained great importance by increasing population and industrialization. Degrading water quality directly affects water allocation and forms another reason for water scarcity. This time, available water cannot be used due to its degraded quality. Thus, water quality should be the most emphasized issue in the IWRM concept.

One of such basins is the Gediz River Basin in the Aegean region. In the presented thesis, besides demonstrating a modest approach to IWRM, the approach is applied to a case basin – Gediz River Basin. Gediz River Basin is one of the basins in Turkey, that has the most productive soil of Aegean Region and Turkey, and that makes important contributions to the region's and country's economy by its ground and underground wealth besides its industry and tourism potential. On the other hand, Gediz basin with about millions of inhabitants, is currently one of the most highly polluted basins. Up to the 1960s, this basin was largely dominated by agriculture, but this situation is changed due to industrialization and urbanization within a decade. This led to considerable problems with drinking and industrial water supplies. The presented concept is applied to the case basin using the available data. There is a great lack of data. Available data is very scattered or insufficient. Because water quality is the major limiting issue in IWRM in Gediz River Basin, the approach is considered particularly in the case of water quality.

In the following chapter, the new approach called "Integrated Water Resources Management" is briefly described with its major components and main steps. The approach is identified on national scale in Chapter 3. Chapter 3 determines that IWRM approach is not applied in the country completely but the applied methodology is given in the chapter. In the thesis, IWRM approach is applied in Gediz River Basin. The basin is briefly identified in Chapter 4 and assessed in terms of water allocation, water distribution and water quality respectively in chapters 5, 6 and 7. In order to assess the basin, several water quantity and quality data are collected by several institutions and governmental organizations. By assessing the available data collected throughout the basin, a mathematical model is used to emphasize the use of models in IWRM concept. Chapter 8 includes the processing of these collected data, model run and model results in graphical forms. Finally in the last chapter, IWRM concept is summarized and the results of the model are evaluated.

CHAPTER TWO
INTEGRATED WATER RESOURCES MANAGEMENT CONCEPT

2.1. Complexity of Water Resources Management

Water is the basic natural source that provides homes for fish and animals, refuge, food, navigation, electricity and mechanical power, coolant, a waste stream and opportunities for recreation. No body of water, however, can support all of different uses without suffering some degree of degradation: under poor management, degradation may result from even one primary use.

The major issue is that water quality is threatened at an increasing level due to the anthropologic activities. Therefore, water quality control or improvement efforts are important but they are rather difficult and complex and generally fall into two categories as stated by Perry & Vanderklein in a study; non-structural techniques that do not involve physical changes to the river and structural changes that more directly change the flow and conditions of the river. Non-structural changes include the historical favorite that is neglected. This technique is effective but requires patience. A second non-structural approach is action through legislation and administrative procedures. This strategy includes regulating flow requirements, establishing water quality standards, identifying best management practices, undertaking public education efforts and altering water rights laws to account for primacy of minimum ecological requirements. Structural management techniques may range from efforts to improve species-specific habitats to recreation of historical channel morphology. Some of these activities include changing in-stream woody debris characteristics, altering stream bank vegetation and deflecting currents (Perry & Vanderklein, 1996).

Accordingly, environmental management has emerged recently due to the detoriation of natural sources. The concept may be considered in three folds; (a) water resources, (b) solid wastes and (c) air quality management, as depicted in Figure 2.1. These three main topics cover the main aspects of environment, the pollution sources and their mitigation measures. The sub-management topics in the figure contain many branches, expertise, disciplines and areas, however, in the thesis especially water resources management part will be considered.

In recent years, population increase and industrial growth have led to serious environmental problems. These problems lead not only to economic losses but also to several adverse effects on life conditions on earth. Thus, all communities, including managers, engineers, decision-makers and the society itself, are in search of better means of protecting and improving the quality of the environment.

Urban development introduces a complex array of water quality impacts that range from localized impacts, such as those from sewage outfalls, to landscape-level impacts, such as those caused by the construction of dams to meet urban water and energy needs. Although each impact results from a different component of urban development (e.g., paving, industrial growth, waste removal needs), management must consider urban problems as an interrelated whole to achieve adequate water quality protection.

One of the major problems faced by any urban society is waste disposal and its associated pathogens. Urban waste streams contain more than human disease agents. Run-off from paved streets includes lawn chemicals and fertilizers, waste oil from cars, road salts and other substances. Household waste streams frequently include corrosive cleaning agents, paints and other persistent compounds. Wastes from the industrial sector contain ever greater numbers of toxic pollutants. Processing wastes is one of the most significant water quality problems in existence and has been a constant companion to human settlement throughout history.

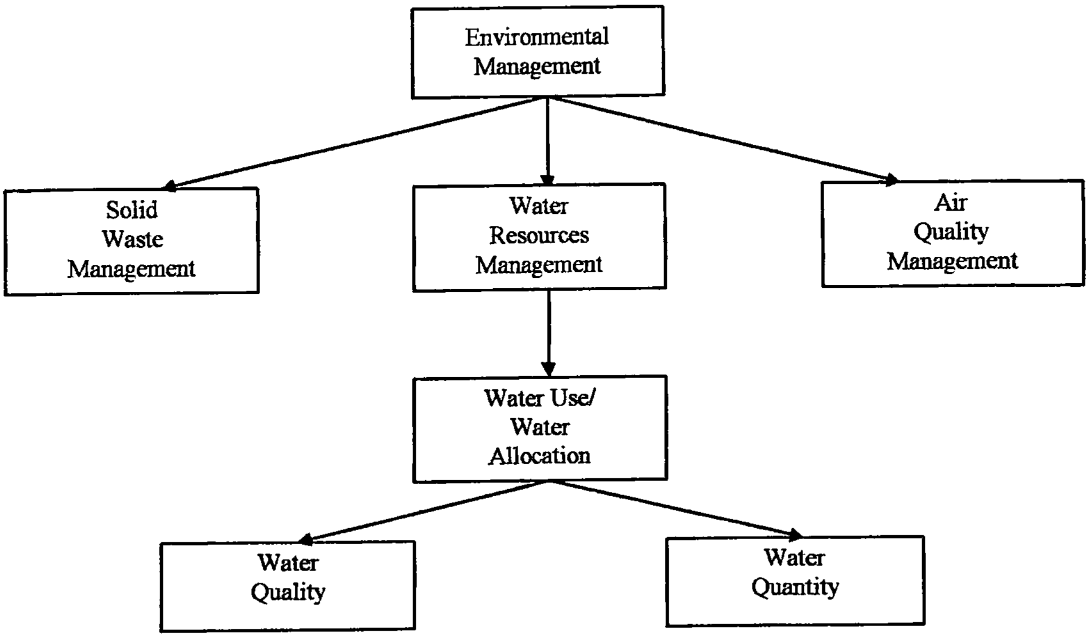


Figure 2.1. Environmental Management in a Basin.

The problem of urbanization is a problem of concentration and additive effects. When populations concentrate in cities and towns, the amount of water needed for drinking, industrial uses, waste disposal, energy generation and other purposes grows exponentially. In addition, water quality impacts multiply as the human population expands, bringing with it a contaminant increase in waste; likewise, more diverse uses of water result in more diverse kinds of waste (Perry & Vanderklein, 1996). The other side of the problem is industrial growth. Globally, industrial growth is enormous. Currently, about one-fourth of total water withdrawals are used for industry production. Industrial expansion is proceeding at an extraordinarily rapid rate and current water withdrawals are expected to double by 2005. In addition to the quantity of water withdrawn for industrial purposes, industrialization presents unique problems for waste management and potentially severe stresses on aquatic and human populations because of both the diversity and the toxicity of some of the compounds contained in industrial effluent (Perry & Vanderklein, 1996).

As stated earlier, the largest area where environmental pollution occurs is water resources. Most river basins suffer from the degraded quality of surface waters. Individual river basins must be assigned to authorities or organizations that will be responsible for coordinating and implementing any actions needed to improve water quality in the river basin (IWA,2000). Scientists are developing tools, models and understanding that explicitly address issues of increasingly coarser spatial and temporal scale and are recognizing that impacts can be understood only by incorporating explicit attention to ranges of temporal and spatial scale. Managers and decision-makers, on the other hand, are being forced to make decisions on an increasingly more local basis. Effective implementation of integrated water quality management principles will require models and understanding that resolve that dilemma; in particular, these models must incorporate knowledge about longer temporal scales, greater spatial scales and effects at those on more localized decision making. Thus, water resources planning and management must now be based on optimum decisions. Such an approach requires better tools to aid in the decision-making process. Among these tools are mathematical models which have found a wide area of application in resource management studies. Modeling has two basic purposes:

a. identification of the basic mechanisms that underlie physical processes;
b. development of management alternatives and selection of the best strategy in protecting and controlling the environment.

Recent studies have developed "Integrated Water Resources Management" approach for basin management and consequently several advances in the computer technology have provided significant facilities in handling these problems. With several computer models, it is possible to investigate large numbers of variables, processes and alternative management decisions. Furthermore, once a computer-based simulation is developed, management scenarios can be developed to infer on consequences of decisions made.

In the thesis, "Integrated Water Resources Management" concept and a mathematical model application of a case study is presented. As a case study, Gediz river basin is selected. Every available data is assessed for the basin and the system is evaluated in terms of water allocation, distribution, quality and institutional aspects including social and legal issues.

2.2. Integrated Water Resources Management: Major Components

Environment is a complex system that includes physical, chemical, biological, cultural and socio-economic resources, so that, human activities are in complex interaction with environment. Fundamentally, environment forms an independent dimension such as space and time, in other words each event and activity materializes in a space, at a time and in an environment (DPT, 2001).

Because development is related to natural resource use, natural resources should not be decreased; otherwise resources will be exhausted. So that, natural resources should be used under sustainable development conditions.

By the increase in population and industrialization, water demand increases in a basin. The main problem is to provide sufficient amount of water in desired water quality, so that, there is a great need for a new concept concerning the whole basin in order to solve the complex situation. "Integrated Water Resources Management" approach has taken place in researches and studies in order to evaluate every detail throughout the basin and to rehabilitate the management strategies.

Watersheds are complex ecosystems in which people live, work and play. While natural unimpacted watersheds in temperate climates are largely forested, the landscape of developed watersheds consists of agricultural lands and urban areas with only fragments of the original forests remaining. It is useful, from a mass balance point of view, to consider large-scale developed watersheds as consisting of 3 sectors: forest, agriculture and urban. (Cassell et al., 2001)

There are several studies that have been carried out to develop several approaches to environmental problems. As shown in Table 2.1, new technologies are developed by years passed and examined as the basic issues of a whole IWRM concept.

Table 2.1. Historical Stages in Approaches to Environmental Protection (Cassell et al., 2001).

Time period	Prevailing abatement concepts	Corresponding technology
Up to 1960s	Dilution of produced pollution	Dilution technologies, e.g., wastewater outlets, high stacks
1970s	Pollution capturing and clean-up	End-of-pipe technologies, e.g., wastewater treatment plants, air cleaning filters
1980s	Re-cycling of polluted materials	Re-cycling and waste less technologies
1990s	Prevention of pollution and cleaner production	Measures integrated within production technologies and/or production sequences.

In another study done by Chour, a new concept called CP (Cleaner Production) is introduced. CP concepts are similar to previously accepted strategies for water management and control according to the ISO 9000 (quality) and ISO 14000 (environment) standards. These standards have brought substantial responses both in simultaneous water quality and environmental improvements and decreased production costs. CP for environmental protection includes permanent application of pollution-prevention strategies on processes, products and services. When applied to production processes; CP includes more effective use of materials and prevention of both raw material waste and pollution of ambient air, water and soil at the source. When applied to products and services; CP strategies focus on decreasing negative environmental impacts during their useful life-time from the development to their use and ultimately their disposal or recycling (Chour, 2001)

CP is a strategy of double benefit (win-win). It is based on permanent and repeated application of preventative environment – protection strategy to processes, products and services aiming to increase effectiveness of production together with limited negative effects on the environment, as summarized in Figure 2.2. This is also said to be an approach to IWRM concept.

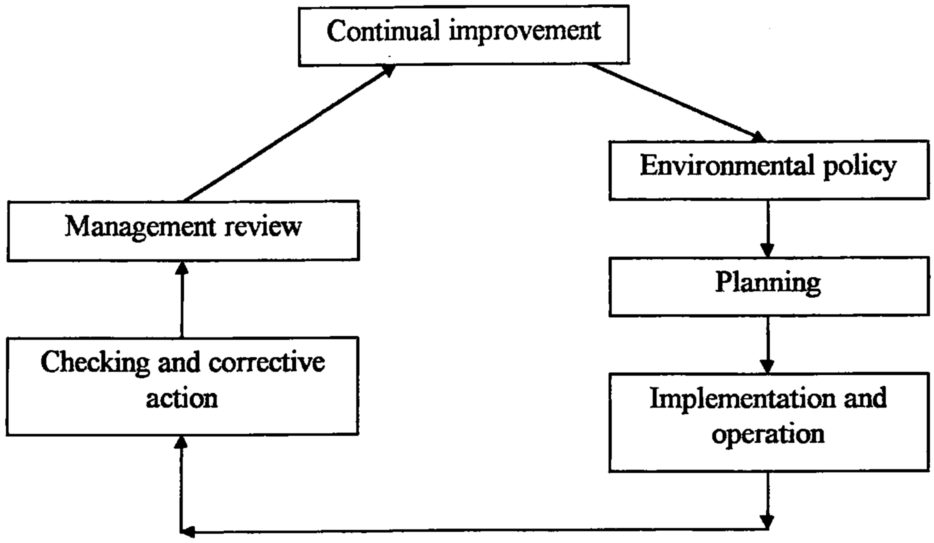


Figure 2.2. Scheme for Cleaner Production (CP).

The integrated water flow and water quality management practiced by the associations covers all the river basin management aspects of directive, including wastewater treatment, flow control, drinking and industrial water supply.

All these items are briefly indicated in the draft Water Framework Directive of the European Union that is for the integrated, sustainable management of water bodies. This approach is intended to achieve good ecological status throughout the entire catchment area of a river.

The draft EU Water Framework Directive sets a good status of all water bodies as a target for the river basin "good status" is defined as (IWA, 2000);

(a) good ecological status in terms of biological, hydromorphological and physico-chemical characteristics, and

(b) good chemical status measured particularly by compliance with limits for 30 priority substances.

The idea is to control the main water problems within their natural boundaries: the river basin, while at the same time preserving the rights of the existing authorities (IOW, 1999).

"Integrated Water Resources Management" (IWRM) concept is first presented at the DSE-IWMI-DWAF workshop in South Africa by Hofwegen. IWRM is the management of surface and subsurface water in qualitative, quantitative and ecological sense. IWRM is needed to protect the environment; in other words, water quality management is an essential part of IWRM. The aim of IWRM is to discard with the one-sided management perspective of single interests of one sub-sector by one government agency and to strive for a participatory multi-sided management perspective of all interests in management of water resources (Hofwegen, 2000). IWRM is the main step in decision-making due to development and management of water resources for various uses. There are three main functions in IWRM determined in the workshop that are; (1) Operational (water use) function, (2) Organizational (water resources management) function, and (3) constitutional (water policy and law) function, as given in Figure 2.3.

a. Operational Function: This function is focused at use or control of water for specific purposes, including water supply and sanitation, irrigation-drainage, flood protection, hydropower, industrial supplies, recreation, fisheries, etc.

b. Organization Function: This function involves coordination, planning, decision-making and policing of water use and users in water systems such as river basins, aquifers. In order to solve the problems between uses and users, establishment or changes of water use rules are required.

c. Constitutional Function: In order to make organization function possible, an enabling environment has to be created by requiring water policies, institutional development policies.

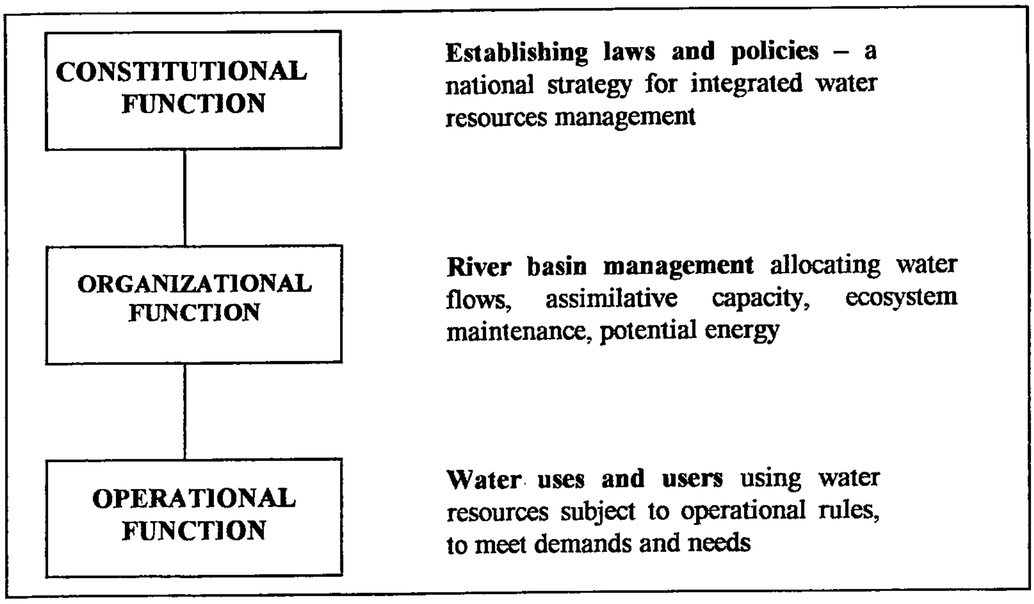


Figure 2.3. Functions in Integrated Water Resources Management (Hofwegen, 2000).

In general, the objectives and measures of river basin management, the methodological approach can be divided into following groups (IOW, 1999);

(a) analysis of the actual situation of the water body (actual condition)
(b) definition of development targets (target condition)
(c) quantitative assessment of deficits
(d) determination of proposed measures
(e) analysis of scenarios, cost-benefit analysis
(f) implementation of measures, and
(g) monitoring of results.

Enforcement problems arise in all areas of human activities, wherever there are rules, laws or standards to regulate the behavior of independent decision-makers (Fang et al., 1994). Governments enact environmental laws and set environmental standards to protect the environment. Another example of environmental management activity is carried out in Canada since 1989. As declared in the Canadian Environmental Protection Act, "the protection of the environment is essential to the well-being of Canada". In the stated study, it is stated that in the enforcement process, an organization or person (called an inspector) has to decide whether an organization or person (an inspectee) has behaved legally according to a law or other formal requirement. The objective of the verification theory is to study the cost-effectiveness of enforcement policy, i.e. to achieve desired levels of compliance at minimal cost.

Under the Environmental Protection Act of Ontario, Canada, a Director appointed by the Minister for the environment has the power to issue a control order to the operator of a facility believed by the Director to be contravening an environmental law (Fang et al., 1994).

A type of development that links the economy, development and the environment is now called sustainable development. The United Nations' World Commission on Environment and Development saw that the only viable possibility of economic growth was based on policies that sustain and expand the environmental resource base. Canada was the first country in the world that approved the commission's conclusions and built a balanced and integrated approach to economic development and a clean and safe environment (Cuillerier, 1994). Canada has introduced an action called the "Green Plan" in late 1990. The Green Plan is the first attempt anywhere in the industrialized world to make sustainable development a workable national policy for safeguarding and enhancing our environment (Cuillerier, 1994). The main 3 purposes of this plan use;

- to help establish standards for environmental quality and pollution prevention,
- to ensure the wise management and use of renewable resources,
- and to provide Canadians with environmental information in the public interest.

The United States of America has a range of statutes dealing with different aspects of the environment. The Environmental Protection Agency (EPA) is responsible for the implementation of these statutes. As an example of the enforcement process in the United States, consider the Clean Water Act. This act specifies that an inspector has the right to enter the hypothesis of an operator and collect pertinent information (DPT, 2001).

In another study called "Hydro-institutional Mapping" was described at the Annual ISSP Workshop of Izmir in July 1999 as a methodology which provides an understanding of the institutional patterns as an over-lay on hydrologic variations in the basin. The H-I map of the basin will help to analyze the nature and scale of possible institutional gaps (Harmancioglu & Alpaslan (a), 1999). This method pays attention to institutional aspects besides physical aspects.

Hydro-institutional mapping (HIM) provides a framework for analyzing institutional arrangements and their ability to manage water sources in irrigation and drainage systems. HIM follows flows of water in a basin, or those parts which are relevant for issues under consideration (Scheumann, 1999).

Mapping identifies the points;

- where regulation, or control is needed,
- where organizational control of water changes hands,
- where the interfaces between either organizations or actors are likely to be weak.

The main tasks that H-I Mapping pays attention to are;

- water allocation
- water supply
- water distribution
- water disposal
- water quality
- maintenance of irrigation and infrastructure (Scheumann, 1999).

The Hydro-institutional map of the basin will help to analyze the nature and scale of possible institutional gaps. It can give an indication of what kind of water appropriations and uses are mediated by institutional interventions in the form of regulatory agencies, local organizations, rules, procedures, customs, traditions, government policies, etc.

This methodology has been initiated in the scope of ISSP Project as mentioned before and a rather systematic approach to the problem has been investigated. The developed method covers mainly the following tasks:

- identification of the hydraulic infrastructure of the physical system
- identification of actors
- identification of rules
- operation
- assessment of the performance
- impact assessment.

In the scope of H-I mapping approach, actors and rules are determined in identified physical system of a basin. In the further studies, operation, performance and impact assessments are examined due to determined case basin.

This H-I mapping methodology can be taken as one of the basic issues to demonstrate components for IWRM concept. Following this concept, IWRM concept includes major components such as:

a. physical aspects; water allocation & distribution, water quality,
b. institutional aspects,
c. legal aspects,
d. political aspects,
e. social aspects.

The first three component is the main issues that identify the basin physically by technical aspects. The others are the non-technical aspects of the basin management. The technical issues identify the system and shows the inputs-outputs, existing water resources, water demands whereas the institutional issues identify the authorities on management, institutions related to water resources management, related laws and regulations.

In particular, water quality management, which is the most important issue in IWRM, is a very fluid phenomenon: as society and societal values change, new values must be reflected in management directives and strategies. Water quality management is an intriguing mirror on society. The field evolves continuously, reflecting changes in social values, scientific understanding and infrastructure development. While scientific developments control the possible understanding related to water quality questions, cultural dimensions dictate the shape of specific water quality controls (Perry & Vanderklein, 1996). At any given place and time, water quality management goals will reflect a different balance between social pressures such as development status and economic priorities, perceptions of resource scarcity or abundance, environmental values, traditions of public incentives or even experiences with pollution crises. In all cases, water quality management is a multidisciplinary field, whose practice requires knowledge of hydrology and chemistry, biology, sociology and politics.

Water quality is especially emphasized in the thesis because it is the emerging and limiting issue in IWRM concept. In other words, integrated basin management concept has been developed because of degraded water quality. So that, in the presented concept, water quality has become the important issue.

Such as previous studies on WRM, there are also several studies on management in Turkey. Water resources management in Turkey is summarized in the following chapter in the sight of management concept. There are several institutions responsible for water resources. In decision-making process, institutions should act together but in practice, each institution has its own rights to decide on a new formation. In this step, no one wants to share the responsibility both in social and economical sides. It is possible to join all the effective institutions under an authority or a commission but again none of the institutions want to take place in such a commission. On the other hand, there should be legal modifications in order to organize all institutions under a commission. Determination of IWRM concept is the first step of an overall management in a country. After developing some legal issues, it may be possible to force an institution to ask for an idea to another in decision-making process.

In the presented thesis, H-I mapping approach has been taken as a base and Gediz river basin is examined due to the major IWRM components in terms of physical and institutional aspects.

CHAPTER THREE
WATER RESOURCES MANAGEMENT IN TURKEY

3.1. Existing Water Resources and Water Use in Turkey

Population of Turkey has reached 60 million. It is accepted that the population will be 91 million in 2021 by the growing ratio of 2.2%. There is a great urbanization in the country. Because river flows are highly variable, in order to use water resources efficiently, it is needed to construct collection reservoirs. Due to 1993 data, 160 dams have been constructed. 121 of them are for irrigation and the others are for other purposes including also irrigation. Also DSI has constructed 209 artificial lakes again for irrigation.

Turkey is rather young in terms of geological age. According to the topography, river flows are very variable. Average watershed slopes are high and it is impossible to use water until desired corrections are established. Although the amount of water is enough in Turkey, it is not compatible with the desired space and time. The country is hydrologically divided into 26 basins. Throughout the country, the runoff coefficient is approximately 0.37 that means the $186*10^9$ m^3 of annual average flow is obtained from total amount of precipitation of $501*10^9$ m^3. The available water potential is $95*10^9$ m^3 in terms of economical and technical issues. In existing situation,. $27.5*10^9$ m^3 , in other words 29% of the surface waters is used. However, this figure is average of the country. In some river basins, development is completed and the demand has outrated the water potential. The contribution of the rivers originate in neighboring countries is annually $7*10^9$ m^3 . The economically and technically exploitable annual potential is approximately $3*10^9$ m^3 . The hydrometric measurements in rivers are carried by DSI, EIE and GDRS and there is one station in every 511 km^2 (DPT, 2001).

$41*10^9$ m^3 of the total annual average flow ($501*10^9$ m^3) is infiltrated to underground and form groundwater resources and approximately $12*10^9$ m^3 of this amount is the usable annual potential. Groundwater measurements are again carried by DSI due to groundwater level measurement instructions prepared by DSI. $7.6*10^9$ m^3 of usable groundwater potential is provided and $6*10^9$ m^3 of that amount is in use actually (DPT, 2001).

Geothermal waters are stored in acquifers, have high temperatures and contain several minerals. In places near the surface, it is possible to interfere with groundwaters so that quality of groundwater is affected. Temperatures are in interval of 30^0C (Ankara-Ayaş) - 232^0C (Aydın-Germencik). The Institute of Search and Investigation of Mine carry the investigation and management of geothermal waters. Turkey has a great source of geothermal fields and there are more than 600 thermal resources. Geothermal waters are not suitable for irrigation because of their high boron content. Boron is necessary for plant growth but the content in geothermal water is more than needed. On the other hand, geothermal waters are not suitable for drinking purposes because of arsenic, cadmium, mercury, lead, chromium content. The main geothermal areas in Turkey are given as follows (DPT, 2001).

> Denizli–Pamukkale, Kızıldere, Yenice, Buldan, Saraykoy, Tekkehamamı, Curuksu basin, Aydın-Germencik, Gediz basin, Canakkale-Tuzla, Izmir-Seferihisar, Balcova, Dikili, Afyon-Akarcay basin, Afyon-Gocek, Sandıklı, Nevsehir-Acıgol, Kozaklı, Ankara-Kızılcahamam, Ayas, Haymana, Balıkesir-Sındırgı, Gönen, Bolu-Seben, Kutahya-Gediz, Eskisehir, Bursa, Bitlik, Mus, Nemrut, Van-Ercis, Zilan, Erzurum-Ilıca, Pasinler, Agrı-Eleskirt regions.

In recent years, 35% of the total produced electrical energy in Turkey depends on hydro-electricity. It is managed by DSI and EIE. The usable hydropower energy potential is $125*10^9$ kwh in Turkey due to DSI's studies.

According to several studies carried out by DPT, it is stated that in year 2000, the total amount of water demand is 58.1 km^3 as given in Table 3.1.

Table 3.1. Water Demand in Turkey (km3) (DPT, 2001).

Sector	1990	2000
Drinking – Domestic	5.9	9.0
Irrigation	32.3	41.8
Industrial	5.1	7.3
TOTAL	43.3	58.1

On the other hand, according to DSI data, total water use is evaluated according to years through 1990 to 2000 and the results are given in Table 3.2.

Table 3.2. Water Use Ratios (DPT, 2001).

Years	Total water use, 10^6 m^3	Water use					
		Irrigation		Domestic		Industrial	
		10^6 m^3	%	10^6 m^3	%	10^6 m^3	%
1990	30600	22016	72	5141	17	3443	11
1992	31600	22939	73	5195	16	3466	11
1994	33500	24623	74	5293	16	3584	10
2000	42000	31500	75	6400	15	4100	10

In 1950s, 75% of the total population of country lived in rural areas, but in recent years this ratio has decreased to 40% because of the great increase in urbanization. 1/3 of the people live in cities like Istanbul, Ankara and Izmir. Consequently, the drinking water demand becomes unstable. DSI has the responsibility of water demand supply in residential areas having population over 100000 ca. Since 1981, some big cities such as Istanbul, Ankara, Bursa and Izmir have established their own water and sewerage system administrations and they carry out both management and maintenance services. Existing water uses are given in Table 3.3 due to each basin in Turkey.

Similar management and maintenance services are given by provincial banks in smaller municipalities. There are 2715 drinking water treatment plants established by provincial banks since the year 2000. The existing treatment plants either under construction or completed are given in Tables 3.4 and 3.5.

Table 3.3. Water Uses in Basins (DPT, 2001).

Basin	Domestic	Irrigation
Yeşilırmak	158.0	2879.20
Kızılırmak	596.60	4649.0
Ceyhan	146.6	3355.5
Asi	37.4	817.5
South Medit.	50.7	1464.7
Seyhan	332.8	1437.4
West Medit.	86.00	627.18
Van	0.00	475.27
Konya	37.80	2070.94
North Aegean	178.3	456.8
Gediz	125.8	1278.46
K.Menderes	245.88	177.36
B.Menderes	70.50	1981.49
Sakarya	646.2	805.0
Aras	17.8	1560.6
Dicle	142.8	4565.78
West Black Sea	1641.8	231.97
East Black Sea	125.0	-
Fırat	578.43	14894.86
Çoruh	-	104.1
Akarçay	-	165.9
Meriç	45.0	840.1
Marmara	1453.08	527.97
Susurluk	209.93	917.29
Burdur Lake	-	199.74
Antalya	330.48	743.31

Table 3.4.Drinking water treatment plants (completed) (DPT, 2001).

Plant	Source	Capacity (m^3/day)	Water Quality
Akkuş (ordu)	Düvenlik Creek	1728	II
Cumapazarı (Trabzon)	Ahamlı Creek	1037	II
Çatalca (İstanbul)	Karasu Creek	2592	-
Demirköy (Kırklareli)	Demirköy Dam	864	-
Doğubeyazıt (Ağrı)	Balıklı Lake	25 920	I
Eflani (Zonguldak)	Bostacılar Pond	1037	II
Gemlik (Bursa)	Nacaklı Creek	11 232	II
Gökçeada (Çanakkale)	Gökçeada Dam	2592	II
Gürgentepe (Ordu)	Akören Creek	648	II
Gölyazı (Konya)	Well	1382	II
İlküvez-Yoğuluk (Ordu)	Boğmalık Creek	2765	II
Işıktepe (Ordu)	Domcu Creek	1728	II
Keban (Elazığ)	Keban Dam	2992	II
Küre (Kastamonu)	Uzunöz Creek	1296	II
Korgan (Ordu)	Değirmendere	1296	II
Sağlamtaş (Tekirdağ)	Müstecep-Deliler Pond	1900	II
Şarköy (Tekirdağ	Şarköy Pond	1728	II
Ulubey (Ordu)	Kurşuncal Creek	3024	II

Table 3.5.Drinking Water Treatment Plants (under construction) (DPT, 2001).

Plant	Source	Capacity (m^3/gün)	Water Quality
Barbaros (Tekirdağ)	Yazır Pond	4320	II
Bodrum (Muğla)	Mumcular Dam	28 080	I
Çubuk (Ankara)	Çubuk II Dam	8640	II
Düzce (Bolu)	Uğursuyu Creek	60 480	I
Keşan (edirne)	Kadıköy Dam	12 960	II
Kırklareli	Kırklareli Dam	25 920	II
Kırıkkale Grup	Kapulukaya Dam	240 000	II
Rize	Andon Creek	51 840	II
Şarköy (Tekirdağ)	Kocadere and Karadeğirmen Pond	20 736	I
Tavşanlı (Kütahya)	Kayaboğazı Dam	30 240	II
Akçaköy (Trabzon)	Çamurluk Creek	565	II
Armutlu (Bursa)	Armutlu Pond	2592	II
Aybastı (Ordu)	Aybastı Creek	6048	II
Baydarlı (Tokat)	Mere Creek	1123	II
Bazlamaç (Samsun)	KocamanCreek	2160	II
Çamaş (Ordu)	Teberik Creek	2851	II
Çaybaşı-İnkur-Tekkiraz (Ordu)	Çağlayan Creek	2808	II
Gölköy (Ordu)	Tez Creek	4925	II
İkizce (Ordu)	Çandır Creek	2592	II
Karapürçek (Balıkesir)	Kavak Creek	864	II
Korgan(Bolu)	Apsut Creek	4320	II
Kurucaşile (Bartın)	Kapısuyu Creek	1382	II
Pelitliyatak (Ordu)	Karadere	1814	II
Perşembe (Ordu)	Kacalı 1-2 Creek	3024	II
Sarıköy (Balıkesir)	Alaman Creek	2592	II
Salman (Ordu)	Sulak Dere	864	II
Şalpazarı (Trabzon)	Değirmendere	3456	II
Üsküp (Kırklareli)	Üsküp Pond	432	II

GDRS is responsible for these processes in residential areas where there are no municipalities. 22% of the total drinking water project investments is done by GDRS, 32% by DSI and 46% by provincial banks. For these purposes, water is provided 48% from groundwaters, 52% from springs and surface waters. Water is provided to 97% of urban and 85% of rural area population.

The major water user is the agriculture sector in the country. Projection throughout the country is done on the basis of 24h irrigation. On the other hand, because some farmers irrigate only in the daytime, irrigation yield decreases to 40%. By development in irrigation processes, the water demand ratio of irrigation decreases as in other developed sectors. 90% of irrigation is provided from surface waters. DSI and GDRS irrigate 355325 ha area by groundwater. Farmers irrigate 69120 ha by themselves and total area irrigated by groundwater is 424445 ha as stated by DPT. 50% of irrigation is carried out by DSI, 26% by GDRS and 24% by farmers. DSI has transferred 83% of its irrigation process to several institutions or cooperatives.

3.2. Institutional Aspects of Water Resources Management in Turkey

In the developing world, similarly in all over the world, Turkey is also face to face with several problems in sustainable management of water resources. Although the existing water resources potential is sufficient, present resources and demands are not compatible in space and time. In very rough figures, 76% of water is used for irrigation, 14% for municipalities and 10% for industrial purpose (DPT, 2001). Water resources are abundant in eastern regions; on the contrary, demands become denser in western regions. There is a high water potential; yet there are water scarcity and water allocation problems locally. On the other hand, there are water quality problems because of uncontrolled use of water both in irrigation and industries.

National environmental policy was first articulated in the Third Five-Year Development Plan (TFYDP) (1973-1977). Water resources management is the major component of environmental management, therefore, all rules, approaches, constraints valid for environmental management is also applicable for water resources management. TFYDP was previously developed by separate public organizations, especially local governments, so it was not national in scope. It was later felt that policies alone were not sufficient to prevent and eliminate environmental problems. Following this realization, there was recourse to special constitutional, legal, institutional, and technical arrangements for addressing environmental problems. Also, efforts were initiated to get existing public agencies, private organizations and individual citizens to plan and implement their activities integrating a concern for protection of the environment.

The Seventh Five Year Development Plan (SFYDP) (1996-2000) embodies national policy in all key sectors, including the environment. Its major *Objectives, Principles and Policies* under the heading "Protection and Improvement of the Environment" include (DPT, 2001):

* Emphasizing pollution prevention rather than clean-up;
* Using an appropriate combination of economic and regulatory instruments;
* Developing regional and eco-basin strategies;
* Strengthening the system of environmental management;
* Ensuring that policies and solutions are in accordance with EU norms and international standards;
* Revising and enhancing the financing system for environmental protection, management and improvement;
* Promoting environmental awareness through formal and non-formal channels; and
* Harmonizing legislation to ensure compatibility between economic development and environmental protection.

The instruments to implement these policies are a priority project entitled “Institutional Arrangements on the Environment” and the preparation of a “National Strategy of the Environment”.

Turkey has made great progress over the last fifteen years in creating mechanisms to address its environmental problems: the 1982 Constitution recognizes the right of citizens to live in a healthy and balanced environment; an Environment Act was passed in 1983. The Constitution states that citizens and Government are obliged to cooperate to protect and upgrade the environment. It also addresses the need to protect the shores, land and water resources, forests, and natural, historical and cultural assets. As protection and development can only be achieved with relevant authority, the document authorizes enforcement powers. The **Environment Act (No 2872) of 1983** embodies the *polluter pays principle* adopted by other countries, and sets forth the concept of *absolute liability* to operationalize it. It also defines activities to prevent and solve environmental problems. These involve banning certain polluting operations, requiring environmental impact assessments (EIAs) for specific activities (effective in 1993), identifying sensitive locales to be defined as *special environmental protection areas*, providing sanctions to prevent the discharge of hazardous chemical substances and wastes, banning noise, promoting incentives to pollute less, creating an environmental fund, and securing participation in decision making bodies such as the Environment Council (ENC), Higher Council for the Environment (HCE), and Local Environment Committees (LECs) (see Institutional Setting below). To this end, amendments are now being considered that could strengthen inspections, broaden public participation, promote more efficient collection of revenues that support the Environmental Pollution Prevention Fund, and better protect drinking water resources (DPT, 2001).

Another mechanism related to management concept is the Ministry of Environment that was created in 1991; public awareness and demand for a clean environment are growing; and active non-governmental environmental organizations are emerging. The Ministry of Environment was established by government Decree no. 443 in 1991, which empowers it to conduct activities to protect and improve the environment. These activities involve ensuring appropriate land use, protecting natural resources, plants and animal species, and preventing pollution. Its duties include drafting laws, preparing rules and internal regulations, creating institutions (such as village environment associations and commissions to manage waste), supervising and planning environmental designs, interventions and actions as appropriate, managing watershed water quality and regional waste, creating environmental policies and strategies, coordinating environmental activities at international and national levels, conducting research, applying measurements, monitoring compliance, collecting data, managing finances, and carrying out extension and training. The ME has special consultative organs at three levels to ensure the participation of people in line with the requirements of environmental protection and development activities: The Environment Council (ENC), the Higher Council for the Environment (HCE), and

Local Environment Committees (LECs). At the provincial level, there are "Provincial Directorates of Environment" which, as of 1995, were organized in 33 provinces (DPT, 2001).

Physically, Turkey is at the crossroads linking Asia, Europe and Africa; this implies rich biodiversity, sensitive ecological habitats and a wealth of cultural and historical resources. Country is surrounded by four seas with a total coastline of over 8300 km., presenting a range of issues for managing coastal zones and marine resources. Turkey's rugged topography experiences high seismic activity where earthquakes and erosion can pose hazards. Topography and soil conditions allow only a third of Turkey's total land area to be suitable for various types of agriculture, implying pressure on available fertile land. The country encompasses both the temperate climate that receives precipitation in all seasons and the subtropical climate where summers are dry; the heavy rainfall can increase the risk of landslides and floods. Turkey is generally blessed with an abundance of water resources, though it requires proper management to utilize the water in the most efficient way. Other natural resources whose management should receive attention include certain minerals, forests, fertile soils, and fisheries.

In human terms, Turkey is one of the 20 most populous countries in the world with an estimated 63.7 million people in mid-1997 and has the fastest population growth rate of all OECD countries (1.6% in 1997). A relatively high growth rate normally puts additional pressure on natural resources and results in greater production of wastes. The populations are also rapidly urbanizing at 4.4% or nearly triple the national rate; by 2000, 70% of the population will be living in urban areas. Rapid urbanization usually exposes a growing population to a range of concentrated environmental problems and puts pressure on resources (e.g. marine and coastal resources). Rural migration to the urban centers usually originates in areas with low agricultural production where the use of land often exceeds its carrying capacity. Excessive migration combined with inadequate infrastructure facilities in the urban centers causes environmental concerns. In education, 80% of the population is literate and a quarter of the country is involved in some process of education and training each year; this situation can facilitate the spread of environmental awareness. In health, life expectancy is slightly better than the average for lower middle-income countries but under-five mortality is similar, raising questions about whether children suffer from unhealthy environmental conditions (DPT, 2001).

Economically, Turkey has been growing at double the average for OECD countries with a GNP per capita of US$2999 (estimated for 1997) and purchasing power parity was estimated at $5580 for 1995 (DPT, 2001). Rapid economic growth can lead to accelerated consumption of natural resources as well as pressure from increased waste generation. Industry and tourism are the fastest growing sectors of the economy, implying environmental problems with industrial waste and coastal degradation (where the majority of tourist facilities are located). Some 42% of the economically active population is concentrated in the agriculture sector which accounted for only 16% of GNP, suggesting heightened human pressure on soil, water, wildlife, and fisheries (DPT, 2001). Wealth is highly unevenly distributed, both across socio-economic groups and regionally. Poverty has been linked to accelerated environmental degradation and increased vulnerability to environmental risks. Finally, past and current economic policies imply mixed environmental consequences: (a) full implementation of the Customs Union with Europe can increase pressure for higher standards of environmental quality; (b) accelerated privatization offers the potential of reducing pollution; and (c) sustained high growth, combined with a reduced public sector, may make it difficult to manage higher levels of pollution.

Turkey's environmental management system and institutional base were both in place before the 1992 **Rio Declaration** and **Agenda 21** which set forth important changes in environmental protection policies, and management systems. Therefore, it has been necessary to harmonize national environmental policies with approaches adopted by such international documents. DPT (State Planning Agency) has several studies on water resources management in Turkey and publish its reports. And one of these reports is that DPT has published a table that summarizes options for the management of water resources and wastewaters as given in Table 3.6.

Turkey's major environmental problems concern the urban environment (air quality, water supply and wastewater, and solid waste management), natural resource management (water resources, soils and land, forests, biodiversity), marine and coastal resources, cultural and natural heritage, and natural as well as man-made environmental hazards.

Among these main issues, mainly water resources is the most important one, because water is the basic element in human life. The problem is that present source have never been compatible with demands in terms of time and space.

The major reasons for these environmental problems especially in western regions are mainly population movements, urbanization and industrialization. The population movement, urbanization trends and impacts on environment and environmental impacts of industrialization in Turkey can be seen in Figures 3.1, 3.2 and 3.3 respectively that is published by DPT. As seen in Figures, the most critical regions are western regions in terms of population growth/movement, urbanization and industrialization. Each Turkish city is examined in terms of stated issues based on several index given as a note in each figure.

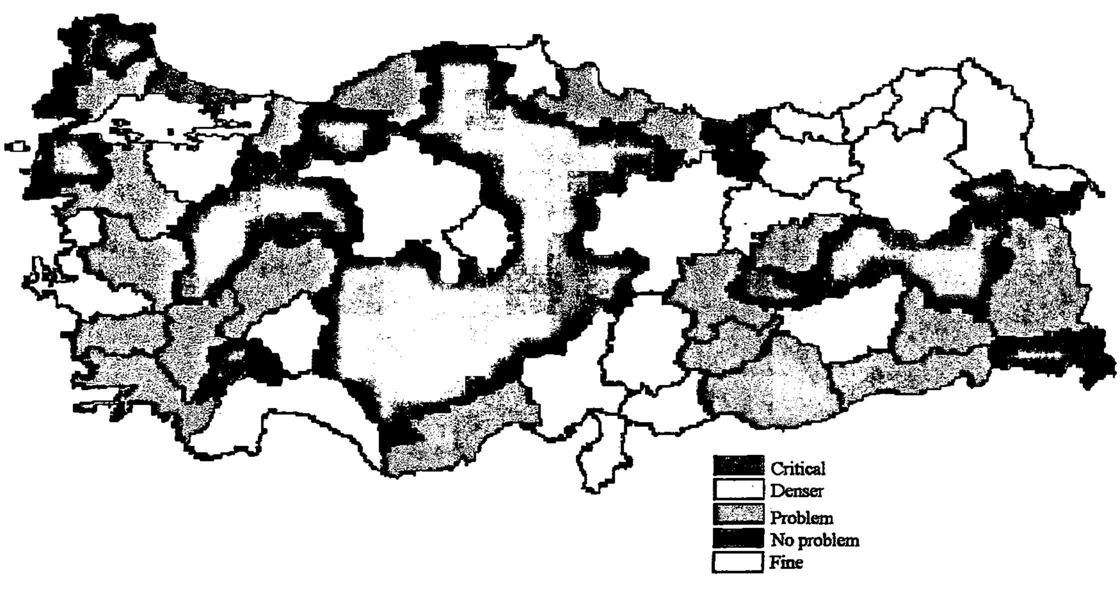


Figure 3.1. Population Movement (DPT, 2001).
(By considering a composite index of quantitative increase in population, population density, changes in population density)

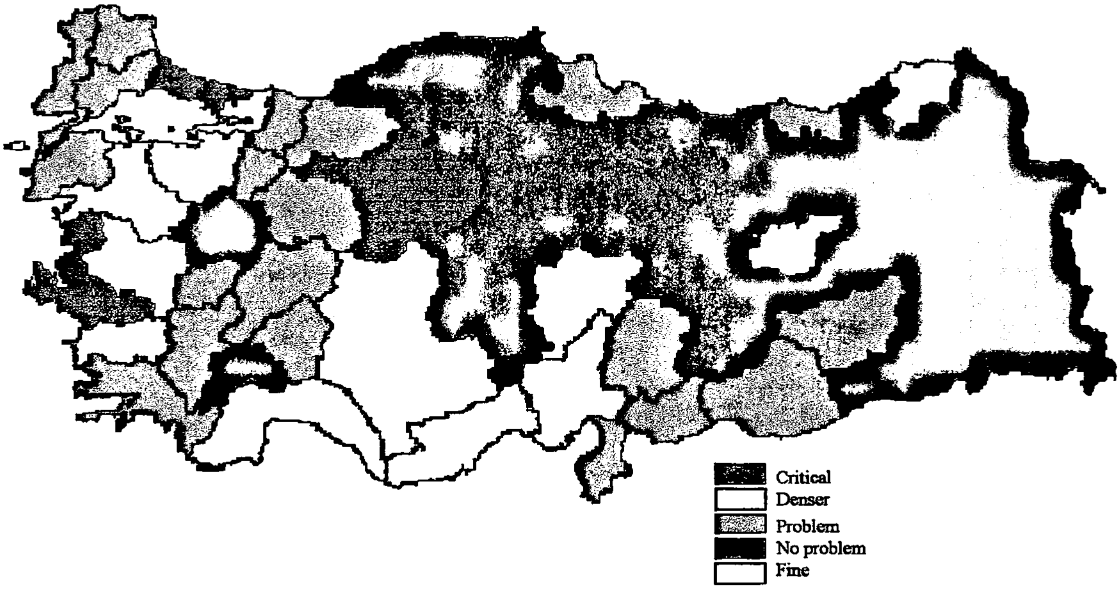


Figure 3.2. Urbanization Trends and Impacts on Environment (DPT, 2001).
(By considering a composite index of total urban population, ratio of urban to total population, net migration, rate of growth of urban population, rate of construction, intensity of motor vehicles)

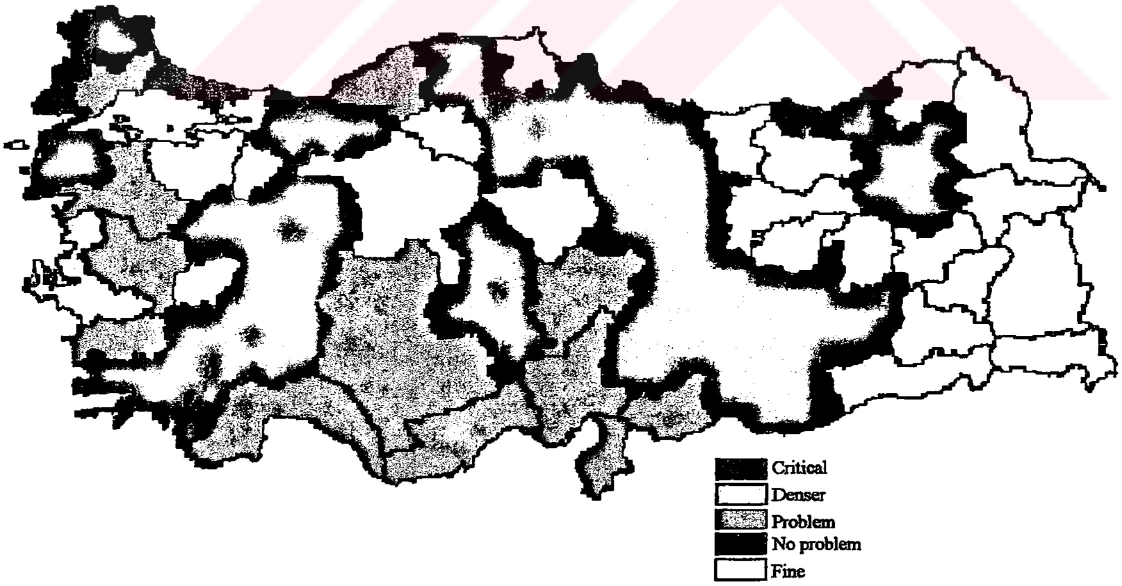


Figure 3.3. Environmental Impacts of Industrialization (DPT, 2001).
(By considering a composite index of share of active population employed in manufacturing industry, share of industrial value added, rate of the establishment of industrial enterprises, density of motor vehicles, total number of enterprises in small scale industrial sites)

There are 26 basins in Turkey stated by DPT and DSI (DPT, 2001). Precipitation areas and average flows of each basin given in Table 3.7. A stated again by DPT, river pollution sites, problems and sources are given in Table 3.8.

Table 3.6. Options for the Management of Water Resources and Wastewaters.

Areas of Action	Options
Policies	1. New policies to protect and manage water basins, aquifers and wetlands, including integrated water resources management.
Institutional Reform	2. Establishment at regional level of "water resources protection and development unions" composed of the representatives of fishermen, farmers, related ministeries, local governments, and professional and voluntary organizations; 3. Active representation in all international organizations and arrangements directly or indirectly related to the management of water resources. 4. Transfer of the management of state irrigation schemes to farmers/their organizations
Legislative Arrangements	5. Harmonization of national arrangements with international legislation and agreements; 6. Preparation of "Water Basin Management Regulations" by considering the economic, ecological, social and cultural conditions existing in water basins; 7. Implementation of edict on wastewater collection and treatment; 8. Revise legislation to allow for more private sector involvement in developing and managing water supply and sanitation facilities and services; 9. Enactment of Water Law; 10. Revision of Groundwater Act (No. 167).
Economic & Financial Measures	11. Setting waste water charges according to the characteristics of individual settlement areas; 12. Institutionalizing the practice of Build-Operate-Transfer (BOT) for water supply and treatment; 13. Ensuring the utilization of wastewater charges for improving wastewater management; 14. Raising the rates of taxes/fees in highly sensitive areas for the sustainability of water resources; introduction of new measures when necessary; 15. Linking wastewater discharge standards and fees to quality of the receiving body.
Education-Training	16. Development of programs for households, industrial entrepreneurs and water utilities to ensure the efficient utilization of water resources; 17. Wider practice of reusing domestic and industrial waste water; 18. Initiation of middle level vocational schools for training environment technicians in regions to be identified;
Participation	19. Support to voluntary organizations engaged in activities related to the protection and development of water resources as well as monitoring water quality;
Techniques	20. Development of water quality standards; 21. Design of "Water Quality Maps" and monitoring them; 22. Preparation of an inventory of ground water reserves; 23. Introducing watershed management techniques with decision support systems; 24. Development of standards related to the tools and equipment for measurement, sampling and analysis; 25. Encouragement of the use of the effluents of wastewater treatment facilities in irrigation; 26. Establishment of database on wastewater characteristics; 27. Implementation of water conservation and recycling measures; 28. Application of sustainability standards for groundwater usage.
R & D	29. Identification of "hydraulic basins", "coastal areas", "special protection zones" and "touristic areas" for transition to a basin based management; and remapping of water basins with clear borders; 30. Systematic and regular gathering of data in water basins, in line with EU directives; 31. Development of the concept of "primary pollutants"; 32. Investigating pollution originating from precipitation; 33. Identification of the characteristics of water resources in receiving environments;

Table 3.7: Water Basins in Turkey (DPT, 2001).

Basin No	Basin Name	Precp.Area (km²)	Water Potential of rivers in Turkey				
			Annual Ave. Flow (10^6 m³)	Annual Average Flow (mm)	Annual Ave. Flow (m³/s)	Annual Ave. Prod. (l/s/km²)	Flow constant
1	MERİÇ-ERGENE	14560	1,33	83,8	38,5	2,6	0,14
2	MARMARA	24100	8,33	334,0	255,2	10,5	0,46
3	SUSURLUK	23765	5,43	213,8	161,0	6,8	0,30
4	NORTH EGE	9032	2,09	231,4	66,2	7,3	0,37
5	GEDİZ	17118	1,95	107,5	58,6	3,4	0,19
6	K.MENDERES	7165	1,19	157,7	35,8	5,0	0,22
7	B.MENDERES	24903	3,06	122,9	97,1	3,9	0,19
8	WEST MEDITR.	22615	8,93	448,8	321,1	14,2	0,51
9	ANTALYA	14518	11,06	728,1	335,1	23,1	0,73
10	LAKE BURDUR	8764	0,50	51,3	14,3	1,6	0,11
11	AKARÇAY	8377	0,49	52,5	14,0	1,7	0,12
12	SAKARYA	56504	6,40	105,3	188,7	3,3	0,20
13	B KARADENİZ	29682	9,93	337,9	317,9	10,7	0,42
14	YEŞİLIRMAK	36129	5,80	159,4	182,8	5,1	0,32
15	KIZILIRMAK	7546	6,48	79,2	197,4	2,5	0,18
16	KONYA	55554	4,52	85,5	154,2	2,7	0,21
17	EAST. MEDTR.	22484	8,07	448,8	345,7	15,4	0,60
18	SEYHAN	20731	8,01	349,2	229,5	11,1	0,56
19	ASİ	10885	1,17	152,5	37,0	3,4	0,19
20	CEYHAN	21222	7,18	333,1	224,0	10,6	0,46
21	FIRAT	120917	31,61	261,4	992,3	8,2	0,48
22	E. BLACK SEA	24022	14.90	684,3	521,3	21,7	0,57
23	ÇORUH	19894	6,30	330,3	208,3	10,5	0,52
24	ARAS	27548	4,63	171,3	149,8	5,4	0,40
25	VAN	15254	2,39	171,8	82,9	5,4	0,36
26	DİCLE	51489	21,33	428,3	700,8	13,6	0,53
	TOTAL	766878	186,05		5929,3	209,7	

Table 3.8: River Pollution Sites, Problems and Sources (DPT, 2001).

Basin	River	Pollution	Sources
Meriç	1) Ergene River 2) Meriç River	1) BOD, suspended matter, alkalis, heat 2) BOD, ammonia, orthophosphate	1) Textile & food stuff industries, domestic waste 2) Industries, domestic waste from Edirne
Susurluk	3) Nilüfer Stream 4) Simav Creek	3) DO, BOD, ammonia, COD, orthophosphate 4) BOD, ammonia, orthophosphate	3) Industrial & domestic waste from Bursa 4) Industrial & domestic waste from Balıkesir & Susurluk
Gediz	5) Gediz River 6) Nif Creek	5) BOD, COD, heavy metals 6) BOD, COD, nitrogen, phosphorus	5) Industrial & domestic waste, irrigation runoff 6) Metal, textile, chemical, leather & other industries
Sakarya	7) Porsuk Creek 8) Ankara Stream 9) Çark Stream	7) DO, BOD, ammonia, nitrate, phosphate 8) DO, BOD, ammonia, nitrate, phosphate 9) DO, BOD, nitrogen, phosphate heavy metal	7) Kütahya sewage, industries, power plant 8) Domestic & industrial wastes from Ankara 9) Industrial & domestic waste from Adapazarı

The foundations of the Turkish system for environmental management were laid with the Third Five Year Development Plan (1973-1977), and the main features of this system were cast in the 1982 Constitution, the 1983 Environment Act, and establishment of the Ministry of Environment in 1991. Thus, Turkey's environmental management system and institutional base were both in place before the 1992 **Rio Declaration** and **Agenda 21** which set forth important changes in environmental protection policies, and management systems. Turkey recognizes the necessity to harmonize national environmental policies with approaches adopted by such international documents.

The current system for protecting and managing Turkey's environment is challenged by: (a) over-reliance on regulatory mechanisms; (b) little integration of environmental factors in planning; (c) limited public participation; (d) inadequate enforcement capability to implement environmental laws; (e) little use of environmental information; (f) over-centralization of budgets, authority and information; (g) low levels of awareness about environmental rules; and (h) inadequate environmental content in the educational system.

CHAPTER FOUR
CASE BASIN: GEDIZ

4.1. Introduction to the Basin

Gediz River Basin is located in West Anatolia between the Aegean Sea and Küçük Menderes and Bakırçay river basins. The basin is the largest in the Aegean region, covering 2.3% of the total surface area of Turkey (Gündoğdu, 1991). The Gediz river is selected for purposes of this study since the basin needs water quality management practices due to the increasing problem of water pollution.

The basin is covered with mountains of 2000 m. high from the north, south and the east, and it reaches the Aegean Sea from the west. The length of the river is 276 km., and the main tributaries are Deliiniş stream, Selendi stream, Demirci stream, Nif stream, Alaşehir stream and Kumçay. The drainage area of the river is 16 775 km^2.

The basin has a geographical structure dominated by mountains extending perpendicular to the Aegean shores and the grassy plains between these mountains. The sediment carried from upper basins to the grassy plains are filling the river bed and causing floods by bank overflows. Thus, floods threaten the agricultural and residential areas very frequently. Adala, Ahmetli, Menemen, Akhisar, Selendi, Kapaklı and Alaşehir plains make up the lower Gediz plains. In the upper basin, there are little plains along the river valley. Near the Gediz village, the valley expands and forms the Gediz plain.

The main water resources of the basin are the main stream of the Gediz river, and the tributaries of Alaşehir and Gördes streams. The main lakes are Marmara Lake and the Demirköprü Dam Reservoir.

4.1.1. Geology

Gediz valley is one of the greatest alluvium beds of West Anatolia. The mountains on the north and south of the valley where Salihli, Alaşehir and Sarıgöl are located, are formed of metamorphite and have a height of 2000 m. The highest mountain is Bozdağ with a height of 2169 m. This mountain is between the Küçük Menderes and Gediz valleys.

Ash fans and new lava surfaces can be observed between Kula and the Demirköprü Dam. The Gediz River reaches the valley from the north of Salihli. The direction of this valley is approximately east-west.

There are a lot of faults between the Gediz valley and the mountains around it. The formation of the valley can be explained by these faults.

4.1.2. Climate

The basin is in the typical Mediterranean climate - summers are hot and dry; winters are warm and rainy. January and February are the most rainy months whereas July and August are the driest months. The annual average temperature is 15.6°C.

The annual average rain in the basin is 635 mm, annual total minimum rain 327 mm, and the maximum rain is 1116 mm. The 25% of the annual total rain falls in the April - October period whereas 75% of it occurs in the November - March period. While the average water need of plants is 900 mm, the effective part of the annual rain is approximately 170 mm.

4.1.3. Population

In the basin, there is one large city, Manisa, with 12 towns together with a few towns in the İzmir area. The populations of these residential areas are given in Table 4.1.

Table 4.1. Population of Residential Areas in the Gediz Basin.

District	Population (as of 1990)	Population (as of 1997)
IZMIR		
Foça	25222	33061
Kemalpaşa	56075	67223
Menemen	76043	99325
MANISA		
Centrum	221694	259621
Ahmetli	19554	18666
Akhisar	152397	152404
Alaşehir	91362	98122
Demirci	60184	70767
Gölmarmara	16729	16997
Gördes	38853	37908
Köprübaşı	15847	11602
Kula	48132	48809
Salihli	132735	143016
Sarıgöl	34682	34721
Saruhanlı	73888	65129
Selendi	25415	25376
Turgutlu	100697	114774
Soma	76641	86788
Kırkagac	45608	47315
KUTAHYA		
Gediz	66675	76796
USAK		
Centrum	145505	165615
Eşme	39658	41622

The state highways passing through the basin are İzmir-Manisa-Balıkesir, Manisa-Salihli-Simav-Kütahya and Salihli-Kula-Uşak. Besides this, there are two railways; İzmir-Manisa-Balıkesir and İzmir-Manisa-Alaşehir-Uşak. There are also two airports, one in İzmir and one in Akhisar.

4.1.4. Land Structures

The soil structure in the basin is generally granular, consisting of sand and clay. The depth of the soil is suitable for the growing of deep-rooted plants. In the profiles, stone and gravel layers can be found very often. The permeability of the soil is generally good; parts with a great amount of sodium and heavy structured clay soil have a permeability of 0.50 cm/h.

The muddy soil has a pH of neutral and nearly neutral. At places where it contains a great amount of sodium and lime, pH is above 8. Areas that can not be washed by storm waters are rich of lime. It is stated that places that have bad drainage and little topographical slope show a problem of salinity. Drainage problems are significant in areas close to the river and the sea.

4.1.5. Economy

The major economical activity in the basin is agriculture, and the main products are cotton, vegetable, grapes and cereals. Agricultural area is 643990 ha and covers the 37.4% of the total basin. Table 4.2 summarizes the general field use in the basin. Classification of agricultural area is (Inay, 1999);

- Plowed agricultural field 643990 ha
- Dry agricultural field 419837 ha
- Irrigated agricultural field 123889 ha
- Vineyards and orchard fields 74356 ha
- Olive fields 25908 ha
- Green meadows, pastures 101226 ha
- Forests 545597 ha
- Land covered with heath 373826 ha
- Inhabited places 15358 ha
- Rock, debris, flood beds, water surfaces 41858 ha

There are thread and weaving factories in Salihli; wool factory in Kula; and textile factories in Manisa. There are also salt establishments in Çamaltı. Furthermore, there are small factories and manufacturing facilities to process agricultural products almost in every village center. Handicrafts such as carpet weaving are also characteristic.

There are several mines in the basin, including mica, lignite, marble, chromium, and graphite. However, most of these mines are not processed. The main trade in the basin relies on agricultural products. The major trade centers are Manisa, Akhisar and Salihli. The trade harbor of the basin is the İzmir harbor.

Table 4.2. General Field Use in Gediz Basin (Inay, 1999).

District	Area, ha	Agricultural area, ha	Forest and land covered with heath, ha	Green meadows and pastures, ha	Other, ha
Manisa city	212500	36933	30967	10818	133782
Foça	22800	4800	6539	5400	6061
Menemen	66500	23070	11133	8045	24252
Kemalpasa	63300	25714	33611	1050	3870
Turgutlu	50360	26976	19601	1700	2083
Salihli	130200	58126	29407	10200	32167
Demirci	123300	23064	64636	3500	31100
Alasehir	97100	39061	25928	6000	27341
Gediz	146800	40729	64910	13999	27162
Akhisar	175400	80030	72450	7400	15520
Gördes	80000	13500	41371	5500	19629
Kula	96342	18897	25167	4720	47216
Saruhanli	88779	46758	13098	3547	25376
Selendi	75100	25600	24490	10500	14510
Ahmetli	23640	9550	7510	1500	6430
Gölmarmara	23630	9769	8513	2777	2571
Köprübasi	25200	8100	12100	2000	3000
Çigli	13000	2129			
TOTAL	**1514551**	**429806**	**491801**	**96361**	**422070**

4.2. Current Pollution Status of the Gediz River Basin

4.2.1. General

Western Turkey is an excellent example of a water-short region where there has been substantial rapid movement towards local management of major irrigation systems. This transfer has occurred in an area where there has also been a large and important expansion of locally managed groundwater development that complements traditional local management of smaller rivers and streams.

Average rainfall throughout most of these basins ranges from 400-700 mm/year, generally below the average for Turkey, but demands for water are higher than in most of the rest of the country (Harmancioglu & Alpaslan (a), 1999). Irrigation has been important for cotton, an important economic crop throughout the area and increasingly for grapes, fruit and vegetables for local and export markets. With high per capita incomes, the population of the area has increasingly high per capita demands for village and municipal water supplies, placing scarce resources under more pressure. Further, the economic growth of the region has led to rapid population increases in major cities and has fostered increased industrial production. This, in turn, not only requires more water for urban and industrial use but also results in more pollution of rivers and the sea. There are fragile environmental areas within the region, notably major wetlands where birds and other threatened species live or breed and there are threats to hydrologic processes in the upper watersheds from soil erosion and degradation of natural vegetation.

All of these conditions require that management of water be done carefully and responsibly, within the context of a national policy that gives an increased role to local and regional management organizations. To date, the process of management transfer in large irrigation has been viewed as a success and while there is increasing concern with threats to the environment and the overall availability of fresh water resources, the experiences of western Turkey should be viewed positively as a good example for others to consider.

Gediz, K.Menderes and Bakircay River Basins, having the most productive soil of Aegean Region and Turkey, makes important contributions to the region's and country's economy by its ground and underground wealth besides its industry and tourism potential. On the other hand, especially Gediz basin with about millions of inhabitants, is currently one of the most highly polluted basins. Up to the 1960s, this basin was largely dominated by agriculture, but this situation is changed due to industrialization an urbanization within a decade. This led to considerable problems with drinking and industrial water supplies.

In Gediz basin, there is considerable competition for water for agriculture, domestic supply, industry and environmental protection. Water is used for several purposes and discharged to the natural system again. In recent years, natural system has the own treatment capability. Because of great development of population and industrialization, the natural system can not treat the impurities no more. The main two concerns with water quality are: (a) domestic wastewater, and (b) industrial pollution. Both are important for human health. It threatens human health either directly or because polluted water is used for agriculture. Domestic wastewater is not always treated before entering the river. In the basin, only the larger municipalities have treatment plants. Many villages still have inadequate facilities such as septic tanks. From each residential area, wastewater enters river system in any way. One of the complex situation reasons is that there is not sufficient treatment plants of facilities in residential areas. The major water quality component in domestic wastewater is organic loading measured in terms of BOD (biochemical oxygen demand) or COD (chemical oxygen demand).

On the other hand, various types of industries are available in the basin in different sizes. Each type of industry generates wastewater in different characteristics and amounts. Discharged wastewater is disposed to river either treated or untreated. Treatment facilities also affect the discharged water quality.

Industries discharge wastewater with different characteristics, so that different types of effects are imposed on river water quality. In industrial wastewater, major water quality components are toxic material, hazardous matter, color, high particular matter, pH, etc. Because of conservative characteristics of industrial wastewater, there is a risk of accumulation. Dissolved-oxygen sag curve of Streeter-Phelps is invalid in the presence of such industrial discharges. Consequently, owing to domestic discharges, dissolved oxygen consumption due to organic matter consumption and results of these processes, several fish deaths occur in aquatic life but the effect of industrial discharges are variable and difficult to estimate.

4.2.2. Pollution Profile in the Gediz River Basin due to Available Studies

As stated earlier, the major components of IWRM concept includes water allocation, distribution and water quality besides institutional and legal issues such as organizations, institutions, laws and regulations. These terms are examined briefly in following sections. The current pollution status is summarized in Table 4.2 for the tributaries of Gediz river in terms of water quality classes stated for river waters as given in **Appendix A**.

According to observations (in Table 4.3) done by DSI in 1993, Gediz river is in a highly polluted situation. Especially from Manisa to the sea, river segment is in IV th class due to high nitrogen, organic matter and heavy metals content. The main pollutants are industrialization in Manisa region and irrigation activities in the basin.

The presented study evaluates the existing situation of pollution in the Gediz basin. Evaluation is done using the available data. In the study, river pollution is assessed, processed and evaluated by a water quality computer model. In the presented thesis, the basin is briefly examined especially in terms of water quality by assessing the available data and information.

Table 4.3. The Status of Gediz River Pollution (DPT, 2001).

Tributaries	KOİ	Hg	NO_2-N	Pb
Alaşehir Stream	I-IV	II	II-IV	I-IV
Değirmendere	I	-	II	I
Kurşunlu	I-II	II	III	II
Tabak	I-II	II	III	II-III
Gencer	I-II	II	III	II
Selendi	I	IV	II	I
Deliinis	I	III	II	II
Demirci	I-II	III-IV	III-IV	I-II
Medar	I		II	
Kum	I		IV	
Nif	II-IV	II	III-IV	I-III
Gencer-Manisa	II-III	II-IV	III-IV	II-I
Manisa-sea	II-IV	II	IV	IV-II

There are a lot of studies done by several researchers. One of these is carried by Provincial Bank of Izmir and presented in Izmir Water Congress, 4-5.June.1999 in Izmir. In the paper, it is stated that Gediz River Basin is one of the important basin due to its high contributions to region's and country's economy.

Considering the impact of Gediz Basin on the economy of the region and the country, studies are started as the protocol required, which was signed up between the Governorships of Izmir and Manisa on 26th of June 1996 about Gediz River Basin Pilot Plan in order to protect Gediz River against pollution and to improve the irrigation water of Menemen Plain. A cooperative commission between the Provincial Office of Ministry of Environment of Izmir and Manisa and DSI was constituted in order to control the pollution of Gediz River, and for 1 year water samples were taken from 17 points on Gediz River and its tributaries, with 10 repetition along Gediz Basin. The analysis of samples were done and their results were evaluated.

"B. Menderes, K. Menderes, Gediz and North Aegean River Basins Integrated Water Resources Management and Pollution Control Feasibility Research Study" is carried out with the coordination of the Provincial Office of Ministry of Environment on the local base, in the frame of Bilateral Cooperation Agreement of Environmental Field between Turkish and French Ministry of Environment. With the study, providing water management on the base of water basins for the first time in the country and determination of water's optimum and efficient use by all consumers, are aimed; the purpose was to provide the coordination of the studies that are carried out by different associations and institutions until today, and thus, to constitute a management model for every water basin in a long time interval is targeted (Gündogdu et al., 1999).

In the paper, the monitoring and pollution determination studies that are carried out on the Gediz River Basin Pilot Plan and the studies that are carried out on Aegean River Basins are summarized and introduced (Gündogdu et al., 1999). After the analysis on the 10^{th} repetition, it is determined that irrigation water quality is determined in the II. and III. Class due to Water Quality Control Regulations, in terms of turbidity and sodium adsorption ratio. The maximum available concentration limits for heavy metals and toxic elements such as manganese, lead, aluminum and chromium are observed where industrialization is dense. Suspended solids, BOD and turbidity concentrations are sometimes in IV. or V. class as seen in Figure 4.1 in terms of BOD concentrations after the 10^{th} repetition.

In scope of the concept of "Integrated Water Resources Management", the main issue is to identify the hydraulic infrastructure or the physical system relevant to water allocation, distribution and water quality. These issues cover the hydraulic structures, storage, delivery and drainage facilities, inflows, withdrawals and discharge points of domestic, industrial pollution loads and irrigation systems in the direction of flows.

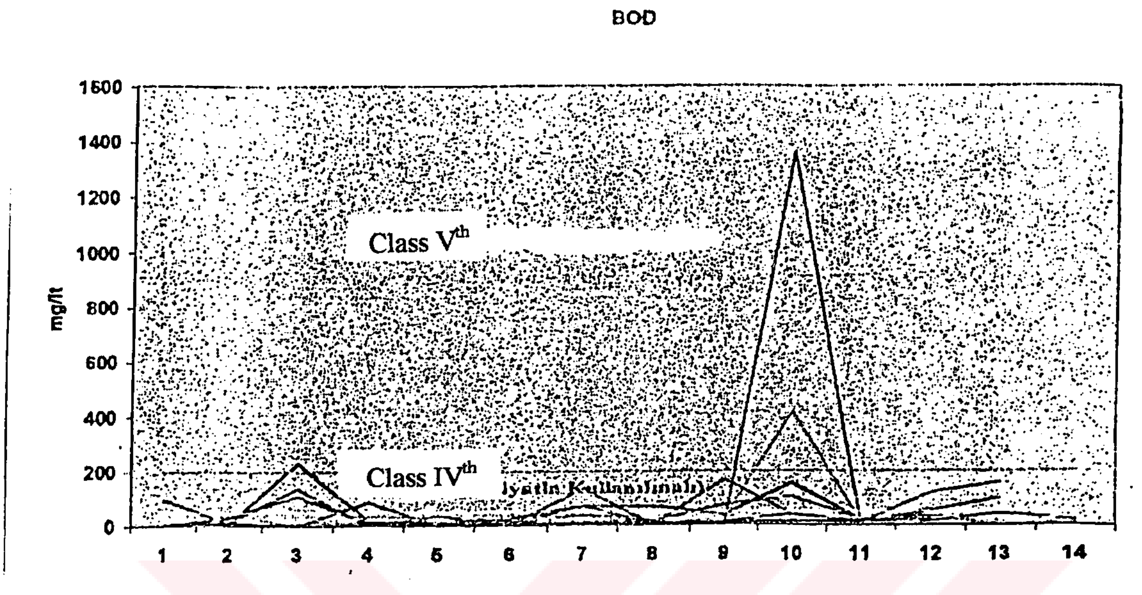


Figure 4.1. Evaluation of BOD Concentrations after 10th Repetition Along Gediz River Basin due to Sampling Points.

Water allocation is examined in terms of available surface and groundwater resources in general. Existing resources are used due to demands, such as; irrigation, hydropower generation, urban and industrial use and wetlands. The desired amount of water is allocated from dams, reservoirs or weirs and distributed by several types of canals. Besides allocation and distribution, water quality is the most important issue because the main problem is to provide the desired amount of water in desired quality. On the other hand, the quality of discharged water to the river is also important in order to preserve the quality of the river water because there is only a limited treatment capacity of the river itself. In the scope of water quality, point and non-point discharges are important issues to be assessed.

In following sections, water allocation, distribution and quality issues are determined in a general framework and examined in detail in the case of Gediz river basin.

CHAPTER FIVE

ASSESSMENT OF WATER ALLOCATION IN THE GEDIZ RIVER BASIN

5.1. Physical System of Water Allocation

The basic water resources are surface water and groundwater. The desired amount of water is obtained from these resources in different ratios according to water availability. The major areas of water uses can be identified as: irrigation, domestic and industrial water supply, hydropower generation and wetland protection. Thus, water resources of the basin are allocated basically to these types of uses. In each basin, water uses also differ from each other; for example, there is no hydropower generation in every basin. Water is allocated for irrigation from dams or reservoirs by weirs and canals. Generally groundwater resources are used for urban or industrial water allocations. Wetlands are unique in their relationship to water quality: they are negatively impacted by certain pollutants and land use activities but are also efficient at removing some pollutants from the water, thus improving water quality (Perry & Vanderklein, 1996). The main sources of water to feed the wetland are precipitation and surface waters (river itself).

5.1.1. Available Water Resources

The main surface water resources of the basin is the Gediz river main stream and Alasehir and Gördes streams. Annual average flow of Gediz river is 1950 hm^3 (that makes up 1.2% of the total surface water resources potential in Turkey), annual average efficiency is 360 $lt/s/hm^2$ and the ratio of runoff to precipitation is 26%. Flows in each tributary is as given in Table 5.1. Drainage is provided by Gediz main branch, streams and creeks. Drainage problems occur where there is a little slope in topography or in fields near the river and the sea.

Table 5.1. Flows in Gediz River Tributaries (GDRS/IWMI, 2000).

Tributary	Drainage area, km^2	Max. Flow, m^3/s	Min. Flow, m^3/s
Alasehir	2536	317	.01
Selendi	721	140	.01
Deliinis	762	353	.01
Gördes	1747	384	.01
Medar	947	128	.01
Nif	860	100	.09
Kum	646	134	.01

The existing groundwater reserve in the basin is 540 hm^3/year. Springs also contribute to the water potential of the basin. The safe yield of these springs is defined by DSI as $195*10^6$ m^3/year. These resources can be used for such water uses as domestic water supply and irrigation. Main springs in the basin and their areas of use are given in Table 5.2. Goksu, Goldegirmeni, Sarikiz, Besgoz and Akpinar springs are the major resources in the basin. The total annual efficiency is approximately 200 hm^3. 55 hm^3 groundwater is withdrawn from the plains of Turgutlu and Salihli and this amount is used for industries.

Table 5.2 The Groundwater Potential of the Gediz Basin (Harmancioglu & Alpaslan (b), 1999).

Spring	Safe yield 10^6 m^3/year	Use
Ilıca (Manisa)	10	Manisa domestic water supply
Akpınar (Manisa)	1.5	Manisa domestic water supply
Gürle (Manisa)	2.5	Irrigation, fishery, domestic water supply
Göksu (Manisa)	63	Izmir domestic water supply
Palamut (Akhisar)	12	Irrigation
Beşgöz (Akhisar)	26	Irrigation
Akpınar (Gölmarmara)	31	Irrigation
Kılıcanlar (Gölmarmara)	3	Irrigation
Sarıkız (Saruhanlı)	45	Izmir domestic water supply
Kemalpaşa (Manisa)	1	Irrigation
TOTAL	195	

Existing dams and reservoirs are Demirkopru, Afsar, Buldan dams and Marmara reservoir that are used for irrigation purposes. The characteristics of the dams and reservoirs are given in Table 5.3.

Table 5.3. Existing Dams and Reservoir in Gediz River Basin (Inay, 1999).

Characteristics	Demirköprü Dam	Afşar Dam	Buldan Dam	Marmara Reservoir
Drainage Area (km²)	6.590	540.0	180	1.780.0
River name	Gediz river	Alaşehir stream	Buldan stream	_
Annual average flow(hm³)	841	92.0	23.5	383
Withdrawn water (hm³)	546	46.92	17.2	109
Regulation ratio(%)	65	51	73	28
Type	Sand filled	Sand filled	Sand filled	Sand filled
Height (from the thalweg)(m)	74	43.5	59	5.6
Faded volume (hm³)	291	5	9	30.0
Total volume (hm³)	1.105	84.0	54	320.0
Irrigated area	72.537	13.270	2.470	13.437
Operated since	1960	1979	1969	1944

There are two ponds – Ucpinar and Karaagac - in the basin as described in Table 5.4.

Table 5.4. Existing ponds in Gediz basin (Inay, 1999).

Pond characteristics	Üçpınar pond	Karaağaç pond
Drainage Area (km²)	27.12	18.44
River name	Mandıra creek	Köy creek
Annual average flow(hm³)	2.95	1.21
Withdrawn water (hm³)	2.21	1.0
Regulation ratio (%)	75	83
Height (from the thalweg)(m)	26.0	20
Faded volume (hm³)	0.5	0.73
Total volume (hm³)	5.31	1.44
Irrigated area (ha)	242	164
Operated since	1992	1993

According to measurements taken at the Selendi streamgaging station, the maximum flow of the Gediz stream is 773m^3/s and the minimum is 2.35 m^3/s. The measurements of Manisa station show that these values range from 482 m^3/s to 14.6 m^3/s. The difference between these measurements is due to the storage at Demirköprü which is located between the two streamgaging stations. The average flowrates are 25.4 m^3/s in Selendi and 107.5 m^3/s in Manisa (Barbaros, 1997).

Alaşehir stream rises from the north of Koparan and Karagöz villages. The length of the stream is 115 km and the drainage area is 2680 km^2. According to measurements of DSI, the average of flow in the stream is 15.7 m^3/s (total of 494 m^3/year). The river bed is made of very fine materials that can be eroded away easily. The stream dries 8 months a year; yet it becomes a great danger for the Alaşehir plain during the rainy season. The Selendi stream rises from the southern part of Salhane and Derbent mountains near Simav, and its total drainage area is 702 km^2. It joins the Gediz river near Tahtacı village. According to observations at Derköy, the average flowrate is 4.5 m^3/s (total of 143 million m^3/year). The Deliiniş stream originates from the southern parts of Simav mountains and flows in the south direction. It joins the Gediz river near Borlu village. The drainage area of this tributary is 827 km^2 , and the average flow is 6.4 m^3/s (total of 201 million m^3/year). The Demirci stream rises from the southern parts of Demirci mountains to join the Gediz river at the eastern part of Adala. It has an average flow of 8.1 m^3/s (total of 254 million m^3/year). The Sarmaşık stream rises from the southern part of Demirci mountains and takes the name of Gördes after the confluence with the Medar stream. The length of the stream is approximately 90 km and the total drainage area is 1560 km^2. The Nif stream, that originates near Ulucak village, passes through Kemalpaşa plains and joins the Gediz river. It is fed by a little stream that rises from Nif mountain and dries in summer. The drainage area is 1087 km^2. This region has a great potential for agriculture with sufficient surface and groundwater resources (Barbaros, 1997).

State Hydraulic Works (DSI) and Electrical Works (EIE) have observed runoff on the Gediz river and its tributaries since 1951. The locations of current streamgaging stations are shown in Figure 5.1 and the average flowrates at each station are given in Table 5.5.

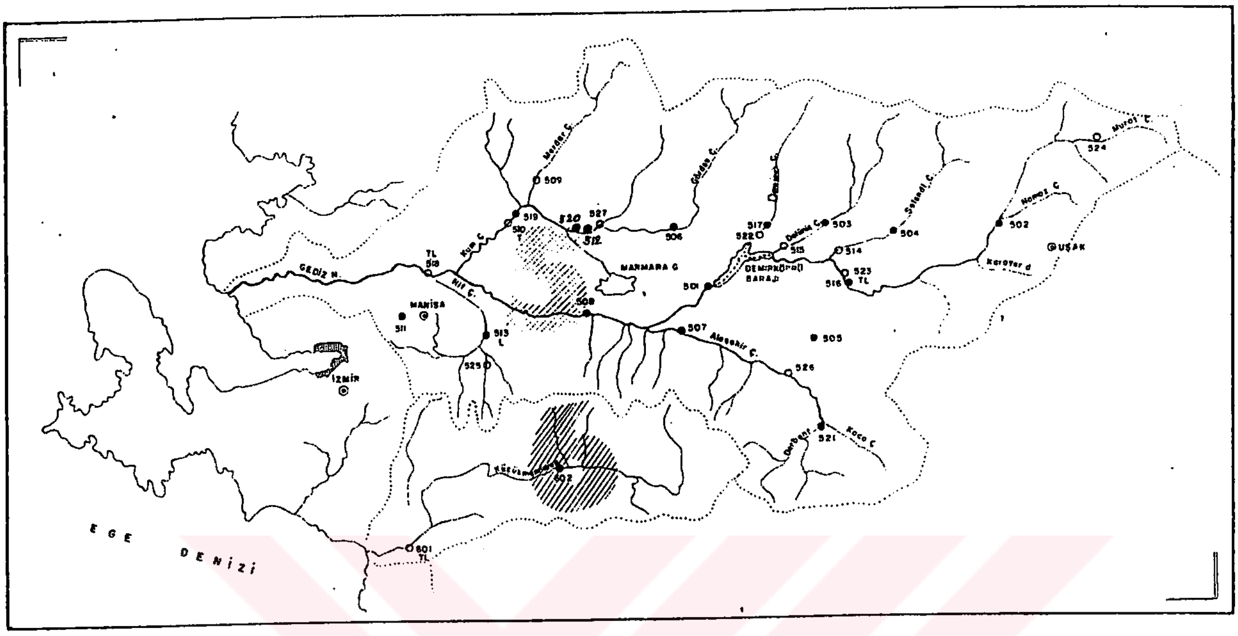


Figure 5.1. Flow Observation Stations of EIE and DSI.

Table 5.5 Streamgaging Stations in the Gediz River Basin (Barbaros, 1997).

Station	Agency	Annual Averages, m^3/s	Seasonal Averages, m^3/s			
			Winter	Autumn	Summer	Spring
Medar Çayı - Kayalıoğlu (509)	EIE	1.466	3.040	0.651	0.649	2.356
Kum Çayı - Killik (510)	EIE	3.523	9.035	3.008	2.283	4.907
Selendi Çayı - Dereköy (514)	EIE	1.336	2.220	0.467	1.685	2.371
Deliiniş Deresi - Topuzdamları (515)	EIE	1.505	2.705	0.718	0.535	2.824
Gediz Nehri - Manisa (518)	EIE	33.651	55.120	44.810	13.290	36.740
Demirci Çayı - Borlu Köprüsü (522)	EIE	1.486	3.134	0.357	0.765	2.993
Gediz Nehri - Acısu (523)	EIE	7.503	12.650	7.335	7.419	14.390
Murat Çayı - Sazköy (524)	EIE	1.371	1.288	0.913	1.744	3.420
Yiğitler Deresi - Yiğitler (525)	EIE	0.802	2.702	0.224	0.072	1.319
Alaşehir Çayı - Baklacı (526)	EIE	1.029	1.301	0.762	0.908	2.099
Gördes Çayı - Darıbükü (527)	EIE	2.553	7.941	0.712	0.993	4.996
Alaşehir Çayı -Baklacı (001)	DSI	361.628	1060.000	20.000	355.000	2120.000
Gediz Nehri-Urganlı (002)	DSI	15.860	18.500	5.600	18.000	32.000
Kum Çayı-Killik (003)	DSI	1310.583	7860.000	1350.000	268.000	3250.000
Medar Çayı-Medar Köprüsü (004)	DSI	2.128	3.800	0.000	0.000	0.900
Gediz Nehri-Muradiye Köprüsü (005)	DSI	183.250	72.000	14.500	23.500	85.000
Gediz Nehri-Menemen Köprüsü (006)	DSI	39.514	72.000	14.500	23.500	85.000

5.1.2. Water uses in the basin

In Turkey, DSI plays the major role in the establishment of river basin management. In this framework, DSI prepares master plans and feasibility studies for exploitation of the water resources in Gediz river basin. In the basin, there are 5 major areas of water uses such as; irrigation, hydropower generation, domestic and industrial water supply and wetland protection.

Irrigation

Gediz delta is one of the major agricultural areas in Aegean region because of its adequate climate and soil conditions. The principal products are cotton and if water is available, rice. Irrigation activities are supported mainly by Gediz main river since 1940 and then three dams are constructed for irrigation and energy purposes. DSI has started Lower Gediz Irrigation Project for the irrigation of Menemen plain. By this project, 23000 ha area is irrigated. Total agricultural area in the basin is 643990 ha (37.4% of the total basin) (Inay, H., 1999). The irrigated areas in the basin are given in Table 5.6.

Table 5.6. Irrigated Agricultural Area in Gediz River Basin (ha) (Inay, 1999).

Residential Areas	Total agriculture Area	Irrigable Area	Non-irrigable Area
Manisa (centre)	36.933	25.725	11.208
Foça	4.800	2.760	2.040
Menemen	23.070	18.000	5.070
Kemalpaşa	25.714	6.442	19.272
Turgutlu	26.976	23.492	3.484
Salihli	58.126	21.339	36.787
Demirci	23.064	3.350	19.714
Alaşehir	39.061	18.227	20.834
Gediz	9.179		
Akhisar	80.030	34.625	45.405
Gördes	13.500	.824	12.676
Kula	18.897	1.985	16.912
Saruhanlı	46.758	22.624	24.134
Selendi	25.600	1.424	24.176
Ahmetli	9.550	4.493	5.057
Gölmarmara	6.769	5.426	4.343
Köprübaşı	8.100	.185	7.915
Çiğli	2.129	1.580	.549
TOPLAM	458.256	192.501	259.576

During the drought period, the amount of surface water is reduced so that, groundwater has been used. Wells have been drilled in an uncontrolled way in order to satisfy the farmers' demand. Groundwater use increases in drought period whereas in normal period, it decreases 40%.

It is the responsibility of DSI to issue permits for most water extractions but there is little firm data available that can be used to accurately assess the total volumes involved, or whether the groundwater table is being lowered as a result of such activities. Data on extractions from wells and springs were available for all the larger villages and cities in the Gediz Basin. Table 5.7 shows the water use per person per day for each different municipality. Of the daily water use, 18% is assumed to be consumed; the rest will return to the vertical water balance of the representative landcover within the basin.

Table 5.7. Irrigated Areas in the Gediz Basin (GDRS/IWMI, 2000).

Municipality	Water extraction from well m^3/year	Water extraction from spring m^3/year	Total water extraction m^3/year	Water use Per person Per day l/day	18% of water use Per person l/day
Akhisar	4,927,500	0	4,927,500	150[1]	27
Gölmarmara	821,250	0	821,250	150[1]	27
Gördes	788,400	157,680	946,080	245	44
Saruhanli	706,275	0	706,275	150[1]	27
Selendi	215,000	0	215,000	84	15
Gediz	1,547,280	763,392	2,310,672	274	49
Kula	1,198,295	0	1,198,295	164	30
Demirci	665,000	1,071,000	1,736,000	165	30
Köprübasi	146,000	0	146,000	70	13
Salihli	2,286,335	0	2,286,335	76	14
Alasehir	4,276,340	0	4,276,340	275	49
Sarýgöl	516,478	0	516,478	129	23
Ahmetli	730,000	0	730,000	191	16
Turgutlu	4,686,600	0	4,686,600	150[1]	27
Kemalpasa	1,300,000	0	1,300,000	162	29
Manisa	17,044,525	0	17,044,525	232	42
Izmir	22,500,000	0	22,500,000	-	-
Izmir	22,500,000	0	22,500,000	-	-
Izmir	63,000,000	0	63,000,000	-	-

[1] *For the villages of which no withdrawal data are available, 150 l/person/day was taken.*

Hydropower Generation

The gross hydroelectric potential of the Gediz river basin is in order of 406.3 MW. At present, the only hydroelectric power plant in the basin is the Demirkopru Dam and Power Plant, which is a multi-purpose scheme serving irrigation and flood control as well. Demirkopru reservoir is the largest reservoir in the basin. It started operation in 1960 and is designed to generate 193 GWh/year of energy at an installed capacity of 69 MW.

At present, DSI carries out the preliminary investigations for the Afsar II dam and power plant which is located upstream of the Afsar Dam – the reservoir that feeds the Alasehir irrigation scheme. The new reservoir is to allocate water to the irrigation of 1780 ha of land and to generate 88 GWh/year of energy at an installed capacity of 4 MW (Harmancioglu & Alpaslan (b), 1999).

Urban water allocations

For domestic water use, water is allocated from groundwater resources. Sarıkız and Göksu springs, Akpınar and Ilıca springs supply domestic water for Izmir and Manisa provinces.

DSI continues planning and project development activities to allocate domestic water supply to the province of Izmir. For this purpose, DSI plans to supply $57*10^6$ m^3 of water from Gordes reservoir, $45*10^6$ m^3 from Caglayan reservoir and $42*10^6$ m^3 from Baslamıs reservoir in the Gediz river basin (Harmancioglu & Alpaslan (b), 1999)

Industrial water allocations

There are no reliable data for industrial water extractions in the Gediz basin, although industrial growth is rapid in certain places. The most rapidly urbanizing area is in the upper Nif valley immediately east of Izmir, where a series of factories has come up along the Izmir-Turgutlu road. Many factories extract groundwater but even if they have received permits for drilling wells, no information is available on how much they actually extract. The Nif valley is probably one of the more fragile groundwater locations as there is no large-scale irrigation in the area, with all recharge coming from the surrounding mountains.

Manisa is also a rapidly expanding industrial area. Most of the expansion is in the north of the city and thus within the main Gediz valley. Again, there is no information on how much water is extracted (GDRS/IWMI, 2000).

Similar to domestic water supply, industries supply water by drilling wells. Wells are drilled with DSI permits. Generally, groundwater is preferred because of water fees, no surface water is allocated to industry. Industries do not prefer to obtain water from distribution systems because they have to pay fee. On the other hand, industries can drill wells and do not pay any fee. Drilling processes are under control of the General Directorate of State Hydraulic Works according to Underground Waters Act – Article 4:

"... Any person drilling a well only be entitled to a limited use of the water explored and found as sufficient to meet its individual utilization requirements. ..."

On the other hand, it is impossible to collect information on either wells used for industrial water supply or on the amount of groundwater sources consumed for industrial uses.

Wetlands

The other water use area is the wetlands. Wetlands have disappeared at an alarming rate in Turkey, over half (1,300,000 ha) of them have been drained or reclaimed since the 1960s. The Turkish Government declared nine wetlands in Turkey as "wetland of international importance" under the Convention of Ramsar. One of these is the Bird Paradise (Kus Cenneti) at the tail end of the Gediz Basin (GDRS/IWMI, 2000).

The Bird Paradise (14,900 ha) has a high biodiversity and is an important breeding or over-wintering area for many bird species such as flamingos, pelicans, herons and others. However, the Bird Paradise is recognized by the Turkish Society for the Protection of Nature (DHKD) as one of the most threatened wetlands of the country. This is mainly due to irrigation projects, industrial and urban developments and pollution.

Protection of the Bird Paradise is difficult as it located at the outlet of the Gediz River and is therefore very sensitive to changes in land use or climate. The nonlinear relationship between these changes and the total runoff to these wetlands are particularly important (e.g., 10% less rainfall in the catchment can decrease runoff into the wetland by 50%). In 1992, the water shortage in the Gediz River led to drying up of significant areas of the wetland and the deaths of thousands of birds (GDRS/IWMI,2000).

The main source of water to feed the wetland is the Gediz river itself. Bird Paradise is located 30 km to the northwest of Izmir on the Gediz delta between Gediz river and Çamaltı tuzla. Wetland is fed by a drainage canal that discharges to the Izmir bay, irrigation canal from the Menemen scheme and groundwater extracted from wells in the Suzbeyli village.

5.2. Institutions Involved (Actors) in Water Allocation

According to the magnitude of environmental problems, national institutions were created to identify, improve, coordinate, monitor and supervise activities, as well as procure resources. The first was a Permanent Board of Consultants for Environmental Problems, in the early 1970s. Then, in 1978, an Environment Organization was attached to the Prime Minister's office, as was a General Directorate of Environment in 1984, which was transformed into the Undersecretaries of Environment in 1989.

The major actor who plans and executes water allocation in Turkish river basins is the *General Directorate of DSI* according to institutional structure in the country. DSI performs this task within the framework of the "5-year Development plans" prepared by the State Planning Agency (DPT) and approved by the Turkish Parliament.

The duties and responsibilities of *DSI* are related to the major tasks of the 7th 5-year Development Plan for the years 1995-2000. The activities of DSI relate to two sectors: (a) agricultural sector comprising irrigation, drainage and flood control objectives, and (b) service sector comprising hydroelectric water supply, domestic water supply for large cities and industrial water supply. DSI's objective as a water resources planning agency is to develop the basin's water and land resources taken consideration into social, economic and environmental status of the basin. As well as in all other basins in Turkey, DSI is the "responsible agency" for water resources development and planning in general and for water allocation among different uses in particular. DSI is established in 1953 via Law No. 6200 that gives DSI the responsibilities of "single and multi-purpose exploitation of surface and groundwaters and mitigation of land erosion and flood impacts".

The Ministry of Environment was established by government Decree no. 443 in 1991, which empowers it to conduct activities to protect and improve the environment. These activities involve ensuring appropriate land use, protecting natural resources, plants and animal species, and preventing pollution. Its duties include drafting laws, preparing rules and internal regulations, creating institutions (such as village environment associations and commissions to manage waste), supervising and planning environmental designs, interventions and actions as appropriate, managing watershed water quality and regional waste, creating environmental policies and strategies, coordinating environmental activities at international and national levels, conducting research, applying measurements, monitoring compliance, collecting data, managing finances, and carrying out extension and training. The ME has special consultative organs at three levels to ensure the participation of people in line with the requirements of environmental protection and development activities: The Environment Council (ENC), the Higher Council for the Environment (HCE), and Local Environment Committees (LECs). At the provincial level, there are "Provincial Directorates of Environment" which, as of 1995, were organized in 33 provinces. The National Assembly is considering proposals to reorganize the ME's structure to improve efficiency; the draft reorganization of ME includes establishing a Sustainable Development Council, increasing public participation, allowing for more flexible hiring of experts, and improving salaries to attract more qualified personnel.

The State Planning Organization (DPT) under the Prime Minister's Office develops economic, social and environmental policies for the 5-year development plans; and prepares annual programs and public investment programs. It approves all public investment projects as well as those proposed by municipalities for financing by either domestic or foreign resources. One of its units, the Local Authorities, Environment and Technological Research Department, formulates environmental policy recommendations for the 5-year plan, evaluates ME's investment projects and programs, and prepares annual environment programs. However, the SPO does not evaluate sectoral investments for their compliance on environmental policy. Higher Council for Planning (HCP) chaired by the Prime Minister, is responsible for decision making on macroeconomic and social policies and evaluation and allocation of resources for big investment projects. Ministers for agriculture, forestry, energy, transport, settlements, finance and undersecretary of SPO are the members of HPC, but not the Minister for Environment.

The other associations related to water allocation practices are; GDRS (The General Directorate of Rural Services), TEAS (Turkish Electricity Generation & Transmission Co.), irrigation associations and municipalities.

The General Directorate of Rural Services (GDRS) is affiliated to the State Ministry and is responsible for irrigation, aqua-culture and water supply issues in rural areas. It develops small water resources (up to 500 lt/sec) for irrigation and supplies water to rural settlements (interim report). Its main activities are;

a. construction of villages, affiliated settlements and roads in rural areas,
b. construction of domestic water supplies and sewage systems for rural areas,
c. development of small-scale irrigation schemes,
d. electrification of villages,
e. soil protection and erosion control in farm development and the reconfiguration of existing agricultural land usage.

TEAS was established in 1993 by the decision of the Cabinet of Ministers to operate all power plants in Turkey. In Gediz river basin, TEAS is involved with the operation of the Demirkopru Dam for electricity generation. This operation is realized jointly with DSI by considering first the water demands of the irrigation areas fed by Demirkopru. In this mode of operation, priority is given to irrigation water supply and thus, electricity generation at the dam is considered as the secondary purpose of the reservoir.

Non-governmental organizations (NGOs) and public participation. A recently prepared "Guide to Non-Governmental Organizations," based on a sample of 1,793 NGOs identified by the Economic and Social History Foundation of Turkey, states that out of a total of 60,000 voluntary organizations, associations and foundations, only 7% are active in environmental issues. Most are in major cities: 39% in Istanbul, 25% in Ankara and 11% in Izmir; 21% have branches, and 14 % have liaison offices. Most are relatively new, with 62% established after 1991. Most get revenues from membership fees, but only 27% were classified as working for the "public benefit." Environmental NGOs have been particularly successful in raising and addressing issues about coastal zone management, protection of endangered species, erosion, mining, and nuclear energy. Although numerous, the effect of these organizations in helping to improve the environment has been limited. Problems involve relations with the Government, inter-organizational solidarity, mobilization of and relations with members, management structures and procedures, remedial approaches and solutions, relations with the media, finances, technical equipment, and self-assurance.

Irrigation associations are created as a result of the transfer of Operation & Maintenance responsibilities of transfer where the irrigation scheme covers more than one local administrative unit (village or municipality) under municipal law. The transfer agreement requires the approval of the Minister of Energy and Natural Resources while the article of association require the approval of the Cabinet of Ministers. In large schemes composed of two or more hydrological units (e.g., left and right main canals), a separate association is often formed for each segment. The general assembly of the IA is made of muhtars (village headman) and mayors of participating villages and municipalities plus additional members. Selection procedures for additional members differ among regions. They can be selected by muhtars and mayors or directly elected by irrigators. Elected members may be from local assemblies, representatives of farmers' organizations such as the Union of Farmers or the Farmer Protection Organization, or members of the community. In most cases, additional members appear to be selected by muhtars or mayors from among the members of local assemblies (Harmancioglu & Alpaslan (b), 1999).

Municipalities are the local administrations of provinces and districts in the Gediz basin. They use groundwater resources of the basin for domestic water supply and surface waters as the receiving media for disposal of urban discharges. In their administrative regions, they also issue permits for the operation of industrial districts and establishments, evaluate urban water demands and control point discharges from urban settlements. These activities have impacts on the exploitation of basin water resources. Municipalities are also members of IA and thus take part in the decision making process for distribution of irrigation water supply, operation and management of irrigation systems and collection of fees. On the other hand, the political nature of municipalities often dominates their activities, impacting also the IAs so that the latter also develop a political character.

5.3. Legal Aspects (Rules) in Water Allocation

The specified institutions –explained in previous paragraphs- are effective in the basin in the way of applying the rules to several activities. These rules and organizations in other words legal constraints are summarized in Table 5.8 according to the problems.

Each authority applies the rules and controls water allocation under various constraints. On the other hand, the responsibilities interfere with each other, and there is no available regulation that solves the responsibility order among authorities. Another side of the subject is that, an authority issues the fees but the responsibility to collect the fees is another authority's duty.

Table 5.8. Rules in Water Allocation.

Institution	Rules	Activity
DSI	Law No. 167 (Law on groundwaters)	Performs all activities pertaining to the use, protection and investigation of groundwater resources
	Law No. 1050	Defines DSI as the agency responsible for supplying domestic water to urban settlements with populations over 100,000, also involves all activities for development of water treatment facilities.
	Law No. 7478	Provides domestic water supply to villages (transferred to GDRS in 1964)
	Law No. 6200 Article 2	Responsible for master-planning, developing, constructing and operating all elements of an irrigation scheme and transferred to public or private organizations.
Villages	Village Law No. 442	Responsible for master-planning, developing, constructing and operating all elements of an irrigation scheme
Municipalities	Municipality Law No. 1580	Responsible for master-planning, developing, constructing and operating all elements of an irrigation scheme
IAs	Municipality Law No. 1580	Responsible for master-planning, developing, constructing and operating all elements of an irrigation scheme
Cooperatives	Municipality Law No. 1163	Responsible for master-planning, developing, constructing and operating all elements of an irrigation scheme
The Turkish Government	Official Gazette Dated 15.04.1988, numbered 23314	Responsible to protect within the framework of RAMSAR Convention

CHAPTER SIX
ASSESSMENT OF WATER DISTRIBUTION IN THE GEDIZ RIVER BASIN

6.1. Physical System in Water Distribution

The major hydraulic structures in the Gediz Basin include three dams and reservoirs (i.e., Demirkopru, Afsar and Buldan) and three weirs (i.e., Adala, Ahmetli and Emiralem). Water distribution is realized via main canals that divert water from the weirs on the right and left banks for eventual delivery to the secondary and tertiary canals. The farmers specify the amount of water to be distributed in the irrigation schemes on the basis of water demand. Farmers convey information on this demand to the irrigation groups (IGs), by IGs to the irrigation associations (IAs) and through IAs eventually to DSI. DSI compares the water demand with that available in the reservoirs and tries to allocate the required supplies to the irrigation schemes.

There are 7 major irrigation schemes and hundreds of small scale irrigation systems as given in Table 6.1 (Harmancioglu & Alpaslan (b), 1999). These are constructed by DSI, GDRS or public efforts and Figure 6.1 schematizes the structures along Gediz and its tributaries.

Mainly Demirköprü, Afsar and Buldan reservoirs are sources of the irrigation schemes. The allocated amount of water differs due to the presence of drought periods. This amount decreased 50% during the major drought period.

Table 6.1. The Characteristics of Each Irrigation Area in Gediz Basin.

	Irrigation area, (ha)	Main crop
Menemen scheme	22865	Cotton
Manisa scheme	24641	Cotton
Turgutlu scheme	16374	Grape
Adala scheme	18338	Grape-cotton
Alasehir scheme	11806	Grape-cotton
Sarıgol scheme	1927	Grape
Saruhanlı scheme	13702	Cotton
Total	109653	

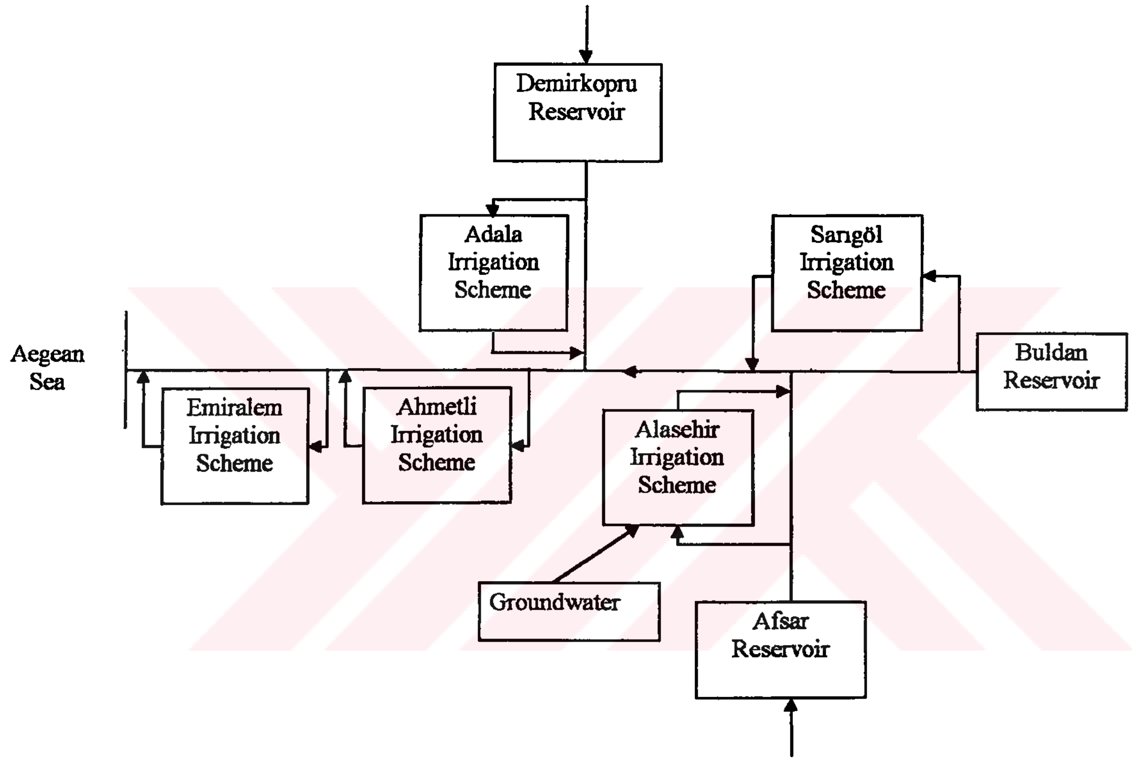


Figure 6.1. Schematic Representation of the Hydraulic Structures Allocating Water to the Major Irrigation Schemes of the Gediz Basin (Harmancioglu & Alpaslan (b), 1999).

Before the drought of 1989-1994, water was issued on a more or less continuous basis to all main and secondary canals for most of the summer. Canal discharges were not fixed, but were varied during the season based on estimates of the actual cropping patterns provided to DSI. However, in response to the very difficult period from 1989-1993, important changes were made in water allocation practices (GDRS/IWMI, 2000).

In recent years, Turkey began an accelerated program of transferring management responsibility for large irrigation systems to locally-controlled organizations in 1993. Within 3 years, the national irrigation agency - DSI, had succeeded in transferring nearly, one million hectares to local government units called "Irrigation Associations". After this formation, in some irrigation schemes, left and right banks are constituted in order to irrigate efficiently. The irrigated areas by these schemes are given in Table 6.2.

Table 6.2. Irrigated Areas in the Gediz Valley (GDRS/IWMI, 2000).

Regulator	Irrigation system	Irrigated area, ha
Alasehir	Alasehir	13,343
Adala	Adala Left Bank	9,237
	Adala Right Bank	9,101
Ahmetli	Ahmetli Left Bank	24,664
	Ahmetli Right Bank	17,951
Emiralem	Menemen Left Bank	16,500
	Menemen Right Bank	6,365
	Others	12,102
Total area		109,263

Note: Irrigated areas the official design areas, not actually irrigated areas.

All main canals, except Adala Right Bank, are concrete lined and trapezoidal in cross section. Secondary canals take off from the main canal at cross-regulators, all of which are vertical sliding gates. In most systems, some tertiary canals also offtake from the main canal, although the majority are offtakes from secondary canals. All secondary canals are lined. Tertiary canal design varies. In order portions of the system, canals are concrete-lined and trapezoidal, but in the newer areas completed in the later 1970s and 1980s, there are many raised parabolic concrete flumes or canalets (GDRS/IWMI, 2000).

The physical characteristics of the existing regulators are given in Table 6.3.

Table 6.3. Existing Regulators in Gediz Basin (Inay, 1999).

Regulator name/ characteristics	Place	Capacity m^3/sec	Operated since	Threshold height, m	Water table level, m
Çömlekci	Çömlekçi	800	1952	44	107,5
Buldan	Asartepe	60	1969	15,5	-
Adala	Adala	50,80	1944	125	117,90
Ahmetli	Ahmetli	46,80	1966	190	67,70
Emiralem	Emiralem	8,6	1944	150	14,95
Marmara	Lake outlet	200	1953	18,5	75,80

In recent studies, the irrigation schemes in the Gediz River Basin are grouped into two major projects as the Lower Gediz and Alasehir in the Gediz basin. The Lower Gediz project covers Menemen, Ahmetli, Akpınar and Adala irrigation schemes whereas the Alasehir project covers Alasehir plains that are fed by Afsar and Buldan reservoirs.

Lower Gediz Project:

A. Menemen Irrigation Scheme: Located within the boundaries of Izmir and covers the whole of Menemen plains. Used for irrigation. Operated since 1944. Fed by Demirkopru and Marmara Lake reservoirs.

B. Adala Irrigation Scheme: Located within the boundaries of the province of Manisa and covers Salihli and Turgutlu plains. Used for irrigation. Operated since 1945. Fed by Demirkopru dam and Adala weir.

C. Ahmetli Irrigation Scheme: Located on Turgutlu, Manisa and Saruhanlı plains. Used for irrigation. Operated since 1962. Fed by the Demirkopru dam.

D. Akpınar Irrigation Scheme: Located close to Marmara lake. Used for irrigation. Operated since 1965.

Alasehir Project:

A. Alasehir Irrigation Scheme: Located on the Alasehir plain. Used for irrigation. Operated since 1979. Fed by Afsar dam. Supported by 72 drilled wells.

B. Sarıgol Irrigation Scheme: Located on the Sarıgol plain over the Buldan creek. Used for irrigation. Operated since 1969. Fed by Buldan dam and reservoir.

Small Scale Irrigation Schemes:

A. Takmak Irrigation Scheme: Located in Esme within the boundaries of the province of Usak. Fed by the Takmak pond and was initiated in 1984. No IAs exist in the system.
B. Ucpınar Irrigation Scheme: Located in Esme. Fed by the Ucpınar pond and was initiated in 1962. No IAs exist in the system.
C. Karaahmetli Irrigation Scheme: Located at the village of Karaahmetli in Esme. Fed by the Karaahmetli pond and was initiated in 1992. No IAs exist in the system.
D. Karaagac Irrigation Scheme: Located at the village of Karaagac within the boundaries of Central Usak. Fed by the Karaagac pond and was initiated in 1993. No IAs exist in the system.

6.2. Institutions Involved (Actors) in Water Distribution

Similar to water allocation practices, DSI plays again the key role in water distribution to the major irrigation schemes in the Gediz river basin. Besides DSI, irrigation associations and irrigation groups also take place in the decision making stage. Since the creation of IAs, water users seem generally satisfied with the service they have received. DSI has benefited to the extent that it does not have to get involved in day-to-day operational decisions at secondary or tertiary level; its role now focused on annual water resource assessment and operation of the reservoir, major regulators and most main canals. IAs operate secondary canals and tertiary headgates and Village Irrigation Committees play whatever role is required to allocate and distribute water at tertiary level. The points of transfer of water from DSI to IAs and from IAs to water users are, by and large, logical and obvious and there is no significant interface in the routine management of the system.

6.3. Legal Aspects (Rules) in Water Distribution

The effective institutions are briefly summarized in section 6.2 due to applied laws and regulations. The applied rules for water distribution activities are summarized in Table 6.4. There is again a problem of proper application of the laws in water distribution.

Table 6.4. Rules in Water Distribution.

Institution	Rules	Activity
DSI	Law No. 167 (Law on groundwaters)	Performs all activities pertaining to the use, protection and investigation of groundwater resources
	Law No. 1050	Defines DSI as the agency responsible for supplying domestic water to urban settlements with populations over 100,000, also involves all activities for development of water treatment facilities.
	Law No. 7478	Provides domestic water supply to villages (transferred to GDRS in 1964)
	Law No. 6200 Article 2	Responsible for master-planning, developing, constructing and operating all elements of an irrigation scheme and transferred to public or private organizations.
IAs	Municipality Law No. 1580	Responsible for master-planning, developing, constructing and operating all elements of an irrigation scheme
	Municipality Law No. 5442	Responsible for master-planning, developing, constructing and operating all elements of an irrigation scheme
	Village Law No. 442	Responsible for master-planning, developing, constructing and operating all elements of an irrigation scheme
	Municipality Law No. 158, Article 138	Identifies the eligibility of associations to process fines and penalities while performing their duties.
IGs	Village Law No. 442	Responsible for master-planning, developing, constructing and operating all elements of an irrigation scheme
	Provincial Local Administration Law No. 5442, Article 56	Allows the chairman of a IG as the village headman (muhtar) and they are the members of the general assembly of IAs.
Municipalities	Municipality Law No. 1580, Article 133	Establishes associations for carrying out such tasks as water distribution and solid waste collection
Ministry of Interior	Laws No. 2886 and 1050	Responsible for reviewing and approving the entire budget of the IA and for periodic reviews of financial accounts submitted by the IA

CHAPTER SEVEN
ASSESSMENT OF WATER QUALITY IN THE GEDIZ BASIN

7.1. Basic principles of Water Quality

Water quality is a neutral term that relates to the composition of water as affected by natural processes and human activities. It depends not only on water's chemical condition, but also on biological, physical and radiological condition. The quality of water also is related to its specific use and usually measured in terms of the concentration of its constituents. The level of water quality and/or pollutant loading is based upon the evaluation of measured quantities and parameters, which then are compared to a set of standards, objectives or criteria. Water quality standards are limits that are established and enforced under state or federal law. Water quality criteria are concentration or quantity loading limits. They are usually determined through scientific research from which a judgment about the quality of the resource can be based (Leeds et al., 2000).

When the quality of a water resource falls below an acceptable level for a particular use, the water may be classified as polluted or contaminated. Pollution and contamination are very similar in meaning and often are used interchangeably. The water is classified as polluted when the concentration of the pollutant exceeds the acceptable standard for a particular use. Water that contains disease-causing or toxic substances is said to be contaminated.

Pollutants affecting water quality may come from point or non-point sources, or a combination of both. Point source pollution is the introduction of an impurity into a surface-water body, like non-point source pollution (Leeds et al., 2000). However, the difference is that the point source impurity enters the water resource at an easily identifiable, distinct location though a direct route. Discharges from point sources of pollution often are continuous and easier to identify and measure compared to non-point source discharges. Because of these properties, point sources are somewhat easier to control, although control measures are usually more expensive compare to non-point source controls. Point source pollutants are usually municipal or industrial wastewater. On the other hand, non-point source pollutants include water washing over the land, agricultural chemicals from farmland and nutrients and toxic materials from urban and suburban areas.

In general pollution sources can be classified as follows and summarized in graphical form in Figure 7.1:

a. Point sources: (1) Domestic discharges; treated or untreated, (2) Industrial discharges; treated or untreated,
b. Non-point sources: (1) Discharge recycled from irrigation, (2) Water washing over the land

Water quality assessment data are available in institutions that are related to water quality. The institutions that make observations, measurements in the river have data over several time intervals and they store data for their own use. Sometimes these data are available for academic researches. On the other hand, available data are often not systematic or scattered. There is a great lack of data. Some data obtained by different organizations are sometimes the same.

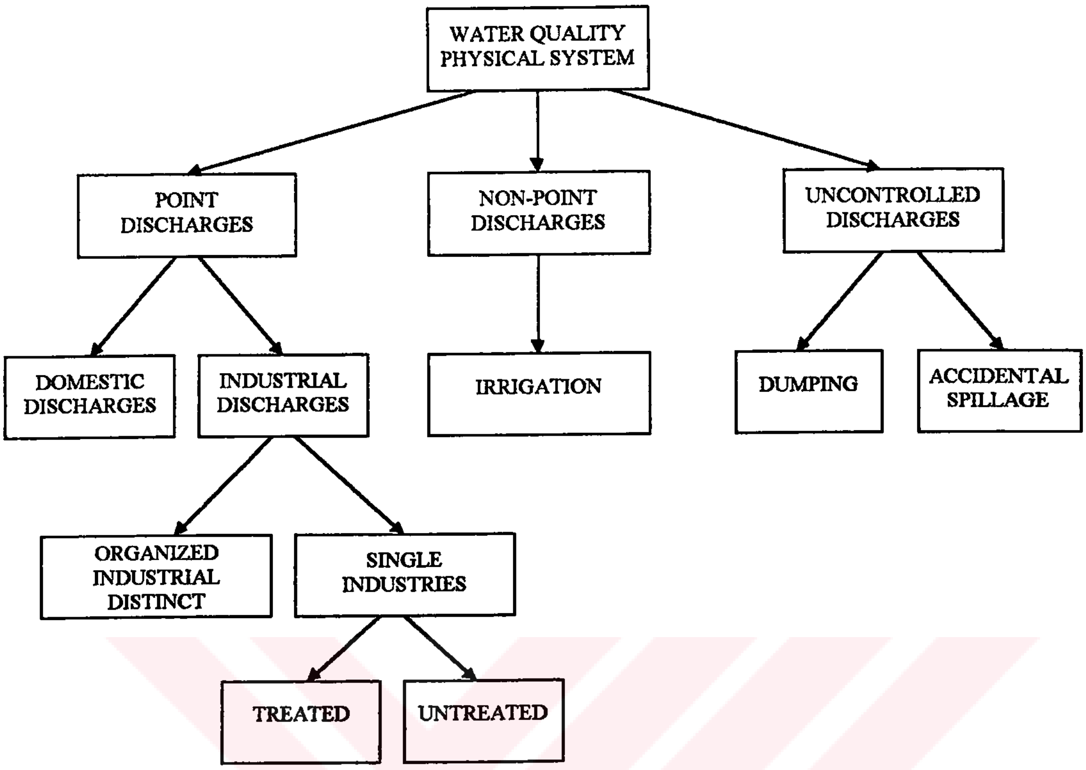


Figure 7.1. Several Pollution Sources.

7.2. Physical System: Water Quality in Gediz River Basin

7.2.1. General

In terms of water quality, it is much more complex to identify the river system. There are a lot of components of water quality. In the identification of the physical system with respect to water quality, the major item is the main discharges to the system. Discharges to the river can be classified into two groups as point and non-point discharges. Point discharges originate from either domestic or industrial sources. Some of these discharges are made to the river after proper treatment whereas in some cases, no treatment is applied to the discharge.

On the other hand, the basic sources of non-point discharges are agricultural practices and land use. Other sources of pollution that degrade the quality of surface waters. include; direct dumping of solid wastes to the river, transport of eroded land, or accidental spillage. In the determination of point discharges, the important issues are; the number of residential areas, and the number of those that have wastewater sewage systems and treatment plants. Similarly for the industries, the same questions are valid. The types of the industries are also important to identify the characteristics of the wastewater discharged from the industry. Determination of non-point discharges is highly difficult. Agricultural practices in a basin contribute to water pollution in the form of non-point discharges. There are two types of non-point discharges: (a) the irrigation return flows which reach the surface waters in a diffused way, (b) the extensive use of agricultural chemicals and fertilizers. Improper use of fertilizers not only leads to water pollution through diffused transport to surface waters but it also degrades the quality of agricultural lands.

Water quality in the Gediz river has been observed by DSI at a number of sites since 1980. These observations started at 6 locations that still continue to operate (with the exception of Baklacı station). In recent years, the number of sampling sites was increased to above 40 for purposes of specific surveys. At present, most of these stations are discontinued, so that the original 6 stations, listed in Table 7.1, have the longest period of observations. At these sites; the parameters that are observed include temperature, pH, electrical conductivity, total dissolved solids, suspended solids, total solids, turbidity, M-Al, P-Al, Cl, organic nitrogen, NH_3-N, NO_2-N, NO_3-N, dissolved oxygen, pV, biochemical oxygen demand, TH, dissolved phosphorus, SO_4, Fe, Mn, Na, K, Ca, Mg, chemical oxygen demand, TKN, phenol, oil, boron, TBI and BMWP.

Table 7.1. Water Quality Sampling Sites Along the Gediz River.

Station No	Station
001	Alaşehir Çayı, Baklacı
002	Gediz Nehri, Urganlı
003	Kum Çayı, Killik
004	Medar Çayı, Medar Köprüsü
005	Gediz Nehri, Muradiye Köprüsü
006	Gediz Nehri, Menemen Köprüsü

The State Hydraulic Works (DSI) observes approximately 35 variables in Gediz. With these collected data, DSI has evaluated the river water quality according to the standard quality classes given in "*Water Pollution Control Regulations - Table 1*", as given in **Appendix A**.

The general situation of the basin shows that: NO_2-N and pH from Group A; BOD, COD and TKN from Group B and Hg, Pb and B from Group C are the characteristic variables of water quality in their group.

In general, NO_2-N and TKN originate from agricultural and domestic; BOD from domestic; COD, Hg, and Pb from industrial sources. B originates from geothermal waste; and pH from high bacteriological activities. The current basin-wide situation of the water quality in the Gediz river basin can be summarized as in Tables 7.2.and 7.3.

Table 7.2. River Water Quality Classes Determined by Bacteriological Parameters.

Region	Quality Classification					
	Group A			Group B		Group C
	NH3-N	NO3-N	NO2-N	COD	TKN	B
Except Nif stream	1st class		3rd or 4th class			
At the discharge points of wastewaters				3rd - 4th class		
Throughout the river						Rather effective in river water quality

Table 7.3. River Water Quality Classes Determined According to Physical and Inorganic Chemical Parameters, Organic Parameters and Inorganic Pollution Parameters.

Streams	Quality Classification		
	A	B	C
On Deliiniş - Selendi streams		1st class	
On Demirci - Gediz streams	4th class		
Throughout the whole river			Hg, Pb, B are in very high conc.
Demirköprü dam lake exit	No change in conc. of pH, NO_2-N	Improvement in conc. according to the entrance of dam lake.	
Before Alaşehir and Gediz junction	No change in concentration	BOD - 3rd class	Boron - 4th class
In the upstream of Alaşehir stream	4th class in all parameter groups; this is due to agricultural activities, fertilizer and pesticides and domestic wastewater discharge		
After Alaşehir stream junction	NO_2-N - 3rd class		Boron - 4th class
Near Turgutlu region		Negative change in BOD. COD - 3rd class	
On Gördes stream	All of them are in 3rd class. This is to the domestic wastewater discharge of Gördes village, carpet-weaving and mine beds		
On Medar stream	pH - 3rd class	Domestic wastewater - 2nd class	
After junction of Medar and Gördes streams	4th class	3rd class	4th class
On Nif stream	NO2-N - 3rd class	2nd class	
After Kemalpaşa	All of them are in 4th class. This is due to industrial and domestic wastewaters.		
After Nif junction	4th class		
Before sea		3rd class	

7.2.2. Point Discharges

Domestic Water Pollution

In general, the volume of domestic wastewater can be taken as approximately equal to the volume of domestic potable water consumption (wastewater flows are sometimes estimated as a large fraction, for example, 80% of the domestic water consumption, to take into account water lost through watering of gardens, leaks from the sewer, etc.) The domestic water consumption was seen to be on the order of 50 m^3/ca.year in urban areas and higher in rural areas (IOW, 1999).

Domestic pollution loads are normally estimated by multiplying the population figures by Per capita pollution loads. In the Aegean region, the estimated Per capita pollution loads used by public administrations (Provincial Bank) are as follows:

BOD_5	54-60 g/ca.d
SS	90 g/ca.d
Total N	10 g/ca.d
Total P	3 g/ca.d

Estimated by capita pollution loads used by the Consultancy is;

BOD_5	50 g/ca.d
SS	90 g/ca.d

In the basin, 4 provinces exist, including Manisa with its 13 district centers, Izmir with its 4 district centers, Kutahya and Usak. There are 19 settlements in the basin with a population of 1,350,000 as of 1997. Among these residential areas, only three have completed wastewater sewage systems and treatment plants. As given in Table 7.4, in some settlements, sewage systems and treatment facilities are either in the Planning/project, or construction phase. The remaining settlements either have a sewage system that discharges into the surface waters without any treatment or they do not have a sewage system at all.

The long-term observation of populations of each residential area is obtained from State Statistical Institute so that it is possible to see the increasing population ratio through 1965 to 1997 as given in Table 7.5.

Table 7.4. Infrastructure Systems Available in the Basin (Manisa PDoMoE (c), 1999).

Municipality	Area (ha)	Drinking Water System	Sewage System
MANİSA			
Aşağıçobanisa	241	Satisfactory	Satisfactory
Hacıhaliller		Project	-
Hamzabeyli	250	Programmed	Satisfactory
Karaağaçlı	219	Satisfactory	Construction Phase
Karaoglanlı	135	Programmed	Not Satisfactory
Muradiye	278	Satisfactory	Satisfactory
Sancaklıbozköy	363	Programmed	Not Satisfactory
Sancaklıiğdecik	126	Programmed	-
Selimşahlar		Programmed	-
AHMETLİ	460	Satisfactory	Projected
Gökkaya	194	Satisfactory	-
AKHİSAR	3850	Satisfactory	Satisfactory
Akselendi	491	Programmed	Projected
Ballıca	491	Projected	Not Satisfactory
Beyoba	466	Satisfactory	Satisfactory
Dağdere	208	Study	-
Kayalıoğlu	320	Programmed	Projected
Mecidiye	879	Satisfactory	Not Satisfactory
Medar	447	Satisfactory	-
Süleymanlı	203	Satisfactory	Satisfactory
Zeytinliova	124	Programmed	Not Satisfactory
ALAŞEHİR	1152	Satisfactory	Satisfactory
Kavaklıdere	362	Programmed	-
Kemaliye	625	Programmed	Satisfactory
Killik	193	Satisfactory	Satisfactory
Piyadeler	379	Satisfactory	-
Uluderbent	133	Satisfactory	Construction Phase
Yeşilyurt	383	Satisfactory	Satisfactory
DEMİRCİ	655	Satisfactory	-
Borlu	496	Satisfactory	Not Satisfactory
İcikler	250	Programmed	Not Satisfactory
GÖLMARMARA	473	Satisfactory	Projected
GÖRDES	330	Programmed	Not Satisfactory
Güneşli	554	Satisfactory	Satisfactory
Kayacık	61	Programmed	Satisfactory

Table 7.4. (Continued).

KIRKAĞAÇ	598	Satisfactory	Projected
Bakır	274	Satisfactory	Satisfactory
Gelenbe	378	Study	Not Satisfactory
İlyaslar	380	Satisfactory	Satisfactory
Karakurt	250	Satisfactory	Not Satisfactory
KÖPRÜBASI	510	Projected	Not Satisfactory
KULA	430	Satisfactory	Projected
Gökçeören	161	Satisfactory	Satisfactory
Sandal		Satisfactory	-
SALİHLİ	1600	Satisfactory	Projected
Adala	660	Satisfactory	Satisfactory
Durasallı	689	Satisfactory	Satisfactory
Gökeyüp	200	Satisfactory	Not Satisfactory
Poyrazdamları		Projected	Not Satisfactory
Sartmahmut	234	Programmed	-
Taytan		Projected	Not Satisfactory
Yılmaz	250	Programmed	Satisfactory
SARIGÖL	753	Programmed	Satisfactory
SARUHANLI	313	Satisfactory	Projected
Alibeyli	392	Projected	Satisfactory
Büyükbelen	454	Projected	Satisfactory
Dilek		Programmed	Not Satisfactory
Gökçeköy	170	Satisfactory	Not Satisfactory
Gümülceli	207	Study	Construction Phase
Hacırahmanlı	192	Programmed	-
Halitpaşa	230	Programmed	Satisfactory
İshakçelebi	553	Satisfactory	-
Koldere	200	Satisfactory	Not Satisfactory
Kumkuyucak	248	Projected	Satisfactory
Mütevelli	566	Projected	Satisfactory
Nuriye	412	Study	-
Paşaköy	390	Projected	Satisfactory
SELENDİ	560	Satisfactory	Not Satisfactory
SOMA	1000	Projected	Programmed
Andan		Satisfactory	-
Cinge	Founded in 1995		
Turgutalp	288	Satisfactory	Not Satisfactory
Yağcıllı	217	Satisfactory	Satisfactory
TURGUTLU	2100	Satisfactory	Satisfactory
Derbent	250	Satisfactory	-
Urganlı	221	Satisfactory	Satisfactory

Table 7.5. Gediz Basin Population Between 1965-1997 (Boyacıoglu, 2000).

	District	1965	1970	1975	1980	1985	1990	1997
İZMİR	Foça	11793	11784	13185	16505	19197	25222	33061
	Kemalpaşa	35025	35710	38706	43489	49175	56075	67223
	Menemen	68523	66739	68476	79623	62915	76043	99325
	Aliağa					33272	42150	52968
MANİSA	Merkez	123442	128031	139370	158982	184452	221694	259621
	Akhisar	121230	129132	139341	146444	159388	152397	152404
	Ahmetli						19194	18666
	Alaşehir	57013	64835	69938	74943	82593	91362	98122
	Demirci	42485	47323	51069	53187	58168	60184	70767
	Gördes	37524	40337	42314	45526	49314	40399	37908
	Gölmarmara						18524	16997
	Kırkağaç	30879	34421	36392	40512	43385	45608	47315
	Köprübaşı						12182	11602
	Kula	34449	36320	39982	41546	45531	48132	48809
	Salihli	87766	94099	103402	111288	125957	134854	143016
	Sarıgöl	24292	27281	28895	30530	32907	34682	34721
	Saruhanlı	58723	58880	65376	64427	70277	72093	65129
	Selendi	19669	21144	22411	24019	25779	25415	25376
	Soma	39104	43797	45523	53739	63938	76641	86788
	Turgutlu	71970	80050	88362	96798	108441	101057	114774
KÜTAHYA	Gediz	58625	66951	65097	68243	74370	66675	76796
USAK	Merkez	69593	80283	96394	110255	128378	145505	165615
	Eşme	36779	39213	38616	38756	42343	39658	41622

In the basin, domestic point loads are examined as inputs from each residential area such as ; Foça, Kemalpaşa, Menemen, Aliağa, Manisa centrum, Akhisar, Ahmetli, Alaşehir, Demirci, Gördes, Gölmarmara, Kırkağaç, Köprübaşı, Kula, Salihli, Sarıgöl, Saruhanlı, Selendi, Soma, Turgutlu, Gediz and Eşme. These places discharge domestic wastewater into the Gediz River or its different tributaries that are schematically shown at Figure 7.2.

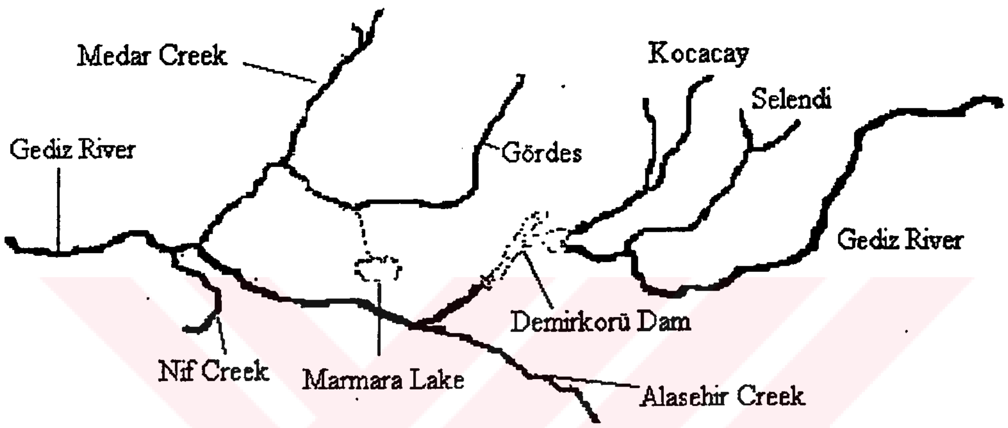


Figure 7.2. Gediz River and Tributaries.

In this study, Gediz Basin is divided into six segments according to discharge points and calculations are made for this condition as given in Table 7.6 and Figure 7.3.

Table 7.6. River Segments.

SEGMENTS AND DISTRICTS					
I	II	III	IV	V	VI
SELENDI	ALASEHIR	MIDDLE GEDIZ	MEDAR	NIF	GEDIZ
Usak province	Sarigol	Ahmetli	Köprübasi	Kemalpasa	Manisa province
Esme	Alasehir		Gördes	Turgutlu	Aliaga
Gediz	Salihli		Gölmarmara		Menemen
Selendi			Akhisar		Foca
Kula			Soma		Muradiye
Demirci			Kirkagac		Karaagacli
			Saruhanli		Cobanisa

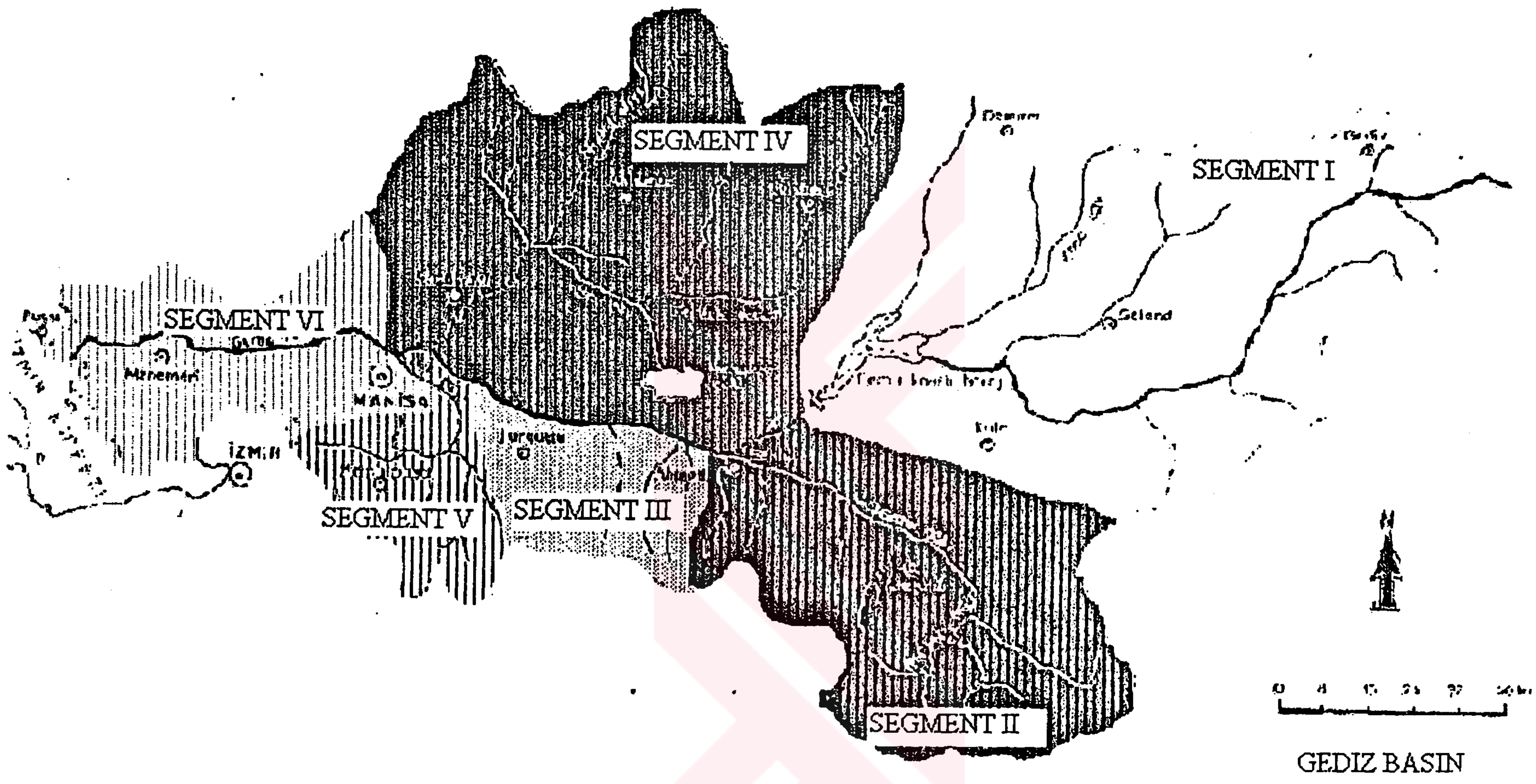


Figure 7.3. Segments in Gediz River Basin.

Industrial Water Pollution

In general, industrial pollution comes from two main sources; (a) various types of individual industries, and (b) organized districts. There are great numbers of individual industries in the basin but these industries are generally small-scale industries. They generally discharge their effluent to Gediz river either treated or untreated. Control of discharge of these industries is the responsibility of Provincial Directorate of the Ministry of Environment (PDMoE). Organized Industrial Districts (OID) are the regions that include various types of industries in a particular area and have a common treatment plant. Ministry of Industry supports OIDs, so that several residential areas are volunteer to have an OID. In the Gediz basin, there are OIDs besides districts that are under planning or construction.

Industries discharge wastewater in the form of different characteristics, so that different types of effects are imposed on river water quality. In domestic wastewater, the major water quality component is organic loading measured in terms of BOD or COD. On the other hand, in industrial wastewater, the major water quality components are toxic material, hazardous matter, color, high particular matter, pH, etc. Consequently, domestic discharges, dissolved oxygen consumption due to organic matter consumption and result of these processes lead to several fish deaths in aquatic life but the effect of industrial discharges are variable and difficult to estimate. Because of conservative characteristics of industrial wastewater, there is a risk of accumulation. Dissolved-oxygen sag curve of Streeter-Phelps is invalid in the presence of such industrial discharges.

Industry uses large volumes of water in its manufacturing processes and in supporting operations. Indeed, the production of foodstuffs, metals, chemicals and other basic commodities calls for a tonnage of water that far exceeds the combined tonnage of other raw materials. Finishing operations generally draw appreciable quantities of water; fabrication and assembly are satisfied with relatively small amounts. Not much of the water entering industrial works actually becomes part of the manufactured product and only a small fraction is otherwise consumed or lost by evaporation. The larger fraction is employed nonconsumptively. It becomes waste water and may contain many pollutants.

As industries have grown in size and diversity, in climatic and hydrological distribution and in awareness of community, regional and national responsibility, water supply and wastewater disposal have become increasingly more important elements in the selection of industrial sites and in the development of industrial operations (Fair et al., 1968).

Industrial polluting sources in the Gediz basin can be classified into four groups:

a. organized industrial districts, where wastewaters are collected and eventually treated,
b. industries that use their own treatment facilities,
c. industries that discharge directly into the river without any prior treatment,
d. industries that are dispersed within settlements and that discharge into the sewage systems of these settlements.

Besides wastewater discharge of industries, the amount of water used in the process is also important. The amount of water supplied by municipal agencies to industries for process purposes is highly variable. Large water-using industries such as canneries, chemical plants and refineries usually have their own supply and are not dependent on public agencies. Other industries such as those involved in "high-technology", which have more modest process water requirements, may depend totally a municipal supplies. Range of flowrates can be calculated in terms of gallons per tons of product processed or m^3 of wastewater per kg of product. Typical data are presented in Table 7.7.

Table 7.7. General characteristics of various industries (Fair et al., 1968).

<table>
<tr><th colspan="2">Industries</th><th>Typical wastewater production</th><th colspan="3">General characteristics and typical values of wastewater</th></tr>
<tr><td colspan="2">Leather</td><td>8-12 gal/lb product</td><td>1000 mg/l BOD
800 mg/l TS
60 mg/l NH_4-N</td><td colspan="2">High total solids, organic matter, salinity, alkalinity, lime, sulfur, H_2S,Cr, pH=9-10</td></tr>
<tr><td rowspan="2">Paper</td><td>Pulp</td><td>60000 gal/ton product</td><td>443 mg/l BOD</td><td colspan="2">Carbonate, oil and grease, high suspended and dissolved solids, paints, sodium sulfide</td></tr>
<tr><td>Paper</td><td>42000 gal/ton product</td><td>22 mg/l BOD</td><td colspan="2"></td></tr>
<tr><td rowspan="2">Textile</td><td>Cotton</td><td></td><td>200-800 mg/l BOD</td><td colspan="2">Organic matter, high pH, toxic matter, solids, oil and grease, H_2S, sulfur, detergent, soap, dye, high ss, organic acids</td></tr>
<tr><td>Wool</td><td>0,7 kg/kg wool</td><td>5000-14000 mg/l BOD</td><td colspan="2"></td></tr>
<tr><td colspan="2">Chemistry</td><td></td><td>10000 mg/l BOD</td><td colspan="2">Low pH, low organic matter</td></tr>
<tr><td colspan="2">Food</td><td></td><td>2000 mg/l BOD</td><td colspan="2">High ss, colloidal and dissolved organic matter</td></tr>
<tr><td colspan="2" rowspan="3">Metal</td><td>1024 billion gal/year (process)</td><td>53-125 mg/l BOD</td><td>Containers</td><td>Dissolved heavy metals, metal salts, phosphates, chromate, oil, solvents</td></tr>
<tr><td>4486 billion gal/year (cooling)</td><td>89 mg/l TS</td><td>Plating</td><td>Acidic or alkali, chromium, cyanide, metals</td></tr>
<tr><td></td><td></td><td colspan="2">Toxicity, low org matter, oil-grease</td></tr>
<tr><td colspan="2">Ferment</td><td></td><td></td><td colspan="2">High ss and COD, total N,P, organic matter</td></tr>
<tr><td colspan="2">Cannery</td><td></td><td>2100 mg/l BOD</td><td colspan="2">High organic content</td></tr>
<tr><td colspan="2">Fuel oil</td><td></td><td>18500 mg/l BOD</td><td colspan="2"></td></tr>
<tr><td colspan="2">Paint</td><td></td><td>6300 mg/l BOD</td><td colspan="2"></td></tr>
<tr><td colspan="2">Soft drinks</td><td>13000 gal/ 1000 cases</td><td>430 mg/l BOD</td><td colspan="2">pH= 10,8</td></tr>
<tr><td colspan="2">Petrochemicals</td><td></td><td></td><td colspan="2">High COD, high TDS, high COD/BOD ratio, compounds inhibitory to biological treatment</td></tr>
<tr><td colspan="2">Slaughterhouse</td><td>359 gal/ Per animal</td><td>929 mg/l SS
324 mg/l org N
2240 mg/l BOD</td><td colspan="2">Deep reddish-brown color, high BOD, considerable amount of suspended material, blood is highly nitrogenous</td></tr>
<tr><td colspan="2">Dairy</td><td></td><td>1890 mg/l BOD</td><td colspan="2">Neutral or slightly alkaline, low pH, very little suspended material</td></tr>
<tr><td colspan="2">Sugar</td><td>660 gal/ ton beets</td><td>1230 mg/l BOD
2220 mg/l TS</td><td colspan="2"></td></tr>
</table>

In a feasibility study done with French government on Aegean rivers, typical characteristics of each type of industry is stated in a more detailed table as given in Table 7.8.

Table 7.8. Typical characteristics of each type of industry (IOW, 1999).

Type of industry		Characteristic	Volume of effluent, m^3/char.	Pollution Load (kg/char. Unit)				Average Conc. of effluent (mg/l)			
				COD	BOD	SS	H. metal	COD	BOD	SS	H. metal
Maltery	2	Tons of barley	3.6						1600	220	
	1	m^3 of beer	4.5		1.1	0.2			240	40	
Brewery	2	hl of beer	1.5						611	303	
	1	m^3 of beer	14.5		15.5	7			10700	4800	
Slaughterhouse											
Poultry	2	1000 poultries	18						750	620	
	1	1000 poultries	37.5	22.4	11.9	12.7		600	320	340	
	3	Tons of poultries	8	21	9	4.5		2620	1100	560	
Beef	2	Head of livestock	1.5						1000	820	
	1	Tons of livestock	5.3		6.4	5.2			1200	1000	
	3	Tons of livestock	8	32	13	12		4000	1620	1500	
Pork	2	Head of livestock	0.5						1050	720	
	1	Tons of livestock	5.3		6.4	5.2			1200	1000	
	3	Tons of livestock	8	27	13	9		3400	1620	1100	
Food											
Olive oil	1	Tons of oil	0.5	59	7.5	33		118000	15000	66000	
Vegetable oil reining	1	Tons of oil	57.5	21	12.9	16.4		370	220	280	
Milk factory	2	m^3 of milk	1.75						3000		
	1	m^3 of milk	2.42	9.2	5.3	2.2		3800	2200	900	
	3	m^3 of milk	4						500	120	
Non-alcoholic drinks	1	m^3 of products	4.3		2.15	0.73			500	170	
Fruits.	2	Tons of products	1.5						800	600	
	1	Tons of products	11.3		12.5	4.3			1100	380	
	3	Tons of products	30	23				770			
Grain mill	1	Tons of products	0.6		1.1	1.6			1800	2700	
Leather	2	Tons of hides	100						650	500	
	1	Tons of hides	52	258	89	138	Cr 3.5	5000	1700	2600	Cr 67
	3	Tons of hides	70	225		110	Cr 2.5	3200		1600	Cr 36
Textile, cotton	1	Tons of products	317		155	70			490	220	
	3	Tons of products	100	100	30	200		1000	300	200	
Paper mills	2	Tons of paper	55		14	19.7			250	360	
	1	Tons of paper	54		8	23			150	430	
	3	Tons of paper	20		5	15			250	750	
Cement	1	Tons of products	5.1			0.9				180	
Motor vehicle	1	Tons of iron sheet painted	55	82	19,3	8,3	Zn 0,44 Cr 0,13 P 0,02	1500	350	150	Zn 0,008 Cr 0,002 P 0,0004

1: WHO, 2: Les eaux residuaires industrielles – MASSON – 1977, 3: Memento technique de l'eau – DEGREMONT – 1989.

Because industrial water use varies widely, it is therefore desirable in practical design work to inspect the plant concerned and to make careful estimates of the quantities of both water used from all sources and the wastes produced.

Industrial wastewater flowrates vary with the type and size of the facility, the degree of water reuse and the onsite wastewater treatment methods, if any. Extremely high peak flowrates may be reduced by the use of detention tanks and equalization basins Typical design values for estimating the flows from industrial areas that have no or little wet-process type industries are 9 to 14 m^3/ha.d for light industrial developments and 14 to 28 m^3/ha.d for medium industrial developments.

According to Water Quality Control Regulation (WQCR), there are discharge standards for various industries as given in Table 7.9.

Table 7.9. Discharge standards of various industries (Water Quality Control Regulation, 1988).

Sector		BOD mg/l	COD mg/l	SS mg/l	Oil and grease, mg/l	pH
Olive			250		60	6-9
Textile	Cotton	90	250	160		
	Wool	200	400	400		
Leather		150	250	200		6-9
Soft drinks		50	160			6-9
Alcohol		40	300		60	
Dairy		50	170	100	30	
Slaughterhouse		40	200	70		
Metal excluding iron			80			
Petroleum		100	400	80		
Paper	Scrap paper	270	870	50		
	Cellulose	300	800			

Industries take support from Environmental Pollution Protection Fund for treatment plant construction and management. Environmental Pollution Protection Fund has been established in order to protect environmental pollution and improve the environment. For this reason, 45% of the needed capital is supported with an credit having a fixed term of maximum 20 years by Environmental Pollution Protection Fund. Facilities have the opportunity to get electricity cheaper for the treatment plants (Barbaros, F., 2000).

Provinces, municipalities and non-governmental organizations force existing industries to have treatment plants. Unless an industry constructs a treatment plant, facility takes the license of an unhealthy plant so that, all these formations forces facilities to have a treatment plant. In recent years most industries have treatment plants. The industries that have treatment plants are given briefly in further sections.

On the other hand, there are existing OIDs and some districts are on planning stage. OIDs are the regions that have small and big scale industries including tradesman sites, small industrial districts and establishments that makes production in the form of cooperatives and have a common wastewater collection systems and treatment plant. Besides OIDs of mixed type of industries, there are districts of specialized industry such as tannery, shoemaker, forestry organized industrial districts, etc.

Small industrial districts generally consist of repairment workshops, where organized districts consist of big-scale industries. In OIDs, there is a planned sewer system and a treatment plant. In spite of a common treatment plant, each industry can have a pretreatment plant in its own facility.

In Gediz basin, there are 3 OIDs; Manisa and Kemalpaşa Organized Districts and Menemen Leather Organized Industrial Districts.

Kemalpaşa industrial region, containing approximately 110 industries in 1990, had been formed as an organized district in 1994. District starts from Belkahve and continues through Kemalpaşa highway. Today, the district includes 193 industries on an 1200 ha area. Among these industries, 130 of them are working. Sectoral distribution is as in Table 7.10 (Karadağ, 1999) .

Table 7.10. Sectors in Kemalpaşa OID.

Sector type	%
Food	28,5
Machine + Metal	20,3
Chemistry	18,6
Textile	10,0
Paper and packaging	5,0
Construction material	8,0

Manisa OID is consists of two sections. The first section has 65 industries and has a wastewater of 152 096 m^3/month (5069.8 m^3/d). This section has a treatment plant constructed in 1993 and treated wastewater discharges to Gediz river by Karaçay creek. Treatment capacity is 6500 m^3/d. The establishment dates, type of industries, number of employee and total wastewater of each industry in Section I of Manisa OID is given in Table 7.11.

Table 7.11. Data of industries in Manisa OID Section I (Manisa PDMoE (a), 1999).

Date	Sector type	# of employee	Total wastewater, m^3/year
1970	Valve industry	440	31804
1971	Textile	397	58993
1971	Textile	49	5867
1972	Packaging	164	2561
1973	Feed production	36	5224
1973	Nasa Construction	48	8903
1974	Casting mold	153	76851
1976	Machinery	45	3788
1976	Furniture	9	1160
1976	Sunflower oil		2166
1976	Sponge production		4063
1976	Plastics	90	8897
1976	Mold manufacturing	8	698
1977	Press machinery	171	42809
1977	Chemistry		5560
1977	Hydrolics	234	58163
1978	Slaughterhouse	729	50849
1978	Electronics	10	866
1978	Hydrolics	170	13428
1978	Forestry		4565
1978	Forestry	280	12642
1979	Automative	134	13374
1981	Sunflower oil	63	10945

Table 7.11. (Continued).

1981	Plastics	26	1401
1981	Steel casting	250	16008
1981	Steel production	73	10788
1982	Pressurized containers	425	55825
1982	Plastics		6413
1982	Plastics		107910
1982	Plastics	683	14968
1982	Ceramics	60	2264
1983	Machinery	80	47837
1983	Constr. Materials	20	11367
1983	Food	65	3460
1984	Leather textile	19	742
1984	Food		
1985	Food		
1985	Acumulator		
1985	Electronics	3364	91847
1985	Electronics		10983
1986	Textile		17031
1986	Packaging		2583
1986	Valve industry	23	21
1987	Natural rubber manuf.	50	2828
1988	Casting mold	138	128886
1988	Packaging	311	5903
1988	Electronics	175	11731
1989	Packaging	16	1339
1989	Packaging		39959
1990	Elsan raw material	811	233411
1990	Textile	432	60742
1990	Valve industry	160	76851
1991	Radiator	20	4219
1991	Cable manuf.	122	27829
1992	Food		5651
1993	Electronics		9379
1994	Electronics		
1994	Türk Tecim		3115
1996	Paper	209	18032
1996	Textile		
1997	Elba Jant	36	7703
1997	Packaging		
1997	Textile	75	2660
1997	Machinery		3840
	Aligaz industry		

Section II is smaller than Section I. There are 19 industries. Section II has wastewater of 103 983 m^3/month (3466.1 m^3/d). 2107.8 m3/d of wastewater is discharged to Gediz River after pretreatment. The rest of the wastewater is discharged without any treatment. The construction of treatment plant of 15000 m3/d capacity has been started. Available data about industries in Section II is given in Table 7.12.

Table 7.12. Data of industries in Manisa OID Section II (Manisa PDMoE (a), 1999).

Date	Sector type	# of employee	Total wastewater, m^3/year
1985	Cement	29	
1990	Merloni Elettrodo.	372	148758
1991	Paper	101	425592
1991	Heating	487	92520
1992	Rim manufacturing	135	128249
1992	Radiator manuf.	74	1391
1996	Electronics	66	45870
1996	Paper	8	1489
1996	Acumulator	336	319736
1997	Rim manufacturing	723	97466
1997	Packaging		8565
1997	Metal	48	15349
1997	Electronics		49948
	Sunflower oil		60231
	Metal		36057
	String manufacturing		
	Industrial gases		3362
	Forestry		159
	Packaging		

In Segment I, there are 40 individual industries according to available data. Most of these industries are small-scale factories. Again most of them have no treatment facility; they have septic tanks. The main sector in the segment is machine carpet manufacturing. Industries discharge either to septic tanks or to sewage systems. Because the existing industries are small-scale or are not discharging wastewater in specific amounts, it can be said that there is not an effective industrial pollution in the Segment I. Thus, the main pollution source of the segment is residential areas, in other words, domestic loads. Available data given in Table 7.13 includes only the residential areas; Demirci, Kula and Demirci.

Table 7.13. Available industrial data for Segment I (Manisa PDMoE (b), 1999).

Sector type	Village	# of ind.s	Q(m3/d)	Wastewater discharge Location
Flour production	Demirci	1		Septic tank
Mach. Carpet Man.	Demirci	16		
String manufacturing	Demirci	8		
Dairy products	Demirci	1		
Flour production	Kula	2		Septic tank
Dairy farm	Kula	3		Septic tank
Wool washing	Kula	1		Septic tank
Textile	Kula	1		Septic tank
Mineral water	Kula	1		to the field
Tannery	Kula	1		Leakage
Roast.chickpea man	Selendi	2		Sewage system
Candy man.	Selendi	1		Sewage system
Dairy farm	Selendi	2		Sewage system
TOTAL		40		

In Segment II, the main industrial sectors are clay-roofing tire – bricks manufacturing and tanneries. Except for only one recorded alcohol industry, the other 90 industries have no treatment plants. Alaşehir Tekel Suma alcohol industry has a treatment plant and their discharging wastewater characteristics reach the discharge standards (40 mg/l BOD, 300 mg/l COD). A few of the industries have no data of wastewater discharge location. The missing flowrate data are estimated for the industries by considering the available data of similar industries. There are 28 brick industries but they have no data of wastewater flowrate, but even if there is, it will not be an effective value in the total figure of flowrate because brick factories do not have a great amount of wastewater. The biggest portion belongs to tanneries. There are 24 tanneries having a flowrate of 600 m3/d wastewater flowrate. Table 7.14 summarizes the available data about Segment II.

Table 7.14. Available industrial data for Segment II (Manisa PDMoE (b), 1999).

Sector type	Village	# of ind.s	Q (m3/d)	Wastewater disch.	Discharge standards		Calculated load(g/d)	
				Location	BOD(mg/l)	COD(mg/l)	BOD	COD
Slaughterhouse	Salihli	1	40	Gediz river				
Flour man.	Salihli	3		DSI channels				
Cannery	Salihli	1	100*	Gediz river				
Grape processing	Salihli	1	100	Gediz river				
Bonito industry	Salihli	2	150*	Gümüş stream				
Concrete	Salihli	1		Tabak stream				
Soft drinks	Salihli	1		Mun. Sewage sys.				
	Salihli	1		Septic tank				
Mineral water	Salihli	1	50*	Kurşunlu stream				
	Salihli	1	50*	Çakallar stream				
Salt	Salihli	1		Sewage system				
	Salihli	1		Mun.sewage sys.				
	Salihli	1						
Plastic pipe	Salihli	2						
Oxygen etc.	Salihli	1		Mun.sewage sys.				
Asphalt	Salihli	1	50*	Tabak stream				
Olive oil	Salihli	2	20*					
Bricks	Salihli	28						
Tannery	Salihli	34	600	Gediz river				
Hot spring	Salihli	1	150	to a stream				
Olive oil	Alaşehir	2	20*	Natural system				
Dairy farm	Alaşehir	1	10*	Natural system				
	Alaşehir	1		Sewage system				
Grape processing	Alaşehir	1	50	Sewage system				
Alcohol	Alaşehir	1	350	stream, has a TP	40	300	14000	105000
TOTAL		91	1740					

(1690 m3/d to the river, 50 m3/d to the sewage system)

*: estimated by considering the available data.

In Segment III, there are no records of industries, their flowrates or wastewater characteristics. Industrial development in this region is lower than other regions. Therefore, there is no information of industries in this segment. Only Ahmetli village is in this segment. In this segment, there is only domestic pollution according to available data.

In the Segment IV, there are 98 recorded industries. 46 of these industries are olive oil manufacturing factories. Most of the industries in this segment are in food sector such as dairy, cheese, cannery, grape processing, tomato paste manufacturing, etc. Available data about Segment IV is given in Table 7.15.

Table 7.15. Available industrial data for Segment IV (Manisa PDMoE (b), 1999).

Sector type	Village	# of ind.s	Q (m3/d)	Wastewater Discharge Location
Olive oil	Kırkağaç	3	5*	to the road
	Kırkağaç	2	10*	to a stream
Dairy farm	Kırkağaç	1	10*	to a stream
	Kırkağaç	1	10*	Gelenbe stream
Olive oil manuf.	Kırkağaç	1		agricultural field
Dairy farm	Kırkağaç	2	15*	to the road
Olive oil manuf.	Kırkağaç	1		sewage system
Cologne	Kırkağaç	3		sewage system
Tomato paste	Kırkağaç	4		sewage system
Cheese man.	Kırkağaç	1		sewage system
Olive oil manuf.	Kırkağaç	1		sewage system
Carpet	Gördes	1	12	to a stream
Dairy products	Soma	1		septic tank
	Soma	7		sewage system
Olive oil	Soma	5		sewage system
	Soma	3		septic tank
Olive production	Soma	1		Mun. Sewage system
Olive oil	Soma	2		septic tank
	Soma	3		sewage system
Electric cable	Soma	1	160	Bakırçay stream
Coal	Soma	2		Bakırçay stream
	Soma	1		ELI pools
Chemistry	Soma	1		
Textile	Gölmarmara	1		Gördes stream
String manuf.	Gölmarmara	2		
Dairy products	Saruhanlı	1	10	resting pools
Cannery	Saruhanlı	1	80	DSI channels
Grape processing	Saruhanlı	1	10	resting pools
Cotton	Saruhanlı	1		

Table 7.15. (Continued).

Grape processing	Saruhanlı	1		resting pools+DSI
String manuf.	Saruhanlı	1		
Dairy farm	Saruhanlı	1	5	Gediz river
Clay roof tire,bricks	Saruhanlı	1		
Soft drinks	Saruhanlı	1		
Agricultural machines	Saruhanlı	2		
Mech. Jack machine	Saruhanlı	1		
Plastic	Saruhanlı	3		
Wood	Saruhanlı	3		
Metal	Saruhanlı	3		
Leather	Saruhanlı	1		
Cannery	Saruhanlı	1	200	Gürle stream
Flour	Saruhanlı	3		
Cheese	Saruhanlı	2		
Olive oil manuf.	Saruhanlı	2	10*	
Chichen	Saruhanlı	1	140	Gürdük stream
Olive processing	Saruhanlı	1		septic tank
	Saruhanlı	3	30*	Medar creek
	Saruhanlı	2		
	Saruhanlı	1	10*	Bekirler stream
	Saruhanlı	3		sewage system
	Saruhanlı	1	10*	to a stream
	Saruhanlı	1		field
Olive oil	Saruhanlı	1	10*	Bekirler stream
	Saruhanlı	1	10*	Medar creek
Olive processing	Saruhanlı	1		DSI channels
Dairy products	Saruhanlı	1	10*	Medar creek
TOTAL		98	757	

(657 m3/d of ww goes to the river)

*: estimated by considering the available data.

The highly polluted segment of the Gediz river is in Segment V. Besides individual industries and residential areas, there is an OID in Kemalpasa. In a study done in Kemalpasa Governorship Environmental Protection Unit, some data are obtained about the pollution sources in Nif creek as given Tables 7.16 and 7.17 and available data shows that there are 88 industries in the segment within the borders of Kemalpasa and Turgutlu. Especially in Turgutlu, there are great numbers of brick factories but there are no recorded data about these industries. On the other hand, there is not so much wastewater discharge from these brick factories, except their domestic wastewater discharge.

Environmental Protection Unit staff requires that an industry that has a flowrate of 10 m3/d should have a treatment plant so that, approximately every industry must have a treatment plant. Most of them have treatment plants but their treatment efficiencies are not known.

Table 7.16. Data about industries that discharge to Nif creek (Coşar, 1999).

	# of industries
Industries discharge wastewater to Nif creek	75
Industries that have treatment plants	53
Industries that only have sedimentation tanks	13
Industries do not have treatment plants	3
Industries that still constructing treatment plants	6
Industries that have discharge permission	25
Industries that apply to discharge permission	28
Industries that recycle wastewater completely	8
Industries that recycle wastewater partially	12
Saved water by recycling Per day	4000 tons
Industries that recycle treatment sludge completely or partially	12

Table 7.17. Pollution sources of Nif creek (Coşar, 1999).

Pollution sources from	
Residential areas	– Domestic garbage – Excavation and rubbish – Sewer system wastes – Slaughterhouse wastes – Medical wastes – others
Industrial wastes	- Wastewater - Process - Domestic - Solid wastes - Process - Treatment sludge - Excavation and rubbish - Dangerous wastes - Medical wastes
Wastes originated From irrigation fields	– Irrigation water – Pesticides – Fertilizers – Rain flows
Chicken farms and plumped sheds	– Garbage – Carnal fluid wastes – Fertilizers – Pesticides – Dead animal wastes
Fuel oil plants	– Car washing – Social plants – Domestic wastewater
Highways	– Garbage thrown from cars – Wastes transported by trucks

Again according to data of Kemalpasa Governorship, there are industries that appraise effluent of treatment plant by reusing effluent partially or completely as given in Table 7.18.

Table 7.18. Industries that appraise effluent of their treatment plant (due to the data of 1997) in Segment V – Nif (Kemalpaşa Governorship Environmental Protection Unit, 2000).

Sector	Treatment plant type	Complete reuse in production	Partial reuse in production	Complete reuse in irrigation	Partial reuse in irrigation	Partial reuse in washing purposes
Marble	Sedimentation	*				
Marble	Sedimentation	*				
Marble	Chemical	*				
Marble	Sedimentation	*				
Marble	Chemical		*			*
Paper	Sedimentation		*			
Paper	Chemical	*				
Paper	Lagoon system		*			*
Paper	Chemical + biological				*	
Ceramics	Chemical	*				
Ceramics	Chemical	*				
Ceramics	Chemical + biological		*		*	*
Mobilette	Chemical + biological			*		
Bicycle	Chemical + biological			*		
Soft drinks	Biological				*	
Soft drinks	Biological				*	
Elect. material	Chemical + biological			*		
Emergency material	Chemical + biological		*			*
Textile	Biological				*	
Slaughterhouse	Biological			*		
Ore	Chemical		*			*
Paint	Sedimentation		*			
Paint	Chemical + biological					*

As given in Table 7.19, the number of employees of some industries are available. According to these data and assuming specific BOD load per capita as 60 gr/ca.d, BOD loads are calculated. On the other hand, assuming that a person consumes 0.05 m3/d in an industry for his domestic purposes, domestic wastewater flowrates are calculated. Again for several industries, estimation is done for industrial wastewater flowrates by considering the available data. Total wastewater discharge is 25996 m3/d.

Table 7.19. Available industrial data for Segment V (Kemalpaşa Governorship Environmental Protection Unit, 2000).

Sector	Sector type	# empl.	industrial wastewater m^3/day		Domestic wastewater		Treatment	Settlement
					BOD load	Q (m3/d)		
Buil. Stocks	Floor stocks	23			1380	1,15	No	Kemalpaşa
Packaging	Liquid food packaging	102			6120	5,1	Chemical+Biological	Kemalpaşa
Slaughterhouse							Biological	Kemalpaşa
Paint	Water-based paint	5			300	0,25	Yes	Kemalpaşa
Mineral water	Filling plant	12			720	0,6	Sedimentation	Kemalpaşa
Leather	Leather processing	155	158			7,75	Chemical	Kemalpaşa
Metal		101	20		6060	5,05	Chemical	Kemalpaşa
Metal	Bicycle, mopet	150	150		9000	7,5	Chemical+Biological	Kemalpaşa
Metal	Electric cable		160*				Chemical+Biological	Kemalpaşa
Metal	Metal coloring	43	5		2580	2,15	Chemical	Kemalpaşa
Textile	Entegre	93			5580	4,65	No	Kemalpaşa
Textile	Textile						Chemical+Biological	Kemalpaşa
Textile	Textile						under construction	Kemalpaşa
Fuel Oil	Washing+Lubricating	16	5		960	0,8	Chemical+Biological	Kemalpaşa
Paper	Paper	174	50*		10440	8,7	Chemical	Kemalpaşa
Paper	Guttered cardboard	25	50*		1500	1,25	No	Kemalpaşa
Paper	Paper 13.2	220	50		13200	11	Chemical	Kemalpaşa
Paper	Recycled paper	45	50		2700	2,25	Chemical+Biological	Kemalpaşa
Paper	Paper 13.7	327	50*		19620	16,35	Chemical	Kemalpaşa
Paper	Paper	87	50		5220	4,35	Chemical+Biological	Kemalpaşa
Paper	Paper	150	1500		9000	7,5	Biological	Kemalpaşa
Ore	Calcit	100	300*		6000	5	Sedimentation	Kemalpaşa
Ore	Ceramics	1250	650		75000	62,5	Chemical	Kemalpaşa
Ore	Ceramics	361	500		21660	18,05	Chemical+Biological	Kemalpaşa
Ore	Marble	20	100*		1200	1	Sedimentation	Kemalpaşa
Ore	Marble	56	100		3360	2,8	Chemical+Biological	Kemalpaşa
Ore	Marble	110	100*		6600	5,5	Sedimentation	Kemalpaşa
Ore	Marble	85	100*		5100	4,25	Sedimentation	Kemalpaşa

Table 7.19. (Continued).

Ore	Marble	8	100*		480	0,4	to the TP	Kemalpaşa
Ore	Marble		100*				Precaution plant	Kemalpaşa
Chemistry	Paint	114	40		6840	5,7	Chemical+Biological	Kemalpaşa
Chemistry	Polymer	351	41,5		21060	17,55	Biological	Kemalpaşa
Chemistry	Paint	20	10		1200	1	Chemical	Kemalpaşa
Chemistry	Paper chemicals	60	50*		3600	3	No	Kemalpaşa
Chemistry	Glue production		10*				Chemical	Kemalpaşa
Chemistry	Paint	103	130		6180	5,15	Chemical+Biological	Kemalpaşa
Chemistry	Pigment pastta	59	3		3540	2,95	Chemical	Kemalpaşa
Chemistry	Paint		130*					Kemalpaşa
Food	Dry grape	125	155*		7500	6,25	Biological	Kemalpaşa
Food	Dry grape	CLOSED						Kemalpaşa
Food	Dry grape	85	155		5100	4,25	Biological	Kemalpaşa
Food	Dry grape		155*					Kemalpaşa
Food	Dry grape	CLOSED						Kemalpaşa
Food	Dry grape	CLOSED						Kemalpaşa
Food	Dry grape	50	155*		3000	2,5	No	Kemalpaşa
Food	Dry grape		155*					Kemalpaşa
Food	Dry grape	39	155*		2340	1,95	Sedimentation	Kemalpaşa
Food	Dry grape	30	155*		1800	1,5		Kemalpaşa
Food	Grape+Apricot	33-40	50*		2220		Biological	Kemalpaşa
Food	Grape+Apricot	80	50*		4800	4	No	Kemalpaşa
Food	Grape+Apricot		50*					Kemalpaşa
Food	Grape+Apricot		50*				No	Kemalpaşa
Food	Apricot		50*				Sedimentation	Kemalpaşa
Food	Hazır yemek	27	100*		1620	1,35		Kemalpaşa
Food	Brine for pickling	25	200*		1500	1,25		Kemalpaşa
Food	Brine for pickling	20	200*		1200	1	Biological	Kemalpaşa
Food	Brine for pickling	25-30	200*		1620		Biological	Kemalpaşa
Food	Brine for pickling		200*				No	Kemalpaşa

Table 7.19. (Continued).

Food	Brine for pickling	40	200*		2400	2		Kemalpaşa
Food	Brine for pickling	23	200*		1380	1,15		Kemalpaşa
Food	Slaughter of animals	4	3		240	0,2	Biological	Kemalpaşa
Food	Slaughter of animals	120	150		7200	6	Biological	Kemalpaşa
Food	Slaughter of animals	80	100		4800	4	Biological	Kemalpaşa
Food	Slaughter of animals	80	250		4800	4	Biological	Kemalpaşa
Food	Slaughter of animals	20	53		1200	1	No	Kemalpaşa
Food	Olive oil		10*				No	Kemalpaşa
Food	Olive oil		10*				No	Kemalpaşa
Food	Olive oil		10*				Sedimentation	Kemalpaşa
Food	Vinegar	205	45		12300	10,25	Chemical+Biological	Kemalpaşa
Food	Soft drinks	238	1000		14280	11,9	Chemical+Biological	Kemalpaşa
Food	Soft drinks	132	100		7920	6,6	Chemical+Biological	Kemalpaşa
Food	Fermante kornişon	34	60		2040	1,7	Chemical	Kemalpaşa
Food	Fruit+vegetable	33	100*		1980	1,65	Biological	Kemalpaşa
Food	Fruit+vegetable	160	100*		9600	8	Sedimentation	Kemalpaşa
Food	Ferment	152	750		9120	7,6	Biological	Kemalpaşa
Food	Meat	465	650		27900	23,25	Biological	Kemalpaşa
Leather	Leather manuf.		150				Yes	Turgutlu
Leather	Leather manuf.		10				under constr.	Turgutlu
Food	Halvah		120				Yes	Turgutlu
Food	Grape processing		100				sewage system	Turgutlu
Food	Grape processing		20				No	Turgutlu
Food	Grape processing		60				No	Turgutlu
Food	Grape processing		100				Yes	Turgutlu
Textile	Textile products		22				under constr.	Turgutlu
Cannery	Cannery		14440				No	Turgutlu
Food	Chicken		125				sewage system	Turgutlu
Slaughterhouse			40*				No	Turgutlu
Flour	Flour production		20				to the field	Turgutlu
	TOTAL		25995,5			334,6		

*: estimated by considering the available data.

PDMoE has done quality observations since 1996 in 3 observation stations determined in Nif creek: (1) Askılı bridge, (2) Irlamaz and (3) Nif II bridge. According to these sampling results, the following graphs are obtained for BOD and suspended solids. These results give an idea about these water quality parameters in Gediz river system as given in Figures 7.4 and 7.5. (Ince et al., 1999).

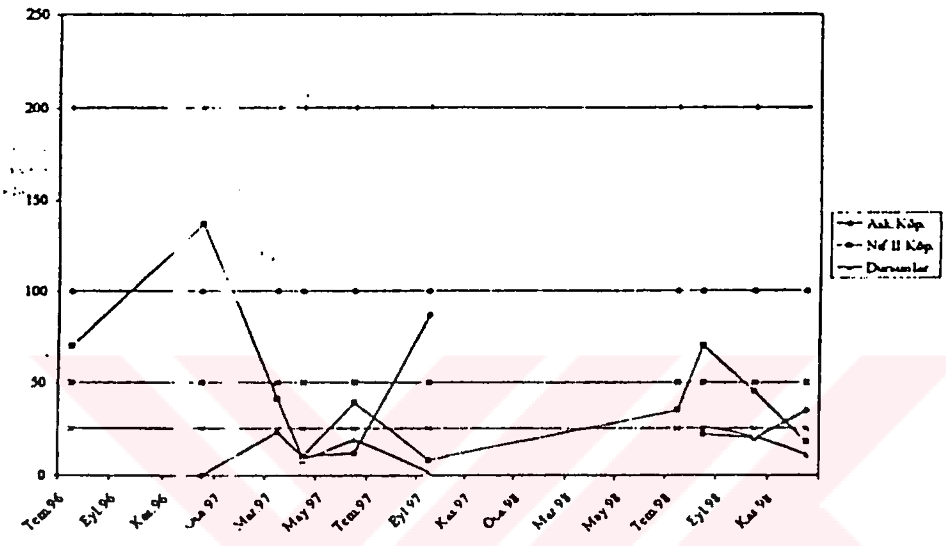


Figure 7.4. BOD.

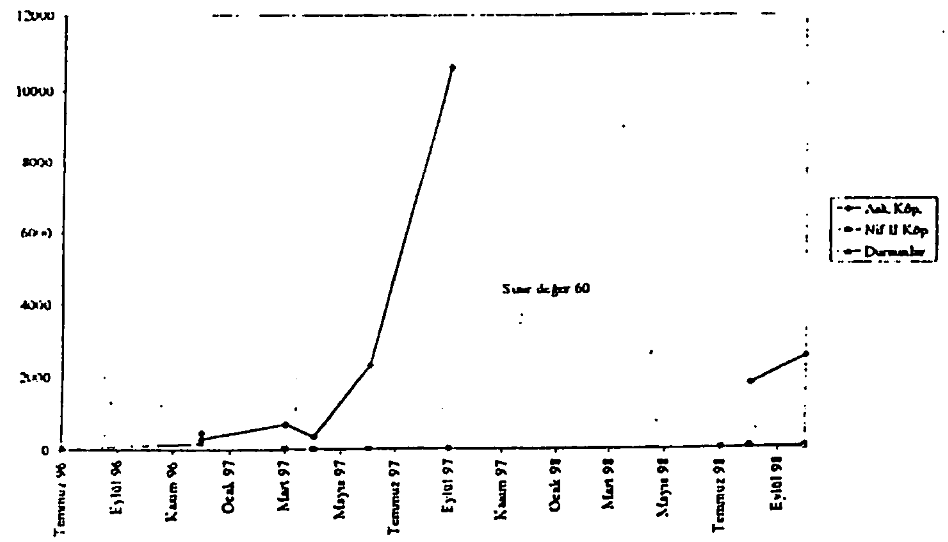


Figure 7.5. SS.

In another study done by E. U. Center of Research and Development of Environmental Problems, observed values of various water quality parameters in Nif creek are given. In May-1997/ May-1998 season, monthly observations took place in 6 stations during one year in Segment V as shown in Figure 7.6.

Stations;

1. Before Nif I bridge
2. After Mopak discharge point
3. From Ansizca bridge
4. Before Kemalpasa landfill
5. From Sütçüler bridge
6. Before Dursunlar sand mine

Sampling had been made in 10-30 cm deep from surface. Annual values of various physical, chemical and microbiological pollution parameters are given in Table 7.20.

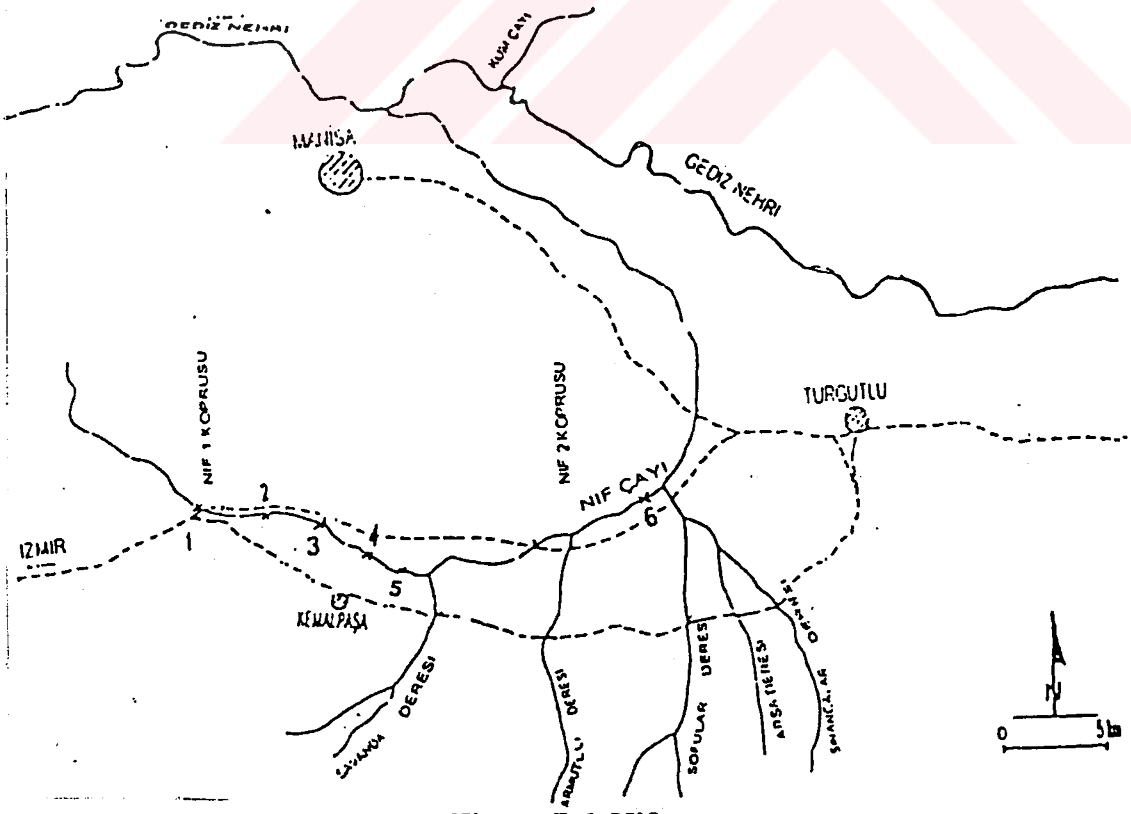


Figure 7.6. Nif map.

Table 7.20. Average values of various parameters in Nif creek for a year (Eltem et al., 1999).

Parameters	STATIONS					
	1	2	3	4	5	6
Temperature, °C	19,7	23,2	19,2	19,2	20,7	17,6
Conductivity	0,5	3,38	2,49	2,5	2,37	0,89
PH	7,38	8,07	7,65	7,68	7,59	7,27
DO, (mg/l)	8,65	3,1	3,2	2,95	4,2	5,9
SS, (mg/l)	21,7	222,3	246,2	136,2	178,1	39
BOD, (mg/l)	14	142	87,3	74,09	93	19,82
COD, (mg/l)	70,3	649,8	504,9	506,1	467,4	97,5
Total bacteri (CFU/ml)	$142,7*10^3$	$3,98*10^6$	$4,26*10^6$	$2,98*10^6$	$9,07*10^6$	$9,57*10^4$
Total coliform (EMS/100 ml)	$5,55*10^3$	$15*10^6$	$2,07*10^7$	$1,05*10^7$	$1,17*10^7$	$4,74*10^4$
Fecal coliform (EMS/100 ml)	$9,82*10^2$	$43*10^4$	$5,54*10^6$	$6,45*10^5$	$3,29*10^6$	$1,39*10^4$

The last segment is also a highly polluted part of the river. This segment includes two OIDs besides several individual industries. One OID is in Manisa and the other is in Menemen. OID in Menemen consists of only tanneries. There is no available information about the wastewater flowrates but there is a treatment plant so that the district discharges wastewater according to discharge standards to the river. There are 69 individual industries, 1500 small industrial districts and 2 OIDs in the section. Industries become denser in Manisa region. Available data about industries and wastewater discharges is given in Table 7.21.

Finally throughout the basin, the existing industries and sectoral distribution can be summarized as given in Tables 7.22 and 7.23 respectively.

Table 7.21. Available industrial data for Segment VI (Manisa PDMoE (b), 1999).

Sector type	Village	# of ind.s	Q (m3/d)	Wastewater discharge Location
Food	Manisa	1	100	Gediz river
Textile	Manisa	1	500	Gediz river
Small Ind. District	Manisa	1500	250	Gediz river
Leather	Manisa	50	4000	Gediz river
Soft drinks	Muradiye	1	170	Gediz river
Food	Muradiye	1		septic tank
Food	Muradiye	1	2040	Gediz river
Food	Muradiye	1		septic tank
Cotton processing	Karaağaçlı	1		
Metal	Karaağaçlı	1	20*	
Electric	Karaağaçlı	1	160*	
Food	Karaağaçlı	1	230	Gediz river
Food	Karaağaçlı	1	100*	
Olive oil man.	Karaoğlanlı	1	5	sewage system
Olive oil man.	Karaoğlanlı	2		sewage system
Cotton	Karaoğlanlı	1		septic tank
Food	Çobanisa	1	200	sewage system
Food	Çobanisa	1	550	Gediz river
Food	Çobanisa	1	200	sewage system
Food		1	6000	sewage system
Manisa IOD – I	Manisa	65	5070	treatment plant
Manisa IOD – II	Manisa	19	3466	2108 m3/d pretreated
				1358 m3/d untreated
Menemen Leath. IOD	Menemen			treatment plant
	Total		23061	

*: estimated by considering the available data.

Table 7.22. The existing industries in each segment.

Segments	Number of	
	Individual industries	OIDs
I	40	
II	91	
III	-	
IV	101	
V	200	1 (Kemalpasa)
VI	21	2 (Manisa, Menemen)
TOTAL	453	

Table 7.23. Sectoral distribution for each segment.

Sectors	Segments				Total
	II	IV	V	VI	
Slaughterhouse	1				1
Food	19	74	48	14	155
Tannery	34		3	50	87
Bricks	28				28
Carpet		1			1
String		3			3
Chemistry			8		8
Ore			9		9
Paper			7		7
Fuel oil			1		1
Textile			4		4
Metal			4		4

7.2.3. Non-point Discharges

Agricultural practices in the basin contribute to water pollution in the form of non-point discharges. Two types of discharges occur; irrigation return flows which reach the surface waters in a diffused way and the extensive use of agricultural chemicals and fertilizers. Improper use of fertilizers not only leads to water pollution through diffused transport to surface waters but it also degrades the quality of agricultural lands.

7.2.4. Other Sources of Degradation

There are other factors that contribute to the degradation of both water and land resources in the basin. One of them is water-based erosion which treathens about 84% of the areas in Gediz and which also leads to wind erosion. Other factors include earth and sand mining for various purposes, improper selection of solid waste dumping areas and various other uncontrolled discharges to the river. Municipalities further dispose of the sludge from these tanks by dumping it to the river without any pretreatment. It is not known where and how much sludge is dumped into the surface waters by municipalities.

7.3. Institutions Involved (Actors)

Water pollution control in Turkey is under the responsibility of different governmental agencies and ministries. The ministries working in this field and the major agencies acting under the authority of these ministries are the following (Harmancioglu & Alpaslan (b), 1999):

- The Prime Ministry (the State Planning Agency, the Turkish Atomic Energy Authority)
- The Ministry of Environment
- The Ministry of Energy and Natural Resources (the General Directorate of State Hydraulic Works, the Mining Exploration and Prospection Institute, Turkish Petroleum)
- The Ministry of Agriculture and Forestry (the General Directorate of Aquatic Products, the General Directorate of Forestry)
- The Ministry of Tourism and Promotion
- The Ministry of Industry and Technology
- The Ministry of Public Works and Housing (the Bank of Provinces General Directorate)
- The Ministry of Health and Social Security (the Public Health Institute)
- The Ministry of Transportation (the General Directorate of Maritime Transport).

In addition to the above, local administrations especially in metropolitan municipalities such as ; the Istanbul Water and Sanitation Administration (ISKI), established in 1982; the General Directorate of Ankara Water and Sanitation Administration (ASKI), established in 1987 and the General Directorate of Izmir Water and Sanitation Administration (IZSU), established in 1987. There are also a large number of voluntary foundations, societies and other organizations that actively participate in studies on water pollution and its control in Turkey. Besides, a large number of scientific institutions and universities study on water pollution and its control. The major scientific institution is the TUBITAK, the Scientific and Technical Research Council of Turkey.

The main role of *the Ministry of Environment (MoE)* in environmental management is to establish coordination among various governmental and private institutions towards control and protection of the environment. The organizational structure of the MoE is given in Figure 7.7. Among its various departments, only the

General Directorate on Protection and Control of Environmental Pollution (CEKOK), the General Directorate of Environmental Protection and Provincial Directorates deal with environmental pollution. The provincial Directorates perform a large number of duties including (Harmancioglu & Alpaslan (b), 1999):

- Monitoring and at-site determination of environmental pollution,
- Monitoring, control and regulation of all activities that have adverse effects on the environment,
- Preparation of environmental inventories for the province,
- Preparation of reports, monitoring and intervening with all activities that degrade the quality of receiving media; this duty is realized upon request either by the Ministry or by the local government (governors),
- Development of provincial implementation programs for mitigation of environmental pollution according to the strategies of the Local Environment Councils; establishment of coordination among regional institutions of other ministries and other local institutions,
- Perform all other duties requested by the local governor or the MoE itself.

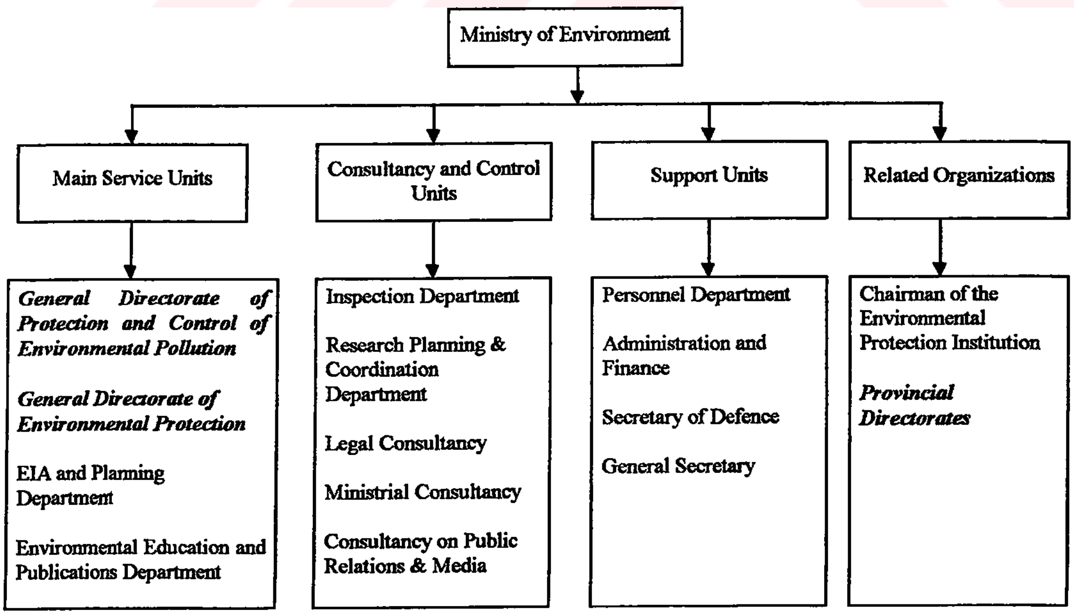


Figure 7.7. The organizational structure of the Ministry of Environment (MoE).

The Ministry of Health is responsible for approval and hygienic quality control of natural springs, mineral waters and all sources of drinking water. It can also serve to control industrial discharges and supervise the regulation of the quality of the drinking waters, the regulation being performed by other institutions. The departments within the Ministry of Health that deal with environmental protection and control are; the Department of Environmental Health of the General Directorate of Basic Health Services and its Provincial Health Directorates, the Refik Saydam Health Protection Center and its provincial directorates. At the local level, the Provincial Health Directorates perform duties of monitoring and regulation of the quality of water exploited for drinking or bathing. Provincial Directorates of the Refik Saydam Health Protection Center are responsible for analyzing the monitored samples.

*The Ministry of Agriculture and Rural Servic*es is responsible for environmental protection which performs its duties through the Environmental Protection Unit. The Environmental Protection Unit comprises directorates of environmental protection.

Figure 7.8 shows all actors related to water quality management in Gediz river basin. In this framework, the basic institution that is responsible for environmental control and regulation is the Ministry of Environment. However, this function is also realized by the Ministry of Health, local governors and mayors of provincial municipalities or local municipalities.

It must be also be noted here that DSI has only a monitoring role with respect to water pollution control in the Gediz basin. It runs a regular monitoring program to observe more than 35 water quality parameters in the surface waters on a monthly or bimonthly basis. This program covers also the monitoring of groundwater (Harmancioglu & Alpaslan (b), 1999).

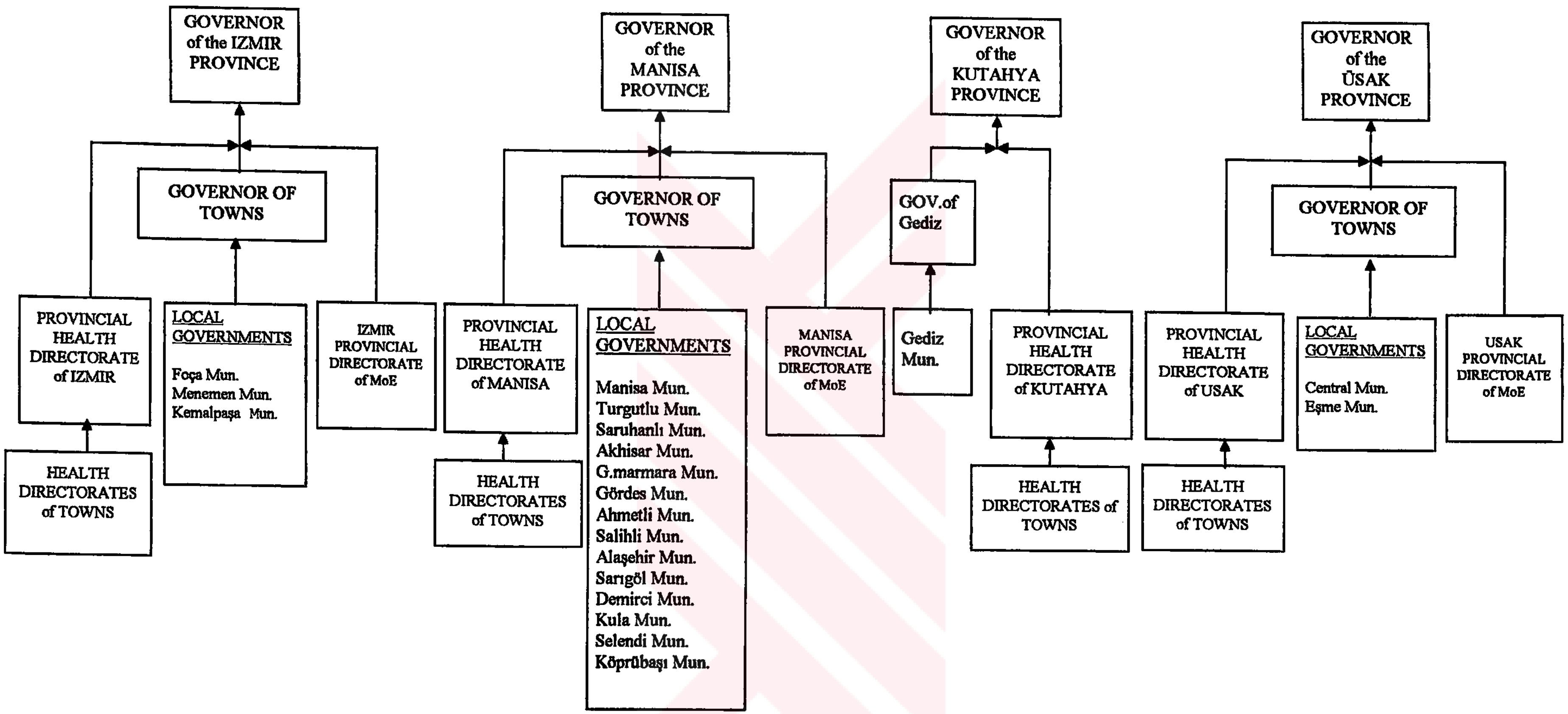


Figure 7.8. Actors involved in the protection and control of water quality in the Gediz River Basin.

7.4. Legal Aspects (Rules) in Water Quality

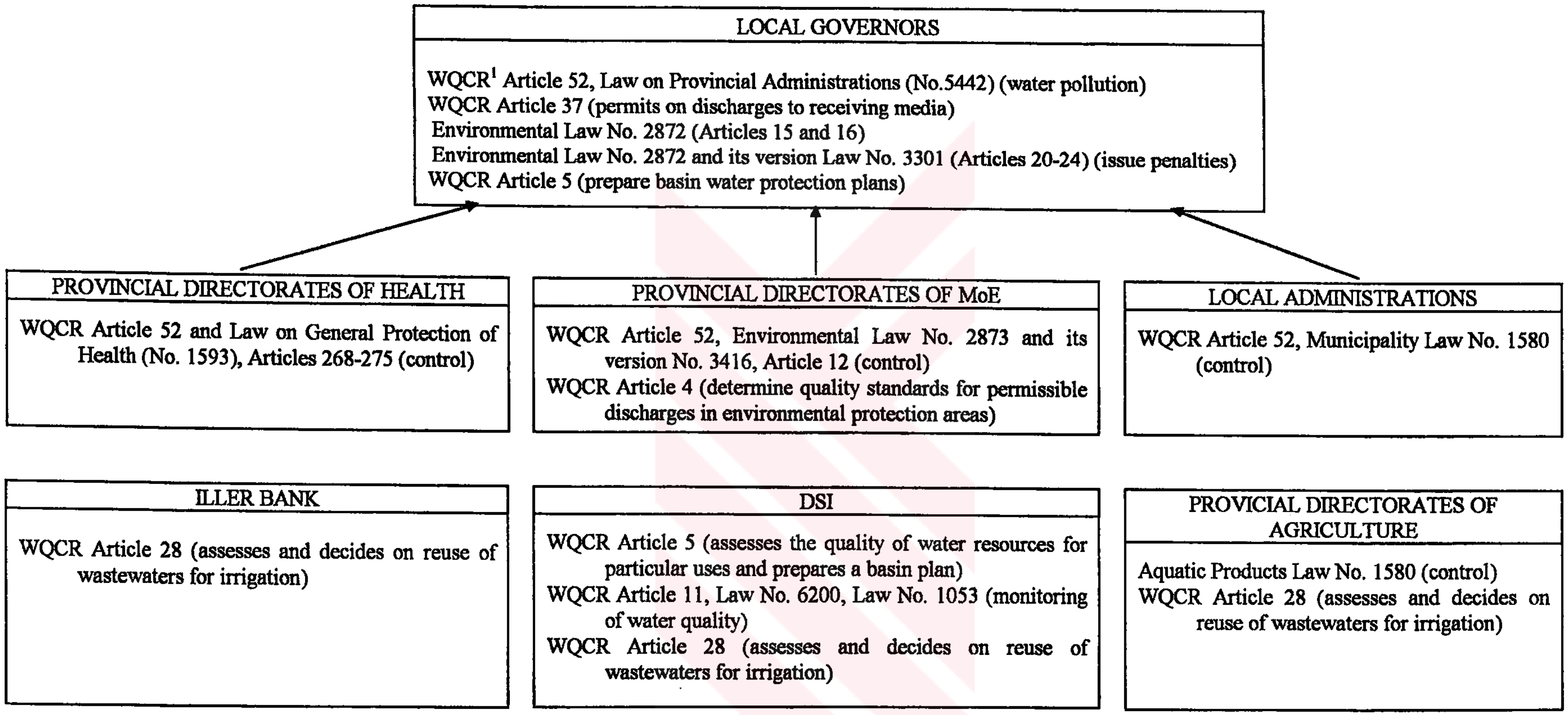
The first step on environmental legislation has been taken in the 1982 Constitution, which led to Environmental Law No.2872, 1983. Several regulations regarding the Fund for Prevention of Environmental Pollution (May 1985), Air Quality Control (Nov. 1986), Noise Control (Dec. 1986), Water Pollution Control (Sept. 1988), Solid Waste Control (Mar. 1991) and Environmental Impact Assessment (Feb. 1993) have followed, to implement the Environmental Law.

The main regulation valid in Turkey is "*Water Quality Control Regulation*". The purpose of the Water Quality Control Regulation, which was drafted in line with articles 8, 9, 11, 12 and 13 of Environmental Law No. 2872, is to define the legal and technical principles of protecting the nation's water resources potential, ensuring its use in the best possible way and preventing water pollution in a way harmonious with economic and social development efforts. Prevention of the spread of water pollution over the country's surface, protection of groundwater, prevention of coastal and sea pollution and regeneration of polluted aquatic environments are the main topics in the regulation.

The regulation also describes the classes of water such as;

a. Class I: High quality waters
b. Class II: Moderate quality waters
c. Class III: Polluted waters
d. Class IV: Highly polluted waters

The effective rules in water pollution control are given in Figure 7.9, with the involved actors.



[1] Water Quality Control Regulation

Figure 7.9. Actors and rules involved in water pollution control and regulation.

CHAPTER EIGHT

AUXILIARY TOOLS IN INTEGRATED WATER RESOURCES MANAGEMENT AND CURRENT STATUS ASSESSMENT

8.1. General

There are several auxiliary tools in developed technology for assessing the behavior of the natural system. These tools are generally electronic and user friendly to evaluate the system mathematically and in an easier way. In studies on computer technology, advances have provided significant facilities in handling the problems so that most mathematical models have become computer-based simulation models. With such models, it is possible to investigate a large number of variables, processes and alternative management decisions.

In recent times, data collection is done with the help of several satellites. Satellite images are used for spatial data collection, and there are computer-based tools called Geographical Information Systems (GIS) that process the spatial data obtained from satellite images. There are several GIS programs such as Idrisi, Erdas, Arc-Info, etc., respectively ranging from the basic one to the developed.

In most developed countries, one of the most widely used computer models is the Enhanced Stream Water Quality Model - QUAL2E that serves to simulate surface water quality along river courses. It is not only a simulation model but also a planning model since results of alternative management decisions can be evaluated once the physical system is identified in the model.

In the thesis, the case river system – Gediz river- is examined with the help of QUAL2E computer model using the available data, and the results show the present pollution profile of the river system. In the first step, the available collected data are processed in terms BOD loads. The further step is the QUAL2E model run with processed data.

8.2. Description of the QUAL2E Model

QUAL-I was initially developed in 1960s by the Texas Water Development Board. Then several improved versions of the model were introduced by EPA, and after extensive review and testing, the QUAL-II series became widely used. QUAL2E is provided by the Environmental Protection Agency's Center for Exposure Assessment Modeling (CEAM) (Brown & Barnwell, 1987).

QUAL2E allows the simulation of 15 water quality constituents in a branching stream system using a finite difference solution to the one-dimensional advective-dispersive mass transport and reaction equation. QUAL2E predicts DO, BOD, temperature, and phytoplankton dynamics as affected by nutrients and organic material. It comes with a pre- and post-processor and software that facilitates sensitivity and uncertainty analysis (Donigian et al., 1995). QUAL2E is one of the eleven water quality models that are documented and available to the public.

In the QUAL2E formulation, the conceptual representation of a stream is a stream reach that has been divided into subreaches or computational elements equivalent to finite differences. For each computational element; hydrologic, heat and materials balance are written in terms of, respectively, flow (Q), temperature (T) and concentration (C). Both advective and dispersive transport are considered in the materials balance. Mass can be gained and lost from the element by transport processes, external sources and sinks (waste discharges or withdrawals) or by internal sources and sinks (benthic sources or biological transformations).

The program simulates also changes in flow conditions along the stream by computing a series of steady-state water surface profiles.

The model is applicable to dendritic streams that are well mixed. It assumes that the major transport mechanisms, advection and dispersion, are significant only along the main direction of flow. It allows for multiple waste discharges, withdrawals, tributary flows, and incremental inflow and outflow. It also has the capability to compute required dilution flows for flow augmentation to meet any pre-specified dissolved oxygen level.

The QUAL2E computer program can be operated either as a steady-state or dynamic model. When operated steady-state, the model can be used to study the impact of waste loads on instream water quality and to identify the magnitude and quality characteristics of non-point waste loads by entering the data related to irrigation water to the model. On the other hand, by operating the model dynamically, the user can model the effects of diurnal variations in meteorological data on water quality - primarily dissolved oxygen and temperature - and examine diurnal dissolved oxygen variation caused by algal growth and respiration. However, the effects of dynamic forcing functions, such as headwater flows or point loads, cannot be modeled in QUAL2E.

Prototype representation in QUAL2E consists of dividing a stream into a network of "Headwaters", "Reaches" and "Junctions". The fundamental reason for subdividing sections of a stream into "Reaches" is that QUAL2E assumes that some 26 physical, chemical and biological properties (model input parameters or coefficients) are constant along a "Reach".

The model consists of four main modules. These are:

- AQUAL2 - data preparing program for QUAL2E and QUAL2EU models,
- QUAL2E - main model module,
- QUAL2EU - module for uncertainty analysis,
- Q2PLOT - the graphics module.

The input data in QUAL2E can be grouped into three categories:

a) A stream/river system,

b) Global variables,

c) Forcing functions.

Additionally, there are also three more data groups for simulation control and uncertainty analysis.

In the first step, the complete stream/river system should be described by applying the rules that are defined by the model. The stream system should be divided into reaches that have uniform hydraulic characteristics. Each reach is then subdivided into computational elements of equal length. All reaches must consist of an integer number of computational elements.

The global variables include simulation variables, such as units and simulation type, water quality constituents, and some physical characteristics of the basin.

Forcing functions are user-specified inputs that drive the system being modeled. These inputs are specified in terms of flow, water quality characteristics and local climatology. The climatological factors are: headwater inputs, point sources or withdrawals, incremental inflow/outflow along a reach and the downstream boundary concentration (optional).

Local climatological data are required for the simulation of algae and temperature. The temperature simulation requires air temperatures, atmospheric pressure, wind velocity and cloud cover. The algal simulation requires values of net solar radiation. For dynamic simulations, these climatological data must be input at regular time intervals over the course of the simulation and are applied uniformly over the river basin.

For modeling steady state temperature and algae, average daily local climatological data are required and may vary spatially over the basin by reach. The obligatory and the special data for every modeled variable are given in Table 8.1.

Table 8.1. Obligatory Data for Each Parameter to be Modeled.

A. Temperature Correction Factors (Rate Coefficients)			B. Reach Identification and River-Mile/km Data	C. Computational Elements Flag Field Data
BOD Decay	Ammonia Source	Algae Settling	Reach Order or Number	Headwater Source Element
BOD Settling	Nitrite Decay	Coliform Decay	Reach Identification or Name	Standard Element, Incremental Inflow/Outflow Only
Reaeration	Orp-P Decay	Non-cons. Decay	River Mile/km at Head of Reach	Element on Mainstream upstream of a Junction
SOD Uptake	Org-P Settling	Non-cons. Settling	River Mile/km at End of Reach	Junction Element
Org-N Decay	Dis-P Source	Non-cons. Source		Most Downstream Element
Org_N Settling	Algae Growth			Input Element
Ammonia Decay	Algae Respiration			Withdrawal Element
				Dams

D. Hydraulics Data		E. Temperature and Local Climatological Data	F. BOD and DO Reaction Rate Constants Data
Discharge coefficients	Trapezoidal Channels	Reach Order or Number	BOD Decay Rate Coefficient
Reach order or Number	Reach Order or Number	Reach Elevation	BOD Removal Rate by Settling
Dispersion Constant	Dispersion constant	Dust Attenuation Coefficient	Sediment Oxygen Demand
A, Coefficient for velocity	Side slope 1	Cloudiness	Option for K2
B, Exponent for velocity	Side Slope 2	Dry Bulb Air Temperature	K2 Reaeration Coefficient
C, Coefficient for depth	Bottom width of Channel	Wet Bulb Air Temperature	A, Coefficient for K2
D, Exponent for depth	Channel Slope	Barometric Pressure	B, Exponent for K2
Manning "n" for reach	Manning "n" for reach	Wind Speed	

To create a new data file in QUAL2E Windows interface, there are 24 screens to be represent the data for QUAL2E. The input screen sequences in QUAL2E Windows Interface are given in Table 8.2. According to these input screens, some auxiliary files are formed and used in the main operation action of the model execution.

Table 8.2. Input Screen Sequence in QUAL2E Windows Interface (Brown & Barnwell, 1995).

<table>
<tr><th>Data Component</th><th>Description of input data</th><th colspan="2">Content</th><th>Input Screen no.</th></tr>
<tr><td rowspan="2">1</td><td rowspan="2">QUAL2E Simulation control</td><td colspan="2">Title, simulation type, unit, time step</td><td rowspan="2">1</td></tr>
<tr><td colspan="2">Uncertainty analysis, flow augmentation, trapezoidal channels, no. of reaches</td></tr>
<tr><td rowspan="2">2</td><td rowspan="2">Stream system</td><td colspan="2">Reach ID and river km, headwater, comp. element length</td><td>2</td></tr>
<tr><td colspan="2">Element type for each reach</td><td>3</td></tr>
<tr><td rowspan="5">3</td><td rowspan="5">Global variables</td><td colspan="2">Water quality (no. of constituents)</td><td>4</td></tr>
<tr><td>Geographical & climatological data</td><td>Latitude, longitude, dust attn., elev., evap, coeff.</td><td>5</td></tr>
<tr><td>Plot DO/BOD</td><td>List reach numbers to be plotted</td><td>6</td></tr>
<tr><td colspan="2">Observed DO file</td><td>7</td></tr>
<tr><td colspan="2">Global kinetics, temperature corr. factors</td><td>8,9</td></tr>
<tr><td rowspan="9">4</td><td rowspan="9">Functional data</td><td rowspan="2">Flow</td><td>Flow augmentation</td><td>10</td></tr>
<tr><td>Hydraulic data/local climatology data</td><td>11</td></tr>
<tr><td colspan="2">BOD/DO, algae, N, P, reaction coefficients</td><td>12,13</td></tr>
<tr><td rowspan="6"></td><td>Initial conditions</td><td>14</td></tr>
<tr><td>Incremental flow</td><td>15</td></tr>
<tr><td>Headwater</td><td>16</td></tr>
<tr><td>Point loads/withdrawals</td><td>17</td></tr>
<tr><td>Dams</td><td>18</td></tr>
<tr><td>Downstream boundary</td><td>19</td></tr>
<tr><td>5</td><td>Clim. data</td><td colspan="2">Global climatological data file</td><td>20</td></tr>
<tr><td rowspan="5">6</td><td rowspan="5">Uncertainty analysis</td><td colspan="2">Sensitivity analysis, first order error analysis, Monte Carlo simulation</td><td rowspan="2">21</td></tr>
<tr><td colspan="2">Input conditions, output</td></tr>
<tr><td colspan="2">Input variables for sensitivity analysis</td><td>22</td></tr>
<tr><td colspan="2">Input variables for first order error analysis</td><td>23</td></tr>
<tr><td colspan="2">Reach (element) numbers to be printed</td><td>24</td></tr>
</table>

QUAL2E has been designed to be a relatively general program; however, certain dimensional limitations were imposed during program development (Brown & Barnwell, 1995). These limitations are;

- Reaches: a maximum of 50
- Computational elements: no more than 20 per each reach or a total of 500
- Headwater elements: a maximum of 10
- Junction elements: a maximum of 9
- Point source and withdrawal elements: a maximum of 50

There are also limitations in the system requirements in order to run the model under Microsoft Windows. The minimum system requirements are as below (Brown & Barnwell, 1995).

- Windows version 3.1.
- 80386 processor
- 4 megabytes RAM
- 10 megabytes hard disk space

Note: A math co-processor is recommended but not required.

On the other hand, each model parameter has a literature range for computing and there is a range of the model itself. In some cases, these values do not fit to each other. In this case, model computes the parameters or variables according to the its own range.

The minimum, maximum and default values of the parameters in the model are given in **Appendix B**.

In order to model river water quality with the QUAL2E program, the river system must first be defined hydrodynamically in terms of slope, roughness, flow and cross-sectional properties. As a second step, the quality properties of the river are defined according to parameter concentrations and discharge locations. In other words, the first phase of modeling is to collect data on the river basin and prepare the data set necessary for the model.

After defining the basin with site studies, the points where the hydrologic characteristics change must be marked on the map of the basin. Then, according to these data, the river is divided into parts, called reaches that have uniform hydrologic properties. Each reach is further divided into computational elements, and the number of computational elements is determined. The length of a computational element is constant for each reach and consequently the reach length must be the multiple of the computational element length. In addition, the starting and finishing kilometers of each reach must be determined. As a second step, point loads (domestic or industrial wastewater discharge etc.) or withdrawals (drinking water etc.) and surface flows (storm water, groundwater, infiltration etc.) must be determined in terms of both the flowrates and their locations.

In defining the basin on the model, the main problem is to transfer the physical properties of the basin to the computer correctly. These properties are the locations and the identifying numbers of headwaters, junctions, point loads or withdrawals, the numbers and the starting and finishing kilometers of the reaches (Harmancioglu et al., 1993).

After this step, the hydraulic and quality properties of river must be recorded to the computer. In this step, all point loads, withdrawals, surface flow and the hydraulic and quality data of the upstream point must be entered. In order to run the model, all the preparations must be done. After all these preparations, the QUAL2E model can be run. In order to run the QUAL2EU - the uncertainty analysis module -, uncertainty analysis data must be prepared. After obtaining the output files either from QUAL2E or from QUAL2EU, Q2PLOT graphic program module can be used to observe the results. With this module, graphics can be displayed on screen or can be printed.

8.3. Extraction of Available Data

8.3.1. General

There are different methods used to estimate the pollutant loads originating from residential areas and industries. The most common way of determining quality and quantity of pollutants from residential areas is the analysis of discharged water formed at each province and district. On the other hand, based on experiences, some methods were improved such as in using specific pollutant loads formed by capita per day to estimate these loads. Some typical variables for water consumption and specific pollutant loads are seen as follows (Tchobanoglous & Burton, 1991). Due to these data, BOD loads from each residential area is calculated by considering the literature information given in Table 8.3.

Table 8.3. Characteristics of Typical Residential Wastewater (Tchobanoglous & Burton, 1991).

Parameter	Typical Value
Typical waste water production	200 l/ca.day
BOD (Biochemical Oxygen Demand)	60 g/ca.day
N (Nitrogen)	15 g/ca.day
P (Phosphorous)	2 g/ca.day

Total Pollutant Load = Specific Pollutant Loads (g/ca.day)*Population (Eq.8.1)

Based on literature values, available wastewater flowrate figures for industrial data are processed in terms of BOD load, kg/d. BOD loading is calculated as given in Equation 8.2.

$$\text{BOD Load, kg/d} = \underset{\substack{\text{(mg/l)} \\ \text{(literature data)}}}{(\text{Concentration of BOD}} * \underset{\substack{(\text{m}^3\text{/d}) \\ \text{(available data)}}}{\text{Flowrate})} / 1000 \qquad \text{(Eq.8.2)}$$

Then, BOD load is converted to equivalent population in terms of capita by Equation 8.3.

$$\text{Eq. Pop., ca} = \frac{\text{BOD load (kg/d)}}{\text{Specific BOD load (60 g/ca.d)}} * 1000 \qquad \text{(Eq.8.3)}$$

According to the above equations, domestic and industrial inputs are calculated in terms of BOD loads in the following sections.

8.3.2. Domestic Inputs to the river

As stated before, the Gediz River Basin is examined in six segments. For each segment and each residential area, population data are obtained from Institute of State Statistics of 1965 through 1997 as given in Chapter 6, Table 6.5.

Applying Eq. 8.1, BOD loads are calculated for each segment by using data given in Table 6.5 and given in Table 8.4 for the year 1998. The same BOD calculations done for the years 2010, 2020 and 2030 by estimating the population figures, given in Tables 8.5, 8.6 and 8.7.

Table 8.4. BOD Load Discharged into Gediz River in 1997.

Segment	District	Population	Q, (m3/day)	BOD, (kg/day)
1	Usak(Province)	165615	33123	9936,9
	Esme	41622	8324,4	2497,32
	Gediz	76796	15359,2	4607,76
	Selendi	25376	5075,2	1522,56
	Kula	48809	9761,8	2928,54
	Demirci	70767	14153,4	4246,02
	TOTAL	*428985*	*85797*	*25739,1*
2	Sarıgöl	34721	6944,2	2083,26
	Alasehir	98122	19624,4	5887,32
	Salihli	143016	28603,2	8580,96
	TOTAL	*275859*	*55171,8*	*16551,54*
3	Ahmetli	18666	3733,2	1119,96
	TOTAL	*18666*	*3733,2*	*1119,96*
4	Köprübaşı	11602	2320,4	696,12
	Gördes	37908	7581,6	2274,48
	Gölmarmara	16997	3399,4	1019,82
	Akhisar	152404	30480,8	9144,24
	Soma	86788	17357,6	5207,28
	Kırkağaç	47315	9463	2838,9
	Saruhanlı	65129	13025,8	3907,74
	TOTAL	*418143*	*83628,6*	*25088,58*
5	Kemalpasa	67223	13444,6	4033,38
	Turgutlu	114774	22954,8	6886,44
	TOTAL	*181997*	*36399,4*	*10919,82*
6	Manisa (Province)	259621	51924,2	15577,26
	Aliağa	52968	10593,6	3178,08
	Menemen	99325	19865	5959,5
	Foça	33061	6612,2	1983,66
	TOTAL	*444975*	*88995*	*26698,5*

Table 8.5. BOD Loads to be Discharged into Gediz River in 2010.

Segment	District	Population	Q, (m3/day)	BOD, (kg/day)
1	Usak(Province)	205409	41081,8	12324,54
	Esme	43593	8718,6	2615,58
	Gediz	81095	16219	4865,7
	Selendi	29205	5841	1752,3
	Kula	56703	11340,6	3402,18
	Demirci	78904	15780,8	4734,24
	TOTAL	494909	98981,8	29694,54
2	Sarıgöl	40556	8111,2	2433,36
	Alasehir	115409	23081,8	6924,54
	Salihli	169070	33814	10144,2
	TOTAL	325035	65007	19502,1
3	Ahmetli	27412	5482,4	1644,72
	TOTAL	27412	5482,4	1644,72
4	Köprübaşı	17038	3407,6	1022,28
	Gördes	63124	12624,8	3787,44
	Gölmarmara	24961	4992,2	1497,66
	Akhisar	204666	40933,2	12279,96
	Soma	123341	24668,2	7400,46
	Kırkağaç	58837	11767,4	3530,22
	Saruhanlı	74834	14966,8	4490,04
	TOTAL	566801	113360	34008,06
5	Kemalpasa	85235	17047	5114,1
	Turgutlu	133109	26621,8	7986,54
	TOTAL	218344	43668,8	13100,64
6	Manisa (Province)	350340	70068	21020,4
	Aliağa	74411	14882,2	4464,66
	Menemen	138451	27690,2	8307,06
	Foça	48403	9680,6	2904,18
	TOTAL	611605	122321	36696,3

Table 8.6. BOD Loads to be Discharged into Gediz River in 2020.

Segment	District	Population	Q, (m3/day)	BOD, (kg/day)
1	Usak(Province)	236269	47253,8	14176,14
	Esme	45055	9011	2703,3
	Gediz	85465	17093	5127,9
	Selendi	31158	6231,6	1869,48
	Kula	61600	12320	3696
	Demirci	87014	17402,8	5220,84
	TOTAL	546561	109312,2	32793,66
2	Sarıgöl	43949	8789,8	2636,94
	Alasehir	128344	25668,8	7700,64
	Salihli	187490	37498	11249,4
	TOTAL	359783	71956,6	21586,98
3	Ahmetli	36839	7367,8	2210,34
	TOTAL	36839	7367,8	2210,34
4	Köprübaşı	22898	4579,6	1373,88
	Gördes	68874	13774,8	4132,44
	Gölmarmara	33545	6709	2012,7
	Akhisar	223396	44679,2	13403,76
	Soma	160605	32121	9636,3
	Kırkağaç	65107	13021,4	3906,42
	Saruhanlı	78149	15629,8	4688,94
	TOTAL	652574	130514,8	39154,44
5	Kemalpasa	105469	21093,8	6328,14
	Turgutlu	146109	29221,8	8766,54
	TOTAL	251578	50315,6	15094,68
6	Manisa (Province)	448947	89789,4	26936,82
	Aliağa	90763	18152,6	5445,78
	Menemen	168980	33796	10138,8
	Foça	68276	13655,2	4096,56
	TOTAL	776966	155393,2	46617,96

Table 8.7. BOD Loads to be Discharged into Gediz River in 2030.

Segment	District	Population	Q(m3/day)	BOD(kg/day)
1	Usak(Province)	267129	53425,8	16027,74
	Esme	46567	9313,4	2794,02
	Gediz	89895	17979	5393,7
	Selendi	33111	6622,2	1986,66
	Kula	66523	13304,6	3991,38
	Demirci	95140	19028	5708,4
	TOTAL	598365	119673	35901,9
2	Sarıgöl	47342	9468,4	2840,52
	Alasehir	141279	28255,8	8476,74
	Salihli	205910	41182	12354,6
	TOTAL	394531	78906,2	23671,86
3	Ahmetli	49508	9901,6	2970,48
	TOTAL	49508	9901,6	2970,48
4	Köprübaşı	30772	6154,4	1846,32
	Gördes	76624	15324,8	4597,44
	Gölmarmara	45082	9016,4	2704,92
	Akhisar	242576	48515,2	14554,56
	Soma	209129	41825,8	12547,74
	Kırkağaç	71327	14265,4	4279,62
	Saruhanlı	81463	16292,6	4887,78
	TOTAL	756973	151394,6	45418,38
5	Kemalpasa	130506	26101,2	7830,36
	Turgutlu	159109	31821,8	9546,54
	TOTAL	289615	57923	17376,9
6	Manisa (Province)	575307	115061,4	34518,42
	Aliağa	107115	21423	6426,9
	Menemen	199513	39902,6	11970,78
	Foça	96309	19261,8	5778,54
	TOTAL	978244	195648,8	58694,64

8.3.3. Industrial Inputs to the River

Similar to the case of domestic inputs, the basin is examined in six segments. Evaluating the data given in Chapter 5 about the industries in each section, it can be said that in Segment I, the main sector in the segment is machine carpet manufacturing. The sectoral distribution is given in Figure 8.1.

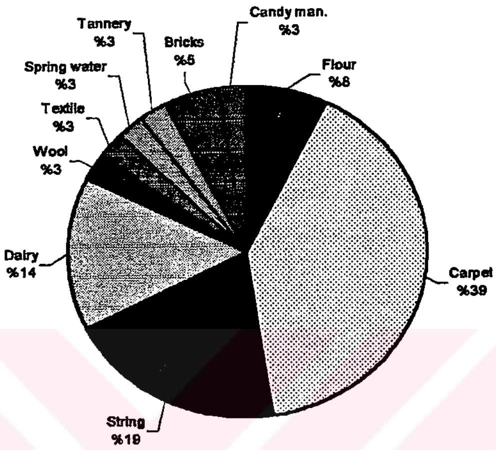


Figure 8.1. Sectoral distribution in Segment I.

Due to available data given in Chapter 7 (section 7.2.2), industries discharge either to septic tanks or to the sewage system. Because the existing industries are small-scale or not discharging wastewater in specific amounts, it can be said that there is no effective industrial pollution in the Segment I. The main pollution source of the segment is residential areas, in other words, domestic loads.

In the assessment of available data given in Chapter 7 for Segment II, Figure 8.2 summarizes the sectoral distribution of the industries. The biggest portion belongs to tanneries. Figure 8.3 summarizes the wastewater flowrates from each sector.

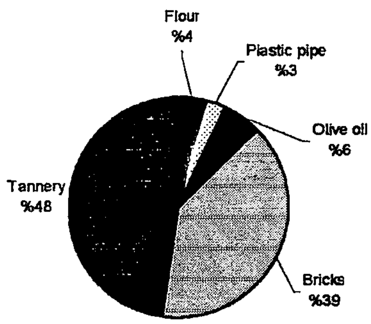
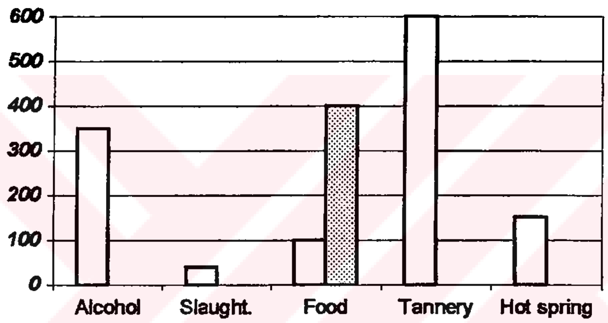


Figure 8.2. Sectoral Distribution in Segment II.



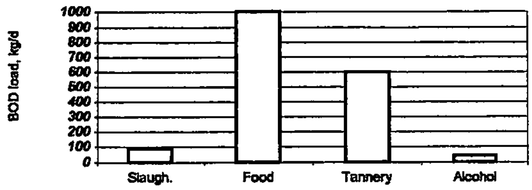
	Alcohol	Slaught.	Food	Tannery	Hot spring
Available	350	40	100	600	150
Estimated			400		

Figure 8.3. Wastewater Flowrate Evaluation in Segment II.

Calculated BOD loads and equivalent population values are given in Table 8.8 and Figure 8.4 for Segment II.

Table 8.8. BOD Load and Equivalent Population Assessment in Segment II.

Sector	Q, m3/d	Typical BOD, mg/l	BOD load, kg/d	Equivalent Population, ca
Slaughter	40	2240	90	1500
Food	500	2000	1000	16667
Tannery	600	1000	600	10000
Alcohol	350	40	40	667
		TOTAL	1730	28834



	Slaugh.	Food	Tannery	Alcohol
BOD load kg/d	90	1000	600	40

Figure 8.4. BOD Loads Evaluation in Segment II.

In Segment III, there is only domestic pollution according to available data. Similar to that in previous segments, in Segment IV, some wastewater flowrate figures are estimated by considering available data. 657 m3/d of wastewater enters the river system while the rest goes to septic tanks, sewage system, agricultural fields or to resting pools. Sectoral distribution is given in Figure 8.5 and wastewater flowrate assessment is given in Figure 8.6.

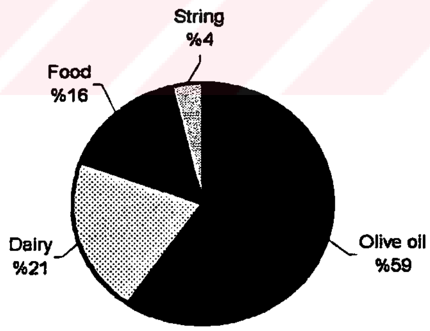
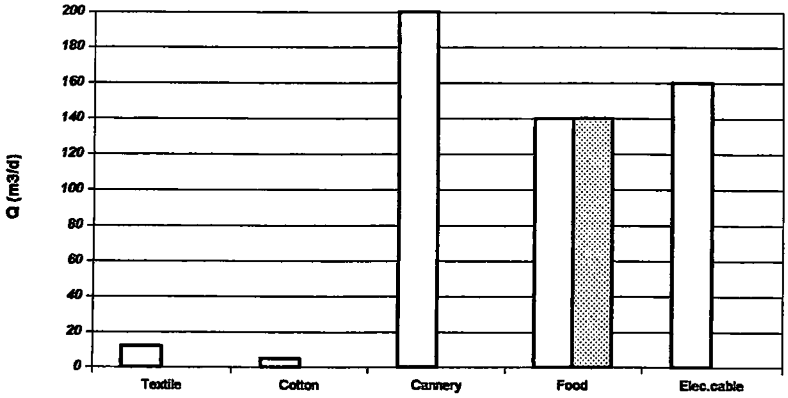


Figure 8.5. Sectoral distribution in Segment IV.



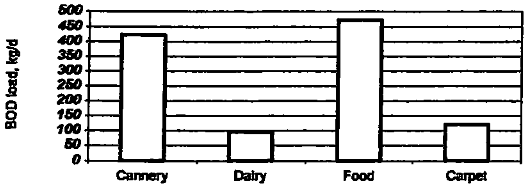
	Textile	Cotton	Cannery	Food	Elec.cable
Available	12	5	200	140	160
Estimated				140	

Figure 8.6. Wastewater flowrate assessment in Segment IV.

By considering the Equations 8.2 and 8.3, given in the previous section, BOD loads and equivalent population values are calculated and given in Table 8.9. Due to calculation results, cannery industries discharge the highest BOD loads to the river as shown in Figure 8.7.

Table 8.9. BOD load and equivalent population assessment in Segment IV.

Sector	Q, m3/d	Typical BOD, mg/l	BOD load, kg/d	Equivalent Population, ca
Cannery	200	2100	420	7000
Dairy	50	1890	95	1583
Food	235	2000	470	7833
Carpet	12	10000	120	2000
		TOTAL	1105	18416



	Cannery	Dairy	Food	Carpet
BOD load kg/d	420	95	470	120

Figure 8.7. BOD loadings in Segment IV.

The highly polluted part of the Gediz river is in Segment V. Besides individual industries and residential areas, there is an OID in Kemalpaşa. Environmental Protection Unit staff require that an industry that has a flowrate of 10 m3/d should have a treatment plant so that, approximately every industry must have a treatment plant. Most of them have treatment plants but their treatment efficiencies are not known.

According to the data obtained from Kemalpaşa Governorship, there are approximately 200 industries in the region but only 86 of them are operating and the sectoral distribution is shown in Figure 8.8.

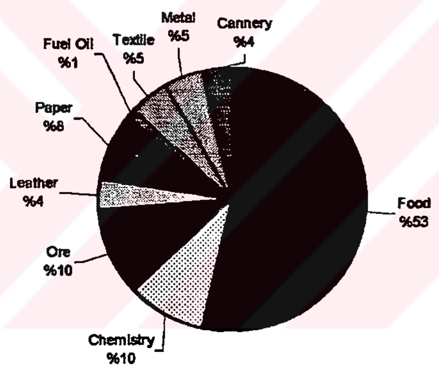
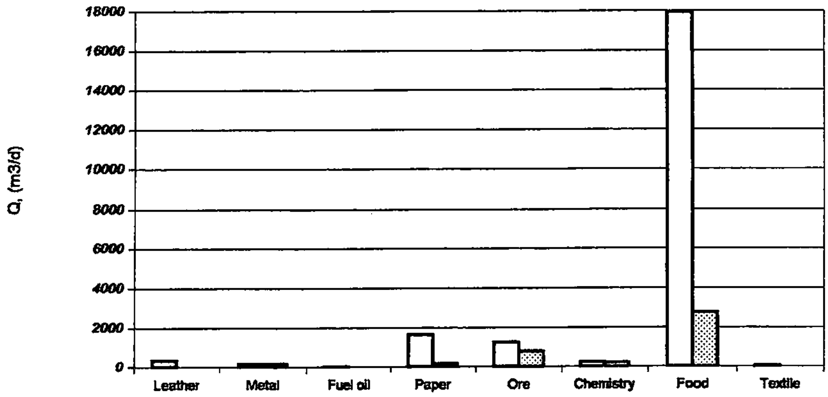


Figure 8.8. Sectoral distribution in Segment V.

Similar to those in other segments, wastewater flowrate, BOD loadings and equivalent population figures are calculated and given in Figure 8.9, Table 8.10 and Figure 8.10, respectively.

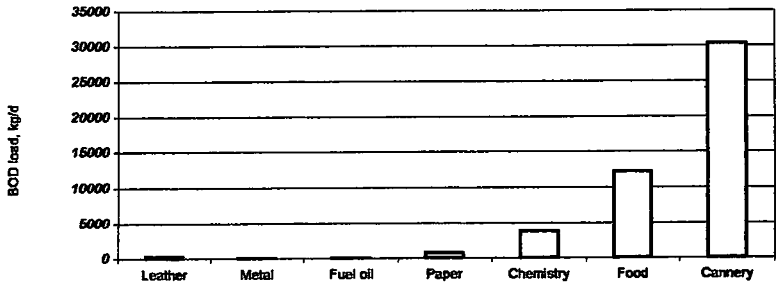


	Leather	Metal	Fuel oil	Paper	Ore	Chemistry	Food	Textile
Available	318	175	5	1650	1250	225	17916	22
Estimated		160		150	800	180	2750	

Figure 8.9. Wastewater flowrate assessment in Segment V.

Table 8.10. BOD load and equivalent population assessment in Segment V.

Sector	# of emp.	# of ind.	typical BOD, mg/l	Ind.ww.input Q (m3/d)	Domestic ww input BOD, mg/l	Domestic ww input Q (m3/d)	Process Q (m3/d)	BOD Load, kg/d	equivalent pop., ca
Buil.stocks	23	1			1380	1,15			
Packaging	102	1			6120	5,1			
Paint	5	1	6300		300	0,25			
Spring water	12	1			720	0,6			
Leather	155	3	1000	318	9300	7,75	310	310	5166,667
Metal	294	4	53-125	335	17640	14,7	320	28,8	480
Textile	93	4	0,2kg/kg wool	22	5580	4,65	17		
Fuel oil	16	1	18500	5	960	0,8	4	74	1233,333
Paper	1028	7	443	1800	61680	51,4	1749	775	12916,67
Ore	1990	9		2050	119400	99,5	1950		
Chemistry	707	8	10000	415	42420	35,35	380	3800	63333,33
Food	2337	45	2000	6226	140220	116,85	6109	12218	203633,3
Cannery		3	2100	14440			14440	30324	505400
Slaugh.			2240	40			40	90	1500
TOTAL	6762	88		25651	405720	338,1	25319	47619,8	793663,3



	Leather	Metal	Fuel oil	Paper	Chemistry	Food	Cannery
□ load, kg/d	310	28,8	74	775	3800	12218	30324

Figure 8.10. BOD loadings in Segment V.

The last segment is also a highly polluted section of the river. This segment includes two OIDs besides several individual industries. One OID is in Manisa and the other is in Menemen. OID in Menemen consists of only tanneries. There is no available information about the wastewater flowrates but the OID has a treatment plant so that the district discharges wastewater according to discharge standards to the river. There are 69 individual industries, 1500 small industrial districts and 2 OIDs in the segment. Industries become denser in Manisa region.

According to recorded data, small-sized IDs are mostly available. There are 50 tanneries besides food and cotton industries as shown in Figure 8.11.

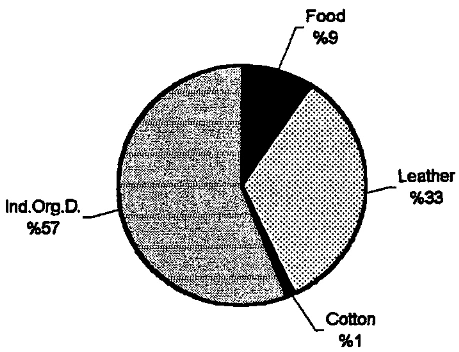
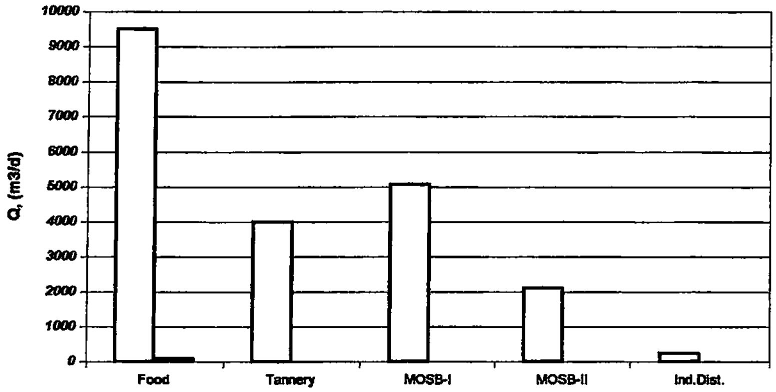


Figure 8.11. Sectoral distribution in Segment VI.

Wastewater flowrates are assessed and BOD load, equivalent population figures are calculated and given in Figure 8.12, Table 8.11 and Figure 8.13 respectively.

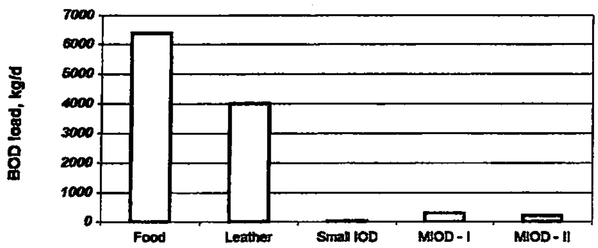


	Food	Tannery	MOSB-I	MOSB-II	Ind.Dist.
Available	9495	4000	5070	2108	250
Estimated	100				

Figure 8.12. Wastewater flowrate assessment in Segment VI.

Table 8.11. BOD load and equivalent population assessment in Segment VI.

Sector	Q (m3/d)	typical BOD, mg/l	BOD load, kg/d	Equivalent Population, ca
Food	3190	2000	6380	106333,3
Leather	4000	1000	4000	66666,67
Small IOD	250	100	25	416,6667
MIOD - I	5070	60	304,2	5070
MIOD - II	2108	100	210,8	3513,333
MIOD - II	1358			
TOTAL	15976		10920	182000



	Food	Leather	Small IOD	MIOD - I	MIOD - II
kg/d	6380	4000	25	304	210

Figure 8.13. BOD loadings in Segment VI.

The sectoral distribution throughout the basin is given in Figure 8.14 where it is seen that the major sectors are food and tanneries.

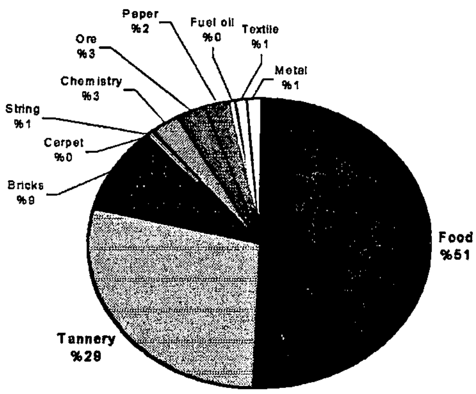


Figure 8.14. Sectoral distribution in the basin.

Table 8.12 summarizes the overall BOD loads and equivalent population for various industries. The total equivalent population figure is 1.022.246 ca. throughout the river. The real figure is more than this calculated figure. It is about more than 2 million capita. This figure is also in terms of BOD, in other words, it is an organic based result. If it were possible to obtain complete data of all water quality parameters, the result would be more realistic. If it is needed to have the result in terms of COD, the conversion factor of BOD/COD= 0.68 can be used.

Table 8.12. The overall BOD loads in the basin.

Sector type	SEGMENTS									
	II		IV		V		VI		TOTAL	
	BOD	Eq.ca.	BOD	Eq.ca	BOD	Eq.ca	BOD	Eq.ca	BOD	Eq.ca
Food	1000	16667	985	16416	42542	709033	6380	106333	50907	848449
Tannery	600	10000			310	5167	4000	66667	4910	81834
Chemistry					3800	63333			3800	63333
Paper					775	12917			775	12917
Slaugh.	90	1500			90	1500			180	3000
Carpet			120	2000					120	2000
Fuel oil					74	1233			74	1233
Metal					29	480			29	480
OIDs							515	8583	515	8583
Small Ids							25	417	25	417
TOTAL	1690	28167	1105	18416	47620	793663	10920	182000	61335	1022246

kg/d ca

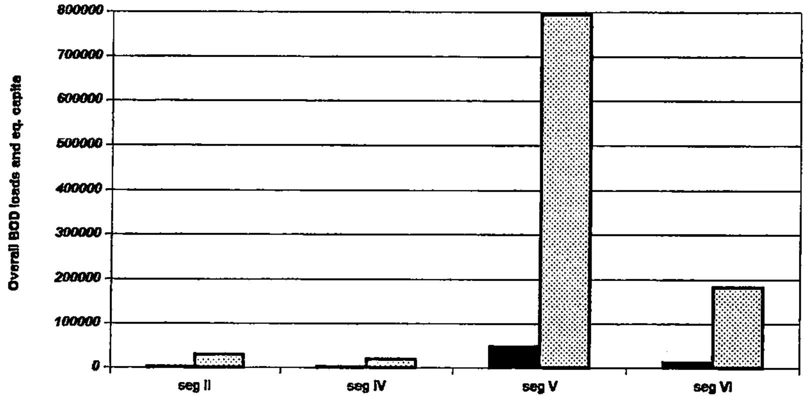
BOD loadings and equivalent population data are evaluated for each segment and the results are given in Figure 8.15.

According to available data and results, the industrial inputs to the river are in an increasing order from upstream to downstream. This is because of great industrialization in downstream sections, especially in Segment V and VI. There are few industries in Segment I. There is sufficient detention time in Demirkopru Dam and water is partially treated in the reservoir. In Segment II, available industries are mostly tanneries and none of them have treatment plants. If there were more available data, the segment could examined in more detail. Similarly in Segment III, there are no records of industries. Segment IV is the secondary polluted region in the basin. There are lots of food industries in the segment and there are also carpet manufacturing factories. The effect of the industrial pollution in the segment is 1105 kg/d BOD load and 18416 ca in terms of equivalent population.

Throughout the basin, the most polluted creek is Nif creek. There are uncontrolled discharges and insufficient treatments in the industries so that Nif creek has highly polluted water.

The downstream part is one of the highly polluted segments. There are small and big-scale organized districts in the section. Only the first segment and a part of the second section of Manisa OID have treatment plants and discharge treated wastewater.

The results of the presented study reflect only the effects of available data. These figures only give an idea of the degree of industrial pollution in the river due to existing data. *It is possible to say that there is an additional pollution of 2 million capita to the domestic pollution load.*



	seg II	seg IV	seg V	seg VI
■ BOD	1730	1105	47620	10920
□ EQ.CA	28834	18416	793663	182000

Figure 8.15. BOD loadings from each segment throughout the basin.

8.4. Preparation of the Input Data for the Model

The QUAL2E model is applied to the case of the Gediz river basin as steady-state simulation using annual values of variables. The annual values of the basic quality variables are obtained from DSI annual printed publications (DSI, 1987) as shown in **Appendix C**. The first step in model application is to divide the river system into reaches. Considering the hydraulic characteristics, cross-sectional areas and the location of gaging stations, the river is divided into 15 reaches as indicated on Fig. 8.16.

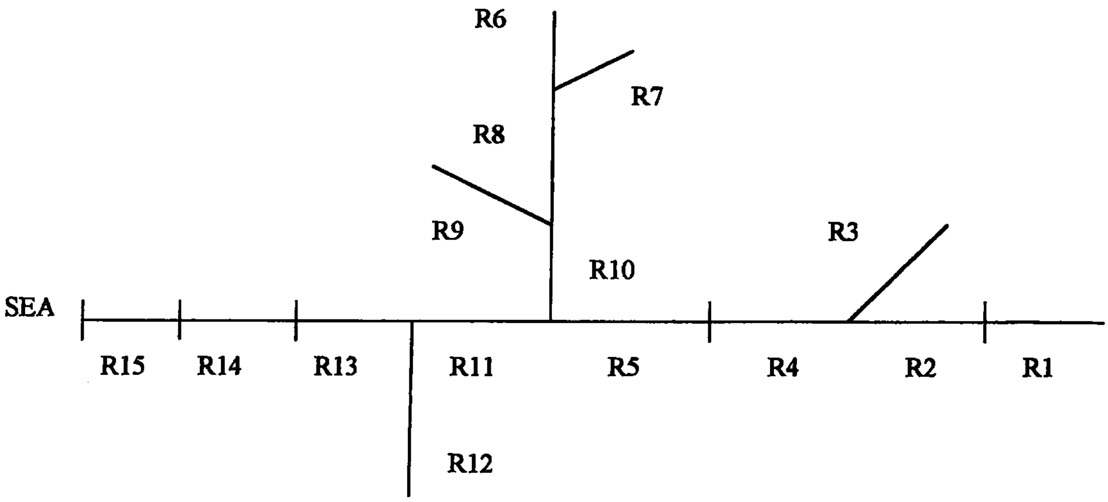


Figure 8.16. The River Reaches.

The initial step in the application is preparation and entering of relevant data using the AQUAL module. Next, the simulation runs are realized through the QUAL2E program module. The outputs are obtained in the form of water quality plots versus distance to show the annual variations of water quality along the river. The simulation data is entered as given in Table 8.13.

Table 8.13. "QUAL2E Simulation" Data Set.

Description of the run: Gediz River Basin

Simulation Type	**Units**
⊗ Steady State	O US units
O Dynamic	⊗ Metric

O Uncertainty analysis	
O Flow augmentation	
O Trapezoidal channels	

Maximum iterations	130
Time step	1
Starting day of simulation	180
Total simulation length	30
Time increment	1

Number of reaches	15

Among these data, the items "*maximum iterations*" and "*starting day of simulation*" should be determined for steady-state simulation, whereas *time step, starting day of simulation, total simulation length* and *time increment* are needed for dynamic simulation.

For the second data set, the reach connections are determined. As noted earlier, the selected river system is divided into reaches and computational elements in order to identify the system on the computer. The river is divided into 15 reaches. It has six headwaters (Alasehir, Demirkopru, Akhisar, Gordes, Kirkagac and Kemalpasa). By selecting the computational element length, Δx, as 4 km, each reach is divided into computational elements.

Another requirement for identifying the river system on the computer is to set the headwater and end location kilometers. These data are specified as in Table 8.14.

Table 8.14. "Stream system" Data Set.

Reach No	Reach Name	Beginning of reach (km)	End of reach (km)	Headwater element	Δx (km)
1	Alasehir	272	232	*	4
2	Salihli	232	212		4
3	Demirkopru	36	0	*	4
4	Ahmetli	212	188		4
5	Turgutlu	188	128		4
6	Akhisar	120	80	*	4
7	Gordes	36	0	*	4
8	Medar	80	44		4
9	Kirkagac	24	0	*	4
10	Saruhanli	44	0		4
11	Gediz	128	88		4
12	Kemalpasa	80	0	*	4
13	Manisa	88	60		4
14	Menemen	60	24		4
15	Foca	24	0		4

The computational element identification is given in Table 8.15. In order to specify the computational element types, the point load identifications must also be determined. The point loads identification data are set as given in Table 8.16. Figure 8.17 shows the graphical representations of domestic wastewater discharges along the river.

Table 8.15. "Computational elements type" Data Set.

No	C. E. no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	10	H	S	S	S	P	S	S	S	P	S										
2	5	S	P	P	S	U															
3	9	H	S	S	P	S	S	S	P	S											
4	6	J	S	S	P	S	S														
5	15	S	S	S	S	P	P	S	S	S	S	S	S	S	S	U					
6	10	H	S	S	S	P	S	S	S	S	U										
7	9	H	S	P	S	P	S	P	P	S											
8	9	J	S	S	S	S	S	S	S	U											
9	6	H	S	S	P	P	S														
10	11	J	S	S	S	S	S	P	P	S	S	S									
11	10	J	S	S	S	S	S	S	S	S	U										
12	20	H	S	S	S	S	S	S	P	S	S	P	S	S	S	S	S	S	S	S	S
13	7	J	S	S	P	S	S	S													
14	9	S	S	S	S	S	P	S	S	S											
15	6	S	S	P	S	S	E														

Table 8.16. Point Load Identification Data Set.

Reach No.	Code name	Name	Type
1	A	Sarigol	Domestic
1	B	Alasehir	Domestic, Industrial
2	C	Salihli	Domestic, Industrial
2*	C	Salihli	Domestic, Industrial
3	D	Demirci	Domestic
3	E	Selendi	Domestic
3	F	Kula	Domestic
4	G	Ahmetli	Domestic
5	H	Turgutlu	Domestic, Industrial
5*	H	Turgutlu	Domestic, Industrial
6	I	Akhisar	Domestic
7	J	Gordes	Domestic, Industrial
7*	J	Gordes	Domestic, Industrial
7	K	Koprubasi	Domestic
7	L	Golmarmara	Domestic
9	M	Kirkagac	Domestic, Industrial
9*	M	Kirkagac	Domestic, Industrial
10	N	Saruhanli	Domestic, Industrial
10*	N	Saruhanli	Domestic, Industrial
12	O	Kemalpasa	Domestic, Industrial
13	P	Manisa	Domestic, Industrial
14	R	Menemen	Domestic
15	S	Foca	Domestic

** : Point loads that added as another load because of model limitation of 1-1000 mg/l BOD.*

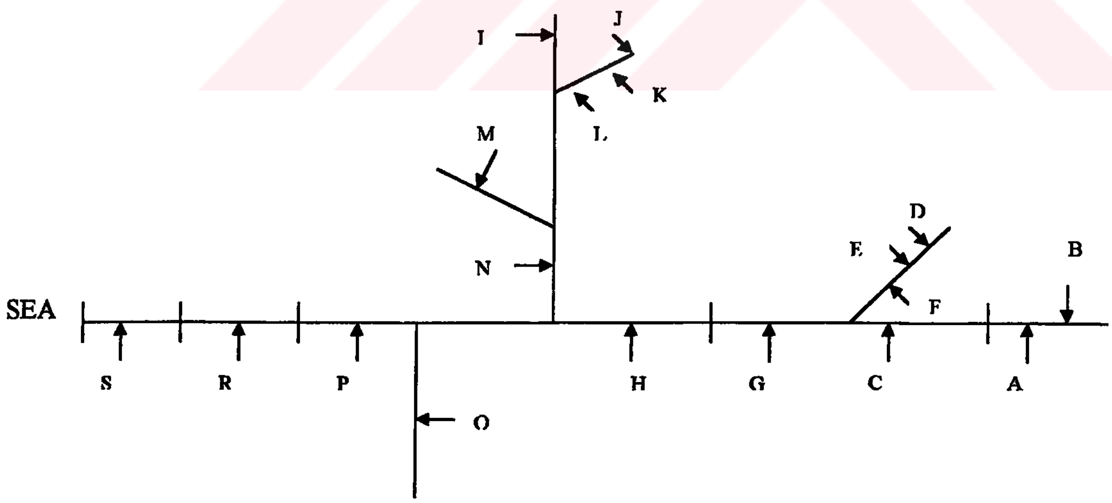


Figure 8.17. The Locations of Domestic Wastewater Discharges.

Using the above sets of information, the river system can be schematized on the screen as in Figure 8.18.

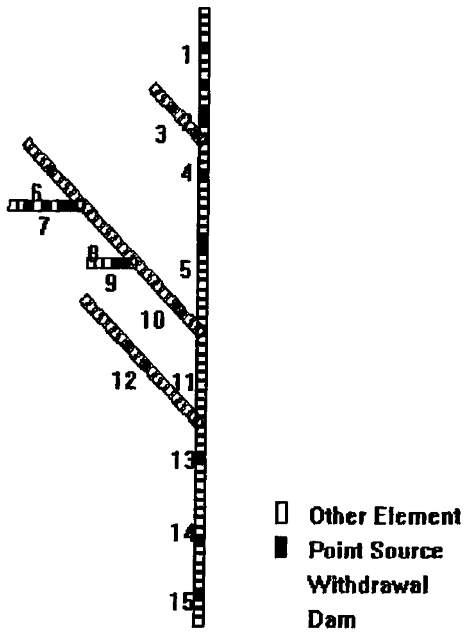


Figure 8.18. Schematized River System.

On "Water quality data" set, the water quality variables to be simulated are identified. Among the 15 water quality constituents that can be modeled with QUAL2E, 10 of them are selected in the scope of this study. Again on this screen, BOD can be defined as either 5-D BOD or ultimate BOD. Downstream boundary constituent concentrations can be specified if desired. These data are given in Table 8.17.

Table 8.17. "Water Quality Data" Set.

O Temperature	⊗ Conservative constituents Number of constituents 2 Constituent No 1 SS mg/l Constituent No 2 EC µmho/cm Constituent No 3
⊗ BOD	
O Algae	O Non conservative constituent
⊗ P cycle	O Specified d/s boundary constituent concentration
⊗ N cycle	O BODE Coefficient for converting 5-D to ultimate BOD 0.23
⊗ DO	
O Fecal coliform	

On the next data set, geographical data and climatological data types should be entered. These data are given in Table 8.18. In this data set, the climatological data section should not be entered for dynamic simulation.

Table 8.18. Geographical and Climatological Data Set.

Latitude (de)	34
Longitude (de)	85
Standard meridian (de)	75
Basin elevation (m)	304.8
Dust attenuation coefficient	0.06

AE ((m/h)/(m/bar))	6.2E-06
BE ((m/h)/(m/bar))	5.5E-06

Temperature correction factors
⊗ Default
O User specified

Climatological data
⊗ Reach variable temperature
O Global values
Climatological file

Output Print
⊗ Summary
O Climatological data printout

⊗ DO/BOD plot
Number of DO/BOD plots 4 Observed DO file

The reach numbers to be plotted and the number of observed dissolved oxygen stations are entered as given in Table 8.19, for the next data set.

Table 8.19. Reach Numbers for DO/BOD to be Plotted.

Plot No	No. loc.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	4	√	√		√	√						√		√	√	√
2	1			√												
3	1						√		√		√					
4	1												√			

The observed dissolved oxygen data are entered in the next step. 4 locations on the main stream and 1 location on each tributary, altogether 7 locations, are selected. Because only a single value of dissolved oxygen is available at a given location, this value is entered in the minimum data position. The data set is given in Table 8.20.

Table 8.20. Observed Dissolved Oxygen Data Set.

Plot	River location (km)	Min DO (mg/l)	Ave DO (mg/l)	Max DO (mg/l)
1	190.0	8.3	0.0	0.0
1	120.0	8.5	0.0	0.0
1	60.0	8.3	0.0	0.0
1	30.0	9.1	0.0	0.0
2	50.0	8.2	0.0	0.0
3	70.0	8.5	0.0	0.0
4	60.0	9.1	0.0	0.0

For purposes of the presented study, only *oxygen uptake by ammonia* and *nitrite oxidation* and *nitrification inhibition coefficient* can be entered because of the selected constituents. If algae simulation has been selected, then all the items on this screen could be entered. For these data, the default values are used. The items on this set are given in Table 8.21.

Table 8.21. Global Kinetics Data Set.

Oxygen uptake by	
Ammonia oxidation	3.43
Nitrite oxidation	1.14
Algae	
Oxygen production by growth	1.6
Oxygen uptake by respiration	2.0
Nitrogen content	0.085
Phosphorus content	0.014
Max. specific growth rate	2.5
Respiration rate	0.05
N half saturation coefficient	0.2
P half saturation coefficient	0.04
Linear coefficient	0.00246
Nonlinear coefficient	0.0

Light	
Light function	
Saturation coeff.	0.0298
Intensity	352.82
Light averaging from solar radiation	
Light averaging factor	0.923
Number of daylight hours	14
Daily radiation	352.82
Light nutrient reactions	
Algal preference factor for NH3	0.9
Solar radiation factor	0.44
Nitrification inhibition coefficient	10

The next data set is the temperature correction factors; again in this set, temperature correction factors should be entered according to the selected modeled parameters. If there is no measured value, as in the thesis, the default values can be used. This screen and the values are given in Table 8.22.

Table 8.22. Temperature Correction Factors.

BOD	
Decay	1.047
Settling	1.024
DO	
Reaeration	1.024
SOD uptake	1.060
Nitrogen	
Org-N decay	1.047
Org-N settling	1.024
Ammonia decay	1.083
Ammonia source	1.074
Nitrite decay	1.047
Phosphorus	
Organic P decay	1.047
Organic P settling	1.024
Dissolved P source	1.047
Algae	
Growth	1.047
Respiration	1.047
Settling	1.024
Coliform decay	1.047
Nonconservative	
Decay	1.000
Settling	1.024
Source	1.000

For the next step, hydraulic and climatological data should be entered. Since "Trapezoidal channels" option is not selected, values for the "Discharge coefficients" option are set on this screen.

In the study, with the cross-sectional areas of Baklaci, Urganli, Medar and Muradiye streams and values of the "Q-h diagrams" measured by EIE, velocity and height values are calculated according to the "Discharge coefficients" technique. Hydraulic data are set according to discharge coefficients. According to the method, the velocity is calculated by the $V = a\,Q^b$ equation and height is calculated with $D = c\,Q^d$ equation. For each reach, the dispersion constant (K), a, b, c and d coefficients and "n" Manning's coefficient are calculated according to the cross-sectional areas of the reaches. In Table 8.23, the cross-sectional area and flow values are given for each reach and hydraulic and climatological data set is entered as given in Table 8.24.

Table 8.23. Cross-sectional Areas and Q-h Values for the Selected Reaches.

Reach Number	Cross-sectional Area	"Q-h diagram" values
1-2-3	Baklaci stream	Baklaci Station
4-5	Urganli stream	Baklaci Station
6-7	Medar stream	Medar Station
8-9-10	Medar stream	Killik Station
11-12-13-14-15	Muradiye stream	Manisa Station

Table 8.24 Hydraulic and Climatological Data Set.

Reach No	Disp. Cons.	Q Coeff. Velocity	Q Expo. Velocity	Q Coeff. depth	Q Expo. depth	Manning n
1	200	0.180	0.604	5.232	0.035	0.05
2	200	0.180	0.604	5.232	0.035	0.05
3	200	0.180	0.604	5.232	0.035	0.05
4	6000	0.047	0.668	5.232	0.035	0.05
5	6000	0.047	0.668	5.232	0.035	0.05
6	146	0.073	0.756	0.547	0.288	0.05
7	146	0.077	0.580	0.745	0.280	0.05
8	146	0.077	0.580	0.745	0.280	0.05
9	146	0.077	0.580	0.745	0.280	0.05
10	146	0.077	0.580	0.745	0.280	0.05
11	436	0.185	0.357	0.232	0.509	0.05
12	436	0.185	0.357	0.232	0.509	0.05
13	436	0.185	0.357	0.232	0.509	0.05
14	436	0.185	0.357	0.232	0.509	0.05
15	436	0.185	0.357	0.232	0.509	0.05

BOD/DO reaction rate constants are set. These values are determined according to literature values and are given in Table 8.25.

Table 8.25. BOD/DO Reaction Rate Constants Data Set.

Reach No	BOD Decay(1/d)	BOD Sett.(1/d)	SOD rate	Type reaeration	Reaction Coeff.	Coeff. (1/d)	Expo.
1	1.5	1		Churchill	5.03	1	1.67
2	1.5	1		Churchill	5.03	1	1.67
3	1.5	1		Churchill	5.03	1	1.67
4	1.5	1		Churchill	5.03	1	1.67
5	1.5	1		Churchill	5.03	1	1.67
6	1.5	1		Churchill	5.03	1	1.67
7	1.5	1		Churchill	5.03	1	1.67
8	1.5	1		Churchill	5.03	1	1.67
9	1.5	1		Churchill	5.03	1	1.67
10	1.5	1		Churchill	5.03	1	1.67
11	1.5	1		Churchill	5.03	1	1.67
12	1.5	1		Churchill	5.03	1	1.67
13	1.5	1		Churchill	5.03	1	1.67
14	1.5	1		Churchill	5.03	1	1.67
15	1.5	1		Churchill	5.03	1	1.67

Nitrogen, phosphorus, algae and other coefficients are taken from literature values and presented in Table 8.26.

Table 8.26. N, P, Algae and Other Coefficients Data Set.

No	O-N Hyd.	O-N Sett.	NH3 Oxi.	NH3 Bent.	NO2 Oxi.	O-P Dec.	O-P Sett.	Dis P Bent.	Chl-a Alg.	Alg. Sett.	Lig. ext.
1	0.5	0.05	0.5	0	2	0.3	0.06	0	10	0.305	
2	0.5	0.05	0.5	0	2	0.3	0.06	0	10	0.305	
3	0.5	0.05	0.5	0	2	0.3	0.06	0	10	0.305	
4	0.5	0.05	0.5	0	2	0.3	0.06	0	10	0.305	
5	0.5	0.05	0.5	0	2	0.3	0.06	0	10	0.305	
6	0.5	0.05	0.5	0	2	0.3	0.06	0	10	0.305	
7	0.5	0.05	0.5	0	2	0.3	0.06	0	10	0.305	
8	0.5	0.05	0.5	0	2	0.3	0.06	0	10	0.305	
9	0.5	0.05	0.5	0	2	0.3	0.06	0	10	0.305	
10	0.5	0.05	0.5	0	2	0.3	0.06	0	10	0.305	
11	0.5	0.05	0.5	0	2	0.3	0.06	0	10	0.305	
12	0.5	0.05	0.5	0	2	0.3	0.06	0	10	0.305	
13	0.5	0.05	0.5	0	2	0.3	0.06	0	10	0.305	
14	0.5	0.05	0.5	0	2	0.3	0.06	0	10	0.305	
15	0.5	0.05	0.5	0	2	0.3	0.06	0	10	0.305	

Initial conditions data set should be entered for dynamic simulation. Since these data are required for dynamic simulation, they are not filled in for the steady-state simulation. On the next set, incremental inflow/outflow values can be set if incremental flow is used in the simulation. Incremental flow values are entered for each reach to represent the contribution of runoff from the drainage areas surrounding the reach. Incremental flow data is ignored in the study due to lack of available data.

Headwater data is necessary to simulate the river system. The entered data set is given in Table 8.27.

Table 8.27. Headwater Data Set (HW: Headwater number).

HW	Flow	Tem	DO	BOD	SS	EC	O-N	NH_3N	NO_2-N	NO_3-N	O-P	DisP
1	1.029	16.4	8.3	1.5	469	696		0.0	0.418	1.92		0.08
3	1.336	17.2	8.5	1.5	148	502		0.0	0.025	0.94		0.25
6	1.466	14.0	9.8		134	873		0.0	0.016	1.2		0.27
7	2.553	17.2	9.3		200	497		0.0	0.029	1.888		0.36
9	3.523											
12	0.802	17.4	9.1		233	566		0.0	0.97	1.5		0.35

On the next set, point load and withdrawal values are required. In the study, the available domestic and industrial inputs that are given in previous sections are taken into consideration. Point load discharges are given in Table 8.28.

Table 8.28. Domestic and Industrial Wastewater Discharges in the Basin.

Reach #	Name	Domestic		Industrial		Total		
		Q (m^3/d)	BOD (kg/d)	Q (m^3/d)	BOD (kg/d)	Q (m^3/s)	BOD (kg/d)	BOD (mg/l)
1	Sarigol	6944	2083			0.08	2083	300
	Alasehir	19624	5887	380	100	0.23	5987	563
2	Salihli	28603	8581	1310	1630	0.35	10211	1544
3	Demirci	9762	2929			0.11	2929	300
	Selendi	5075	1523			0.22	1523	300
	Kula	14153	4246				4246	300
4	Ahmetli	3733	1120			0.04	1120	300
5	Turgutlu	22955	6886	10466	16406	0.39	23292	1868
6	Akhisar	30481	9144			0.35	9144	300
7	Gördes	7582	2275	12	120	0.09	2395	1300
	Koprubasi	2320	696			0.03	696	300
	Golmarmara	3399	1020			0.04	1020	300
9	Kirkagac	9463	2839	50	96	0.11	2889	1220
10	Saruhanli	13026	3908	435	888	0.16	4343	2341
12	Kemalpasa	13445	4033	15185	31214	0.34	19218	2356
13	Manisa	51924	15577	23061	10920	0.87	38638	774
14	Menemen	19865	5960			0.23	5960	300
15	Foca	88995	26699			1.03	26699	300

The quality values of the modeled variables relevant to domestic wastewater are used as the literature values given in Table 8.29. Treatment fraction (TF) of each domestic wastewater discharge is assumed as zero - "0".

Table 8.29. Quality Values of the Modeled Variables.

Parameter	Value	Parameter	Value
Temperature(°C)	20	NO2-N (mg/l)	0
BOD (mg/l)	220 (110-440)	NO3-N (mg/l)	0
TDS (mg/l)	500 (250-850)	Org-P (mg/l)	3 (1-5)
Org-N (mg/l)	15 (8-35)	Dis-P (mg/l)	5 (3-10)
NH3-N (mg/l)	25 (12-50)		

After all the above computations, the data given in Table 8.30 are obtained. The table expresses flow in m^3/sec, temperature in ^{0}C, and quality variables in mg/lt. Because the model limitation allows the BOD load value between 1-1000 mg/l, the figures higher than 1000 mg/l BOD is entered as different point loads near to each other. These figures are entered with the symbol of *.

Table 8.30. Point Load Data Set.

Name	TF (%)	Flow	Temp	DO	BOD	SS
Sarigol	0	0.08	20	0	300	400
Alasehir	0	0.23	20	0	563	450
Salihli	0	0.35	20	0	1000	300
Salihli*	0	0.35	20	0	544	300
Demirci	0	0.11	20	0	300	300
Selendi Kula	0	0.22	20	0	600	500
Ahmetli	0	0.04	20	0	300	400
Turgutlu	0	0.39	20	0	1000	450
Turgutlu*	0	0.39	20	0	868	450
Akhisar	0	0.35	20	0	300	300
Gördes	0	0.09	20	0	1000	350
Gördes*	0	0.09	20	0	300	350
Koprubasi	0	0.03	20	0	300	400
Golmarmara	0	0.04	20	0	300	450
Kirkagac	0	0.11	20	0	1000	500
Kirkagac*	0	0.11	20	0	220	500
Saruhanli	0	0.16	20	0	1000	550
Saruhanli*	0	0.16	20	0	1000	550
Kemalpasa	0	0.34	20	0	1000	600
Manisa	0	0.87	20	0	774	650
Menemen	0	0.23	20	0	300	500
Foca	0	1.03	20	0	300	450

** : Point loads that added as another load because of model limitation of 1-1000 mg/l BOD.*

Table 8.30. (continued).

Name	Org N	NH3-N	NO2-N	NO3-N	Org-P	Dis-P
Sarigol	20	30	0	0	5	5
Alasehir	20	30	0	0	5	5
Salihli	20	30	0	0	5	5
Salihli*	20	30	0	0	5	5
Demirci	20	30	0	0	5	5
Selendi	20	30	0	0	5	5
Kula	20	30	0	0	5	5
Ahmetli	20	30	0	0	5	5
Turgutlu	20	30	0	0	5	5
Turgutlu*	20	30	0	0	5	5
Akhisar	20	30	0	0	5	5
Gördes	20	30	0	0	5	5
Gördes*	20	30	0	0	5	5
Koprubasi	20	30	0	0	5	5
Golmarmara	20	30	0	0	5	5
Kirkagac	20	30	0	0	5	5
Kirkagac*	20	30	0	0	5	5
Saruhanli	20	30	0	0	5	5
Saruhanli*	20	30	0	0	5	5
Kemalpasa	20	30	0	0	5	5
Manisa	20	30	0	0	5	5
Menemen	20	30	0	0	5	5
Foca	20	30	0	0	5	5

** : Point loads that added as another load because of model limitation of 1-1000 mg/l BOD.*

Since steady-state simulation is used in the study, climatological data should be set as global values. Global climatological data are entered and presented in Table 8.31. These data are obtained from DMI (State Meteorological Works). The data obtained from DMI are given in **Appendix D**. Since the climatological data are reach variable, for reaches 1 to 5, Alasehir village data; for reach 6, Akhisar village data; for reaches 7 and 8, Salihli village data and for reaches through 9 to 13, Manisa village data are used. Global values are also determined from these data set.

Table 8.31. Global Climatological Data Set.

Month	Day	Year	Hour	Solar Rad.	Cloud cover	Dry Temp.	Wet Temp.	Baro. Press.	Wind speed
6	15	1983	12			15.6	42.5	1017.0	1.7

8.5. Model Results and Evaluation

As stated in the previous section, the model is run for flowrate and the water quality variables; DO, BOD, N cycle (organic, ammonia, nitrite and nitrate nitrogen), P cycle (organic and dissolved phosphorus), suspended solids and electrical conductivity. The model is run with the annual values of water quality variables. Since the most complete set of water quality observations in the Gediz basin are available for 1983, the data of this year are used to represent the annual values. On the other hand, the point load is dated to the year 2000. Because this model run is for a demonstrative purpose, only the available systematic data is used without fitting the date of input data. Using these values, the results are obtained in the form of graphs and tables for each modeled variable along the main stream. Under these constraints, the result for the current situation is not reliable. The main purpose of the study is to emphasize the use of models in integrated management concept and to determine that models are the main tools in water quality assessment with available complete set of input data.

In the first step, flow versus distance graph is obtained to see the variation of streamflow along the river and resulting graph is shown in Figure 8.19. Along the main stream, the quantity of water increases with confluence of tributaries on the 60th, 144th and 184th kilometers from upstream. On the other hand, each point load input increases the total flowrate. Because the flowrates in headwaters are low, the model simulates according to this value and cannot reach the real value of river flowrate.

The flowrate is an important issue besides water quality parameters in a river system. Also, the relationship between water quality and flow in streams and rivers deserves special mention. Stream flow directly influences many physical features (e.g., depth, velocity, turbulence, reaeration and volatilization), while it also indirectly influences nutrient uptake by attached algae. The velocity and depth associated with a specific flow regime also define the residence time in a reach, which directly influences reach temperature and the spatial expression of decay rates.

The most widely used parameter of organic pollution applied to both wastewater and surface water is the 5-day BOD (BOD_5). This determination involves the measurement of the dissolved oxygen used by microorganisms in the biochemical oxidation of organic matter. BOD is a measure of the quantity of oxygen consumed by microorganisms during the decomposition of organic matter. BOD is the most commonly used parameter for determining the oxygen demand of the receiving water of a municipal or industrial discharge.

BOD is typically divided into two parts- carbonaceous oxygen demand and nitrogenous oxygen demand. Carbonaceous biochemical oxygen demand (CBOD) is the result of the breakdown of organic molecules such as cellulose and sugars into carbon dioxide and water. Nitrogenous oxygen demand is the result of the breakdown of proteins. Proteins contain sugars linked to nitrogen. After the nitrogen is "broken off" into a sugar molecule, it is usually in the form of ammonia, which is readily converted to nitrate in the environment. The conversion of ammonia to nitrate requires more than four times the amount of oxygen as the conversion of an equal amount of sugar to carbon dioxide and water.

In the study, the flowrate graph shows only the increase in flow due to tributary contributions and point load inputs. In the graph, it is possible to see the increasing points due to inputs and contributions.

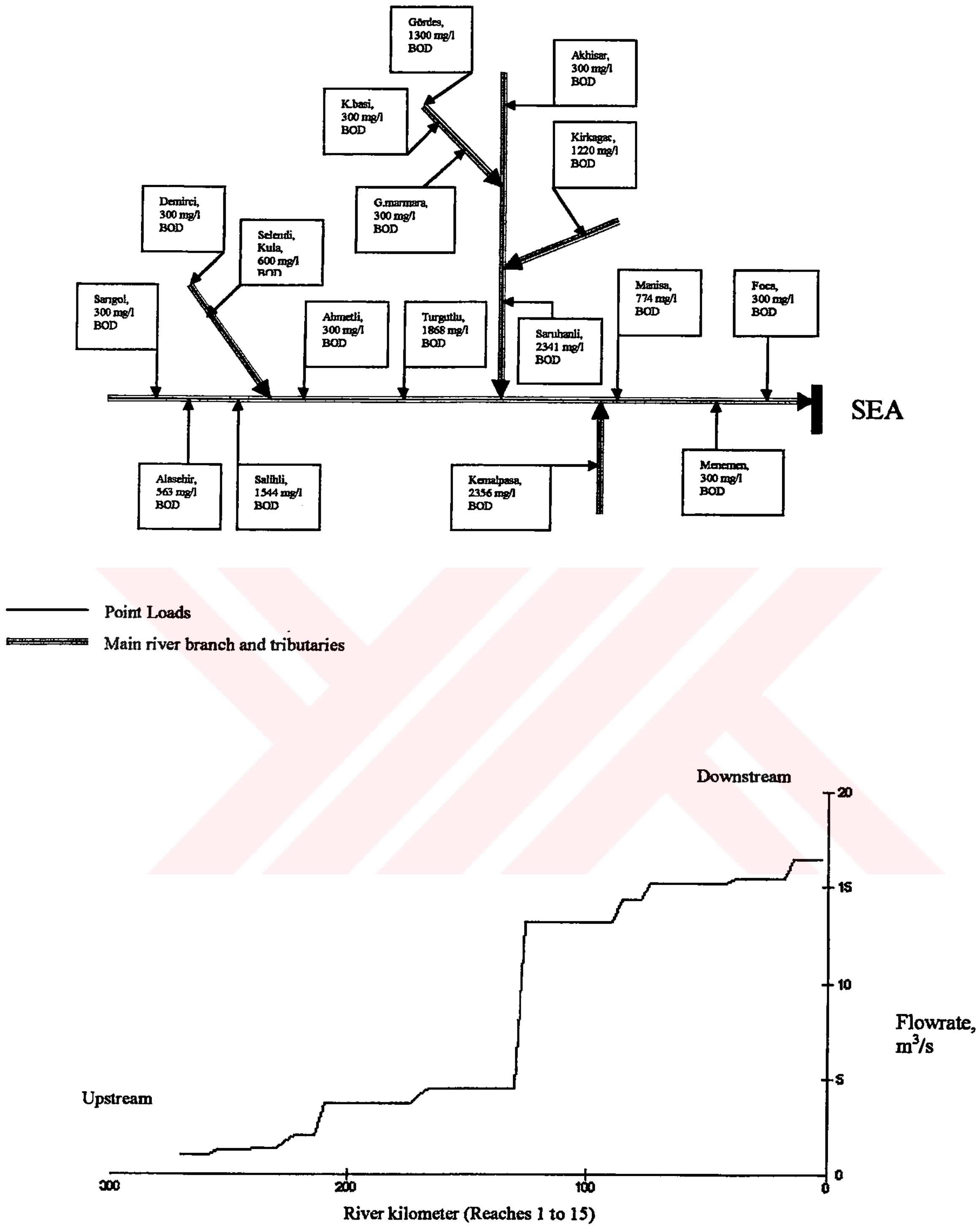


Figure 8.19. Flow vs. distance graph on the Main Stream.

Performing the test for BOD requires significant time and commitment for preparation and analysis. The entire process requires five days, with data collection and evaluation occurring on the last day. Samples are initially seeded with microorganisms and saturated with oxygen (Some samples, such as those from sanitary wastewater treatment plants, contain natural populations of microorganisms and do not need to be seeded.). The sample is placed in an environment suitable for bacterial growth (an incubator at 20° Celsius with no light source to eliminate the possibility of photosynthesis). Conditions are designed so that oxygen will be consumed by the microorganisms. Quality controls, standards and dilutions are also run to test for accuracy and precision. The difference in initial DO readings (prior to incubation) and final DO readings (after 5 days of incubation) is used to determine the initial BOD concentration of the sample. This is referred to as a BOD_5 measurement. Similarly, carbonaceous biochemical oxygen test performed using a 5-day incubation is referred to as a $CBOD_5$ test.

When nutrients such as nitrate and phosphate are released into the water, growth of aquatic plants is stimulated. Eventually, the increase in plant growth leads to an increase in plant decay and a greater "swing" in the diurnal dissolved oxygen level. The result is an increase in microbial populations, higher levels of BOD, and increased oxygen demand from the photosynthetic organisms during the dark hours. This results in a reduction in dissolved oxygen concentrations, especially during the early morning hours just before dawn.

In addition to natural sources of BOD, such as leaf fall from vegetation near the water's edge, aquatic plants, and drainage from organically rich areas like swamps and bogs, there are also anthropogenic (human) sources of organic matter. If these sources have identifiable points of discharge, they are called point sources. The major point sources, which may contribute high levels of BOD, include wastewater treatment facilities, pulp and paper mills, and meat and food processing plants.

Organic matter also comes from sources that are not easily identifiable, known as non-point sources. Typical non-point sources include agricultural runoff, urban runoff, and livestock operations. Both point and non-point sources can contribute significantly to the oxygen demand in a lake or stream if not properly regulated and controlled.

For the values of BOD – the indicator of pollution- the variation of water quality can be observed in Figure 8.20 along the main river stream. All the input loads dilute in the river system. A natural river system has a limited capacity of dilution. On the situation of high input loads, it cannot dilute. Input loads oxidize in transportation in river system generally due to Streeter-Phelps equation given as;

$$b_t = b_o \cdot e^{-k_1 t} \qquad \text{(Eq. 8.4)}$$

where;

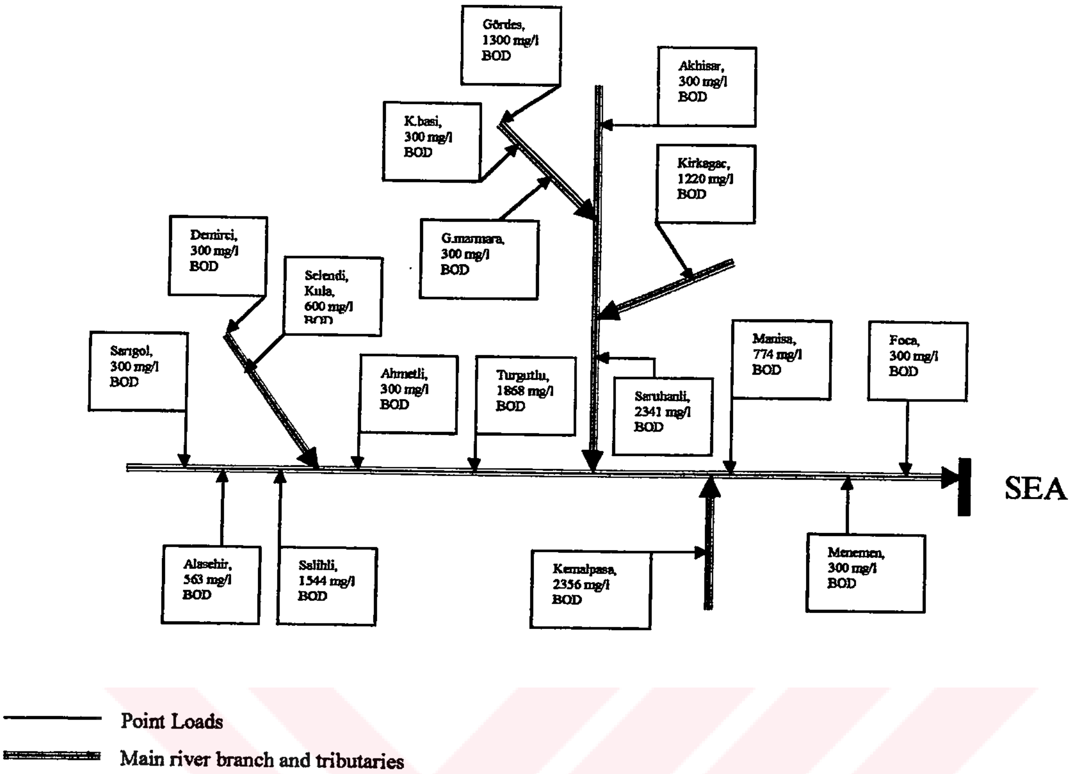
b_t = organic matter concentration, g/m^3 BOD

b_o = initial BOD concentration, g/m^3 BOD

k_1 = biochemical reaction rate constant, day^{-1}

t = time, day

The value of BOD decreases by drawing near to downstream of the system; it only increases by the new input loads. According to the model result, a great BOD load comes from Demirkopru tributary including mainly domestic loads. As seen in Figure 8.20, it is seen that there is no serious BOD input from Medar tributary. The same situation occurs in Nif tributary. Fundamentally, according to recent data, Nif is very polluted. In real situation, river is highly polluted in the downstream so that available model results are not reliable because of existing data.



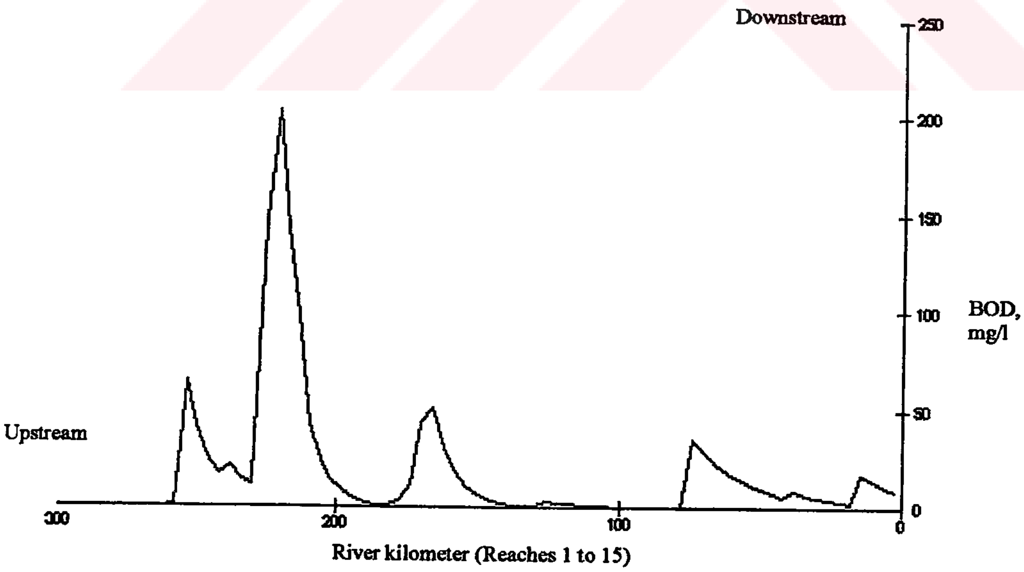


Figure 8.20 BOD (mg/l) on the Main Stream.

Oxygen is a chemical that is found both in the air and dissolved in water. It is necessary for all living things and for many of the chemical processes that take place in water. Dissolved oxygen (DO) refers to the volume of oxygen that is contained in water. Oxygen enters the water by photosynthesis of aquatic biota and by the transfer of oxygen across the air-water interface. The amount of oxygen that can be held by the water depends on the water temperature, salinity, and pressure. Gas solubility increases with decreasing temperature (colder water holds more oxygen). Gas solubility increases with decreasing salinity (freshwater holds more oxygen than does saltwater). Both the partial pressure and the degree of saturation of oxygen will change with altitude . Finally, gas solubility decreases as pressure decreases. Thus, the amount of oxygen absorbed in water decreases as altitude increases because of the decrease in relative pressure.

Once absorbed, oxygen is either incorporated throughout the water body via internal currents or is lost from the system. Flowing water is more likely to have high dissolved oxygen levels than is stagnant water because of the water movement at the air-water interface. In flowing water, oxygen-rich water at the surface is constantly being replaced by water containing less oxygen as a result of turbulence, creating a greater potential for exchange of oxygen across the air-water interface. Because stagnant water undergoes less internal mixing, the upper layer of oxygen-rich water tends to stay at the surface, resulting in lower dissolved oxygen levels throughout the water column. Oxygen losses readily occur when water temperatures rise, when plants and animals respire, and when microbes aerobically decompose organic matter.

Microbes play a key role in the loss of oxygen from surface waters. Microbes use oxygen as energy to break down long-chained organic molecules into simpler, more stable end-products such as carbon dioxide, water, phosphate and. As the organic molecules are broken down by microbes, oxygen is removed from the system and must be replaced by exchange at the air-water interface.

Each step above results in consumption of dissolved oxygen. If high levels of organic matter are present in a water, microbes may use all available oxygen.

The introduction of excess organic matter may result in a depletion of oxygen from an aquatic system. Prolonged exposure to low dissolved oxygen levels (<5 - 6 mg/l) may not directly kill an organism, but will increase its susceptibility to other environmental stresses. Exposure to < 30% saturation (<2 mg/l oxygen) for one to four days may kill most of the biota in a system. If oxygen-requiring organisms perish, the remaining organisms will be air-breathing insects and anaerobic (not requiring oxygen) bacteria.

If all oxygen is depleted, aerobic (oxygen-consuming) decomposition ceases and further organic breakdown is accomplished anaerobically. Anaerobic microbes obtain energy from oxygen bound to other molecules such as sulfate compounds. Thus, anoxic conditions result in the mobilization of many otherwise insoluble compounds. The breakdown of sulfate compounds will often impart a "rotten-egg" smell to the water, affecting its aesthetic value and preventing recreational use.

Model results of DO concentration fluctuations can be seen in Figure 8.21. In the input of organic matter to the system, oxygen is consumed, then oxygen is enriched by aeration. This is realized by again Streeter-Phelps equation given in Eq. 8.4. Parallel to BBOD fluctuation, by the confluence of Demirkopru tributary to the main stream, DO becomes “0-zero”. DO becomes below “0-zero” between 250th and 360th kilometer from downstream, but this is not a possible situation in real system. This is because of the discrepancy between pollution loads and river quality data. If the data were updated, the result would have been more reliable.

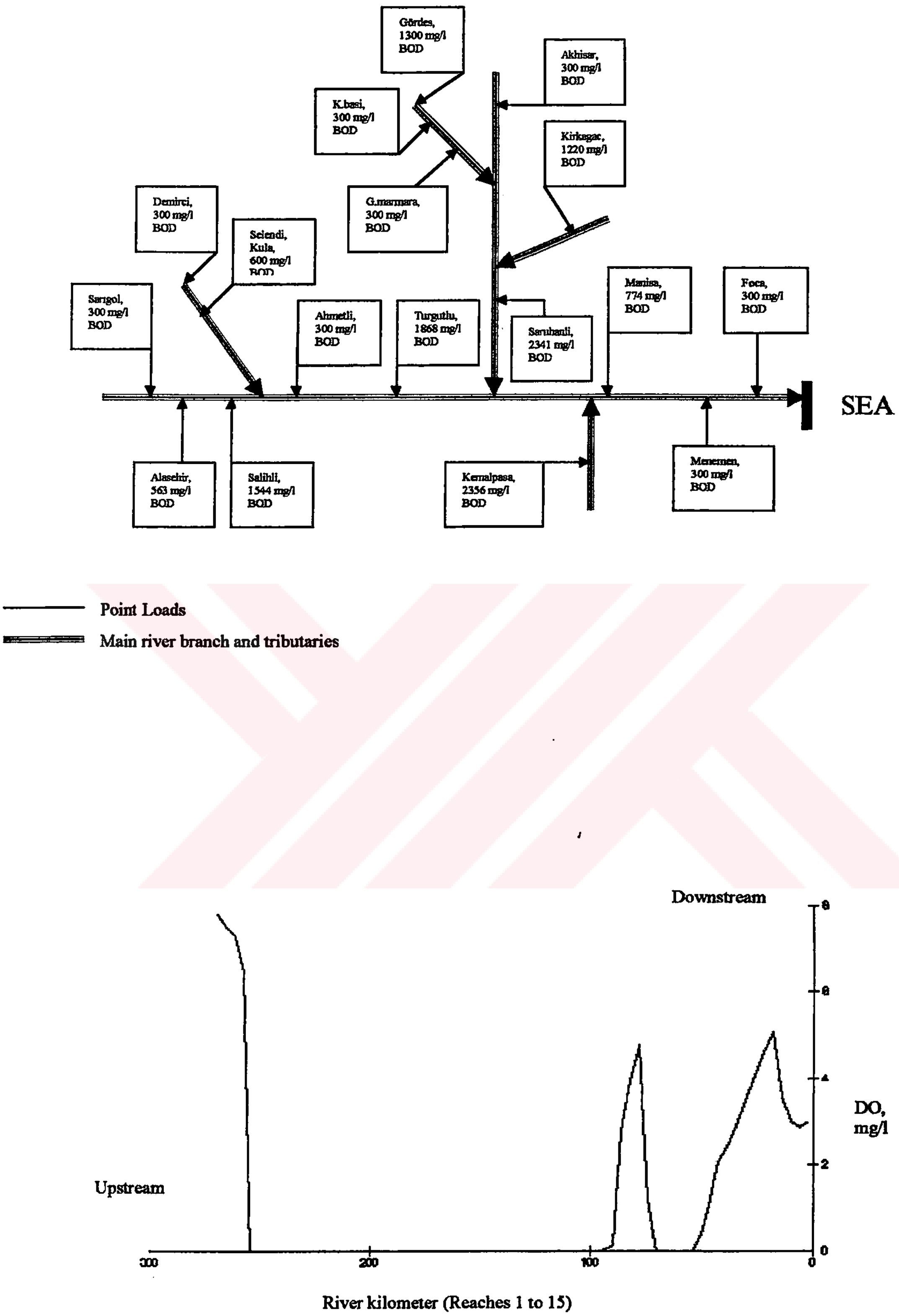


Figure 8.21 DO (mg/l) on the Main Stream.

One of the biggest sources of water pollution is suspended solids. When the suspended particles settle to the bottom of a water body, they become sediments. The terms "sediment" and "silt" are often used to refer to suspended solids. Suspended solids consist of an inorganic fraction (silts, clays, etc.) and inorganic fraction (algae, zooplankton, bacteria, and detritus) that are carried along by water as it runs off the land. The inorganic portion is usually considerably higher than the organic. Both contribute to turbidity, or cloudiness of the water. Waters with high sediment loads are very obvious because of their "muddy" appearance. This is especially evident in rivers, where the force of moving water keeps the sediment particles suspended.

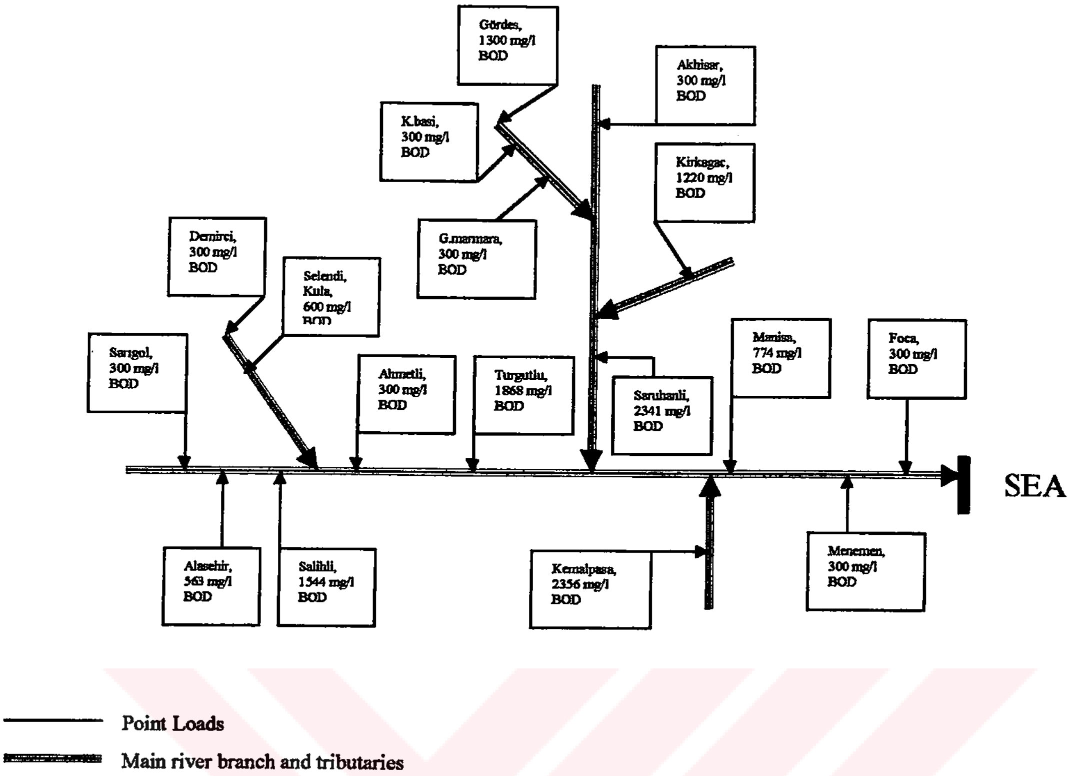
The geology and vegetation of a watershed affect the amount of suspended solids. If the watershed has steep slopes and is rocky with little plant life, top soil will wash into the waterway with every rain. On the other hand, if the watershed has lots of firmly rooted vegetation, it will act as a sponge to trap water and soil and thereby eliminate most erosion. Most suspended solids come from accelerated erosion from agricultural land, logging operations (especially where clear-cutting is practiced), surface mining, and construction sites. Another source of suspended solids is the resuspension of sediments which accompanies dredging that is undertaken to keep navigation channels open in larger rivers.

Suspended solids can clog fish gills, either killing them or reducing their growth rate. They also reduce light penetration. This reduces the ability of algae to produce food and oxygen. When the water slows down, as when it enters a reservoir, the suspended sediment settles out and drops to the bottom, a process called siltation. This causes the water to clear, but as the silt or sediment settles it may change the bottom. The silt may smother bottom-dwelling organisms, cover breeding areas, and smother eggs.

Indirectly, the suspended solids affect other parameters such as temperature and dissolved oxygen. Because of the greater heat absorbency of the particulate matter, the surface water becomes warmer and this tends to stabilize the stratification (layering) in stream pools, embayments, and reservoirs. This, in turn, interferes with mixing, decreasing the dispersion of oxygen and nutrients to deeper layers.

Several methods may be employed to determine suspended solids or the turbidity which it causes. The method employed in this study determines total suspended solids (TSS). A well mixed sample is filtered through a reweighed glass filter. The filter is then dried in a drying oven and reweigh. The weight gain represents the total suspended solids. It is expressed in mg/L. Turbidity is measured using a turbidity meter and expressed in turbidity units. In deep waters, a secchi disk may be used to determine light penetration or transparency. A secchi disk is a weighted disk painted with alternating quarters of black and white. Recording the depth at which the disk disappears from view provides an estimation of the water's transparency.

In the Gediz basin, SS shows a decrease from upstream to downstream as given in Figure 8.22. It is interesting and not expected that the SS concentration is relatively high at the downstream of the dam. However, existing data shows such a contradictory result. Suspended solids show a decreasing trend because of both the erosion in the river and the anthropologic pollution loads. This is also a function of river slope and morphological characteristics. Generally SS concentration in the Fig. 8.22 varies from 200 to 48 mg/l, similar to that in domestic wastewater with a typical SS concentration of 200-400 mg/l. It can only be said that these data are likely due to the inert components (e.g., sand) in the river system whereas in domestic wastewater, the significant fraction of SS is due to particular organic discharges. The main reason of the decrease in SS concentration along the river system is the increase of flow upstream to downstream.



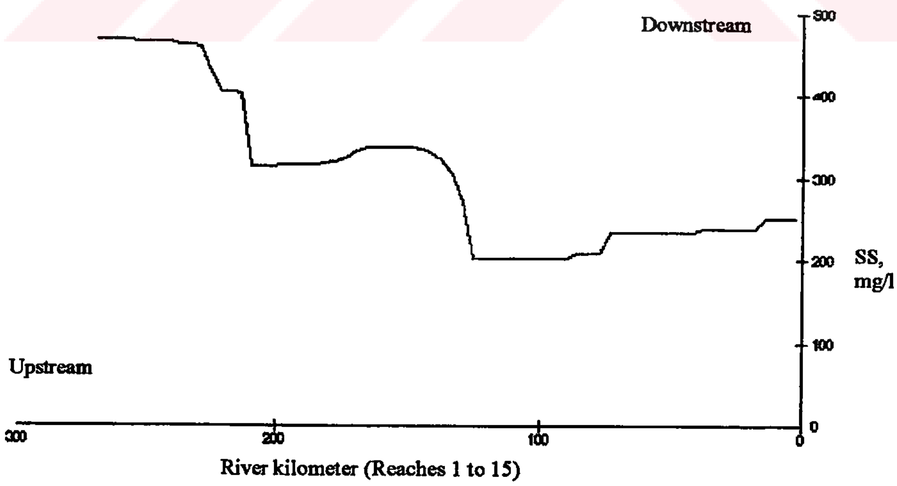


Figure 8.22 SS (mg/l) on the Main Stream.

Conductivity is the ability of a solution to conduct an electric current due to the presence of dissolved salts (ions). Conductivity is also known as salinity and total dissolved solids. Salinity of an irrigation water is determined by measuring its electrical conductivity and is the most important parameter in determining the suitability of a water for irrigation. The electrical conductivity (EC) of a water is used as surrogate measure of total dissolved solids (TDS) concentration.

Aquatic plants and animals need the natural salts contained in water for growth. If the conductivity increases above the normal range of the particular water, the normal community will become stressed and sensitive species will start to die out. Conductivity is effected primarily by the geology of the area, but flow and human caused changes to catchments can significantly alter natural conductivity levels.

Conductivity is measured using a conductivity meter and is reported in microsiemens (&microS/cm). It should be noted that one mmho/cm is equivalent to one dS/m. Values for salinity are also reported as TDS in mg/l. For most agricultural irrigation purposes, the values for EC and TDS are directly related and convertible within an accuracy of about 10 percent. Equation 8.5 can be used to convert EC values to corresponding TDS values;

$$\text{TDS (mg/l)} \approx \text{EC (mmho/cm or dS/m)} * 640 \qquad \text{(Eq. 8.5)}$$

EC shows again a decreasing trend through upstream to downstream along the river as given in Figure 8.23. It is shown that a great decrease at the confluence of Demirkopru tributary to the main stream, and there is no significant difference in EC concentration after contribution.

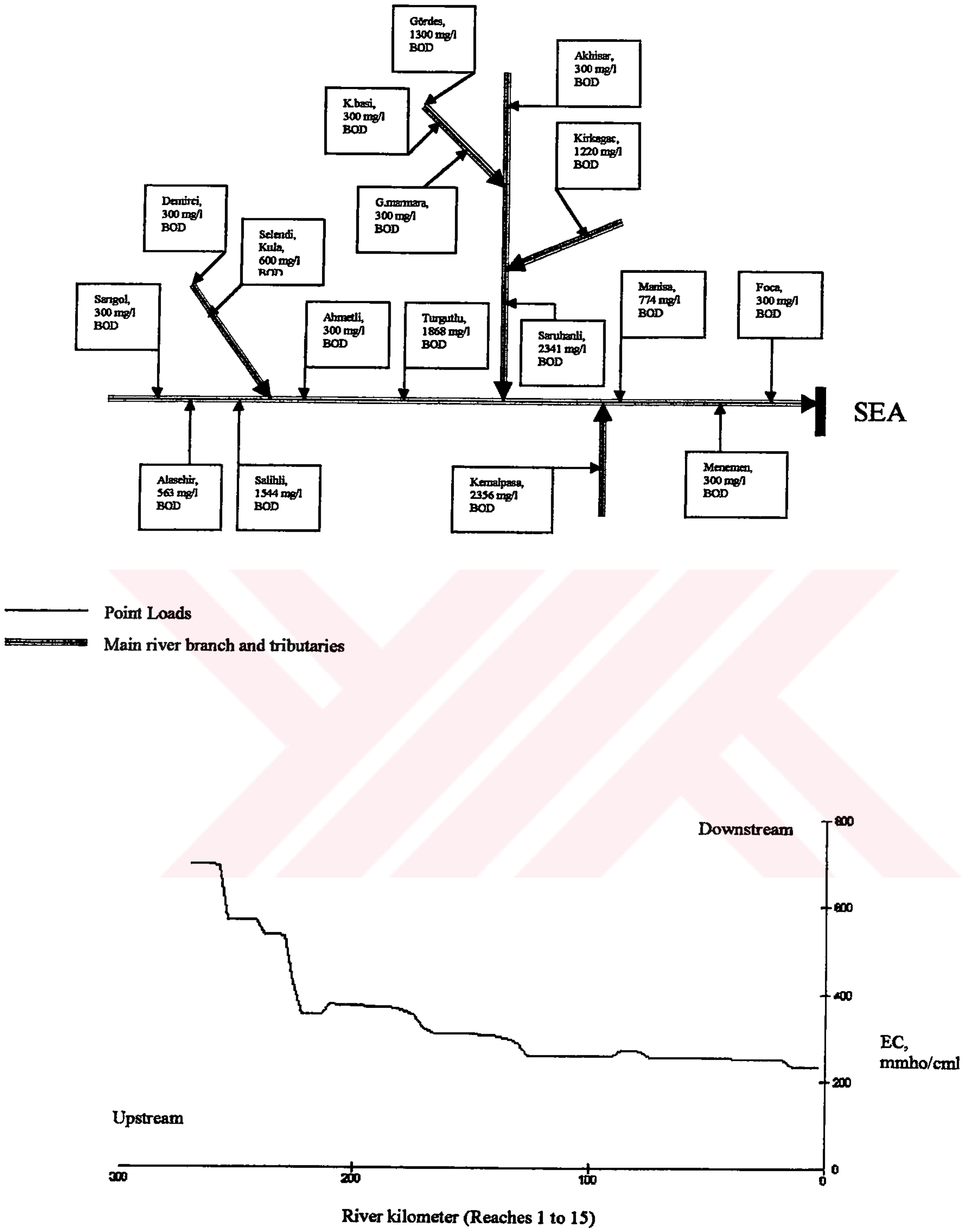


Figure 8.23 EC (μmho/cm) on the Main Stream.

The transport of nutrients from their sources to the waterbody of concern is governed by several chemical, physical and biological processes, which together compose the nitrogen or phosphorus cycle.

Nitrogen continuously cycles in the aquatic environment, although the rate is temperature controlled and thus very seasonal. Aquatic organisms decompose and nitrogen is released as ammonia ions and then converted to nitrite and nitrate, where the process begins again. If a source water lacks adequate nitrogen, nitrogen-fixing organisms can convert nitrogen from its gaseous phase to ammonia ions.

Nitrogen cycle can be measured in several different forms (total nitrogen, nitrate-nitrogen, nitrite-nitrogen and ammonia). The directly available forms are mainly inorganic (nitrate-nitrogen and ammonia), although some algae can use organic forms. As with total phosphorus, total Kjeldahl nitrogen (TKN) is often a good predictor of algal biomass in lakes and reservoirs because much of the particulate fraction already is in the algae. (TKN isthe total of organic and ammonia nitrogen in a sample, determined by Kjeldahl method)

The ammonia molecule is a nutrient required for life. However, if excess ammonia is available, free ammonia may accumulate in the body and cause deleterious secondary effects, such as alteration of metabolism or increases in the body pH.

Ammonia levels in excess of the recommended limits may harm aquatic life. Although the ammonia molecule is a nutrient required for life, excess ammonia may accumulate in the organism and cause alteration of metabolism or increases in body pH. Fish may suffer a loss of equilibrium, hyper excitability, increased respiratory activity and oxygen uptake, and increased heart rate.

Ammonia can be transported to a surface water body by the following means:

1. Overland flow after precipitation or irrigation event.
2. Direct discharge in effluents from industry or sewage treatment plants.
3. Deposition of airborne particulates.

Nonpoint source of ammonia: (a) Natural: Bacteria produce ammonia during decomposition of proteins and other nitrogenous organic substances in the water and benthic sediments. Animal and human excrement may contribute an insignificant amount of ammonia, (b) Agricultural: The primary agricultural sources include accidental releases of ammonia-rich fertilizer during transport (because of vehicle accident, faulty hose connections, and human error); and livestock waste (from barnyards, feedlots, pastures, and rangeland), (c) Residential and Urban: Household use of ammonia-containing cleaning products and improper disposal of ammonia products may contribute to non-point pollution, and (d) Other: Evidence suggests that the atmospheric deposition of nitrogen (directly and via rainfall) constitutes a large portion of total nitrogenous inputs to estuarine and marine systems and a somewhat lesser portion of total N inputs to freshwater systems. Ammonia in the atmosphere is derived from combustion processes such as domestic heating, burning of municipal waste, and internal-combustion engines.

Point source of ammonia: The following industrial processes produce ammonia emissions and effluent: conversion of coal to coke in coke plants, metallurgic operations, ceramic production, strip mining, chemical synthesis (nitric acid, synthetic monomers, and plastics), waste gas treatment, sewage treatment plants, ammonium nitrate explosive production, production of refrigeration equipment, production of household cleaners, oil refineries, and food processing.

The nitrogen cycle is composed of four processes. Three of the processes--fixation, ammonification, and nitrification--convert gaseous nitrogen into usable chemical forms. The fourth process, denitrification, converts fixed nitrogen back to the unusable gaseous nitrogen state.

- *Nitrogen fixation* is the conversion of nitrogen in its gaseous state to ammonia or nitrate. Nitrate is the product of high-energy fixation by lightning, cosmic radiation, and meteorite trails. In high-energy fixation, atmospheric nitrogen and oxygen combine to form nitrates, which are carried to the earth's surface in rainfall as nitric acid. High-energy fixation accounts for little (10%) of the nitrate entering the nitrogen cycle. In contrast, biological fixation accounts for 90% of the fixed nitrogen in the cycle. In biological fixation, molecular nitrogen (N_2) is split into two free N molecules. The N molecules combine with hydrogen (H) molecules to yield ammonia (NH_3). The fixation process is accomplished by a series of different microorganisms. The symbiotic bacteria *Rhizobium* is associated with the roots of legumes. To a lesser extent, some root-noduled nonleguminous plants also exhibit symbiotic relationships with bacteria. Some free-living aerobic bacteria, such as *Azobacter* and *Clostridium*, freely fix nitrogen in the soil. Finally, blue-green algae (cyanobacteria) such as *Nostoc* and *Calothrix* can fix nitrogen both in the soil and in water, yielding ammonia as the stable end product.
- *Ammonification* is a one-way reaction in which organisms break down amino acids and produce ammonia (NH_3).
- *Nitrification* is the process in which ammonia is oxidized to nitrite and nitrate, yielding energy for decomposer organisms. Two groups of microorganisms are involved in nitrification. *Nitrosomonas* oxidizes ammonia to nitrite and water. Subsequently, *Nitrobacter* oxidizes the nitrite ions to nitrate.
- *Denitrification* is the process in which nitrates are reduced to gaseous nitrogen. This process is used by facultative anaerobes. These organisms flourish in an aerobic environment but are also capable of breaking down oxygen-containing compounds (e.g. NO_3-N) to obtain oxygen in an anoxic environment. Examples include fungi and the bacteria *Pseudomonas*.

Nonpoint sources of nitrate and nitrite: (a) Agriculture: Primary agricultural sources of nitrate include livestock excrement (from barnyards, pastures, rangeland, feedlots, and uncontrolled manure storage areas); nitrogenous fertilizers; irrigation return flows; and decomposing plant debris, (b) Residential and Urban: Primary residential sources of nitrate include nitrogenous fertilizer used on lawn and garden, leaky on-site wastewater disposal/septic systems, sewage treatment system outfalls, sewage treatment bypass outfalls, and domestic pet excreta, and (c) Other: The combustion of fossil fuels, industrial and agricultural discharges of nitrogen-containing gases, aerosols, and air-borne particles contribute to the atmospheric nitrogen load. Evidence suggests that the atmospheric deposition of nitrogen in water bodies (directly and via rainfall) constitutes a large portion of total nitrogenous inputs to estuarine and marine systems and a somewhat lesser portion of total nitrogen inputs to freshwater systems. Additional nitrate sources include excreta both from wild animals in the surrounding watersheds, excreta from wildfowl congregating on the water body and boats that discharge raw sewage overboard.

Point source of nitrate and nitrite: Industries that use nitrates in manufacturing may release nitrate in the effluent water. Nitrate is used in the following processes: meat curing, production of fertilizer, explosives, glass, heat-transfer fluid, and heat-storage medium for solar-heating applications. Additional nitrates may be contributed by sewage treatment systems and sewage treatment bypass outfalls (during high flow periods). Estuaries may be particularly susceptible to nutrient enrichment from offshore sewage pipe outfalls.

Water carries nitrates to surface water systems in 1) overland flow (runoff), 2) unsaturated flow, and 3) ground water flow. Overland flow is the most direct route for water transportation. Underground flow is less direct because water flow is impeded by soil permeability and porosity constraints.

The nitrogen cycle graph is given in Figure 8.24. High N contents may not cause problem in irrigation, however, high nitrate concentration indicates high pollution levels. Due to oxygenation in river, ammonia and organic nitrogen quickly convert to NO_2-N to final product NO_3-N. A peak is observed in the 150th kilometer from upstream. This may be due to the high potential of farming on the upper parts of basin (e.g., agriculture, irrigation). In the downstream, activity changes to industries and point loads from irrigation purposes.

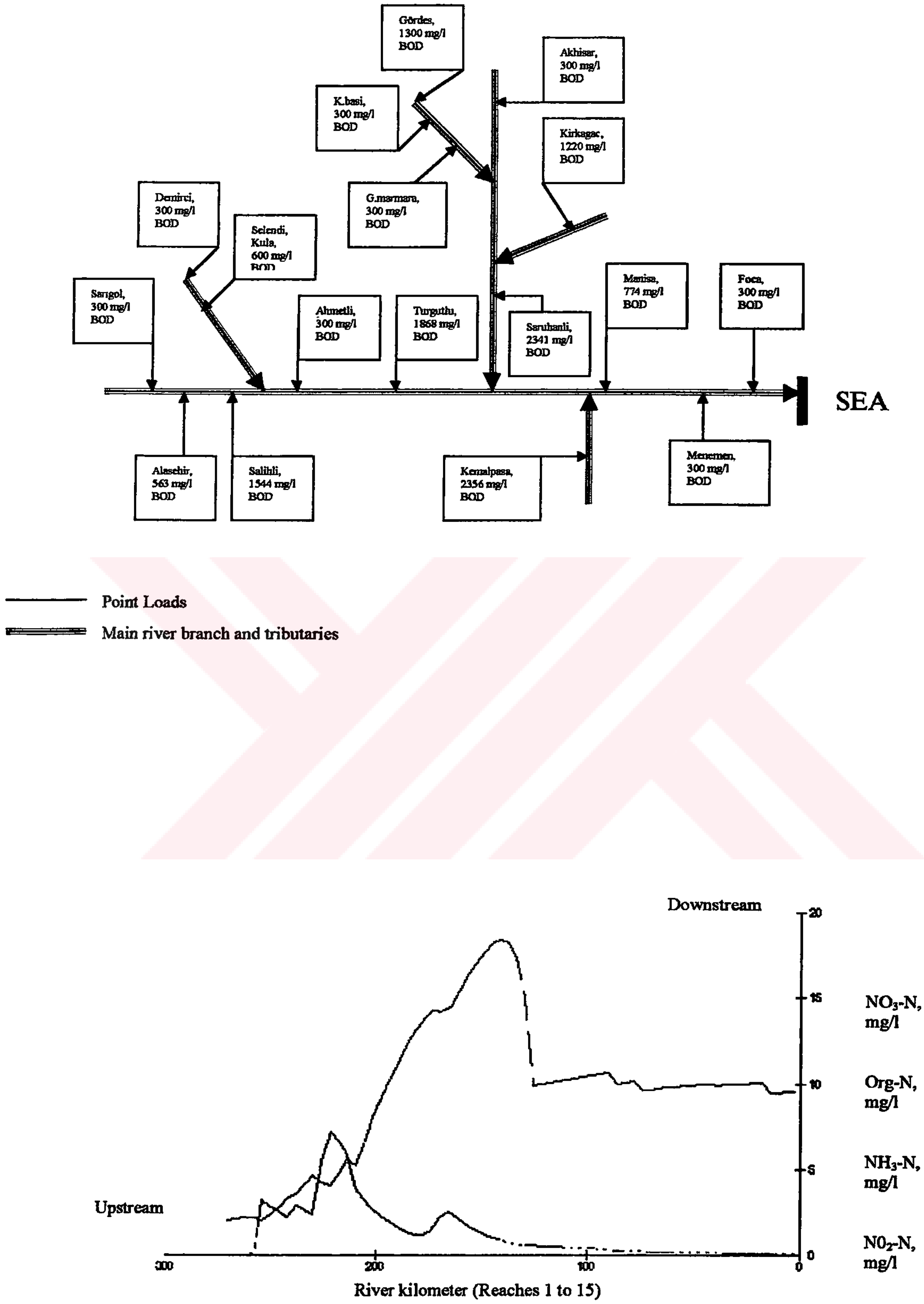


Figure 8.24 Total nitrogen cycle (mg/l) on the Main Stream.

Phosphorus (P) is an essential nutrient for all life forms. Phosphorus plays a role in deoxyribonucleic acid (DNA), ribonucleic acid (RNA), adenosine diphosphate (ADP), and adenosine triphosphate (ATP). Phosphorus is required for these necessary components of life to occur. Phosphorus is the eleventh-most abundant mineral in the earth's crust and does not exist in a gaseous state. Natural inorganic phosphorus deposits occur primarily as phosphate in the mineral apatite.

Under normal conditions, phosphorus is scarce in the aquatic environment. Unlike nitrogen, phosphorus does not exist as a gas and therefore does not have gas-phase atmospheric inputs to aquatic systems. Rocks and natural phosphate deposits are the main reservoirs of natural phosphorus. Release of these deposits occurs through weathering, leaching, erosion and mining. Terrestrial phosphorus cycling includes immobilizing inorganic phosphorus into calcium or iron phosphates, incorporating inorganic phosphorus into plants and microorganisms and breaking down organic phosphorus to inorganic forms by bacteria. Some phosphorus is inevitably transported to aquatic systems by water or wind.

Phosphorus in freshwater and marine systems exists in either an organic or dissolved (inorganic) form; (a) Organic phosphorus: Organic particulate phosphorus includes living and dead particulate matter, such as plankton. Organic non-particulate phosphorus includes dissolved organic phosphorus excreted by organisms and colloidal phosphorus compounds. (b) Dissolved phosphorus: The soluble inorganic phosphate forms H_2PO_4-, HPO_4^{-2} and PO_4^{-3}, known as soluble reactive phosphorus (SRP) are readily available to plants. Some condensed phosphate forms, such as those found in detergents, are inorganic but are not available for plant uptake. Inorganic particulate phosphorus includes phosphorus precipitates, phosphorus adsorbed to particulate and amorphous phosphorus.

Generally, phosphorus (as orthophosphate) is the limiting nutrient in freshwater aquatic systems. That is, if all phosphorus is used, plant growth will cease, no matter how much nitrogen is available. The natural background levels of total phosphorus are generally less than 0.03 mg/l. The natural levels of orthophosphate usually range from 0.005 to 0.05 mg/l.

Many bodies of freshwater are currently experiencing influxes of phosphorus and nitrogen from outside sources. The increasing concentration of available phosphorus allows plants to assimilate more nitrogen before the phosphorus is depleted. Thus, if sufficient phosphorus is available, elevated concentrations of nitrates will lead to algal blooms. Although levels of 0.08 to 0.10 mg/l orthophosphate may trigger periodic blooms, long-term euthrophication will usually be prevented if total phosphorus levels and orthophosphate levels are below 0.5 mg/l and 0.05 mg/l, respectively.

Nonpoint sources of phosphorus: (a)Natural: Phosphate deposits and phosphate-rich rocks release phosphorus during weathering, erosion, and leaching. Phosphorus may be released from lake and reservoir bottom sediments during seasonal overturns, (b) Anthropogenic: The primary anthropogenic non-point sources of phosphorus include runoff from; (1) land areas being mined for phosphate deposits, (2) agricultural areas, and (3) urban/residential areas. Because phosphorus has a strong affinity for soil, little dissolved phosphorus will be transported in runoff. Instead, the eroded sediments from mining and agricultural areas carry the adsorbed phosphorus to the water body. An additional source is the overboard discharge of phosphorus-containing sewage by boats.

Point sources of phosphorus: Sewage treatment plants provide most of the available phosphorus to surface water bodies. A normal adult excretes 1.3 - 1.5 g of phosphorus per day. Additional phosphorus originates from the use of industrial products, such as toothpaste, detergents, pharmaceuticals, and food-treating compounds. Primary treatment removes only 10% of the phosphorus in the waste stream; secondary treatment removes only 30%. The remainder is discharged to the water body. Tertiary treatment is required to remove additional phosphorus from the water. The amount of additional phosphorus that can be removed varies with the success of the treatment technologies used. Available technologies include biological removal and chemical precipitation

Phosphates are primarily discharged directly into the water body by sewage treatment plants. Phosphorus that is adsorbed to sediment particles may be transported in overland flow.

As seen in Figure 8.25, there is a significant decrease in phosphorus concentration in downstream. The confluence of tributaries to the main river are seen in the graph by the increasing points in the phosphorus concentration. The concentration of dissolved phosphorus is between 200 to 100 km from upstream. Similarly, the trends of dissolved and organic phosphorus concentration are approximately the same.

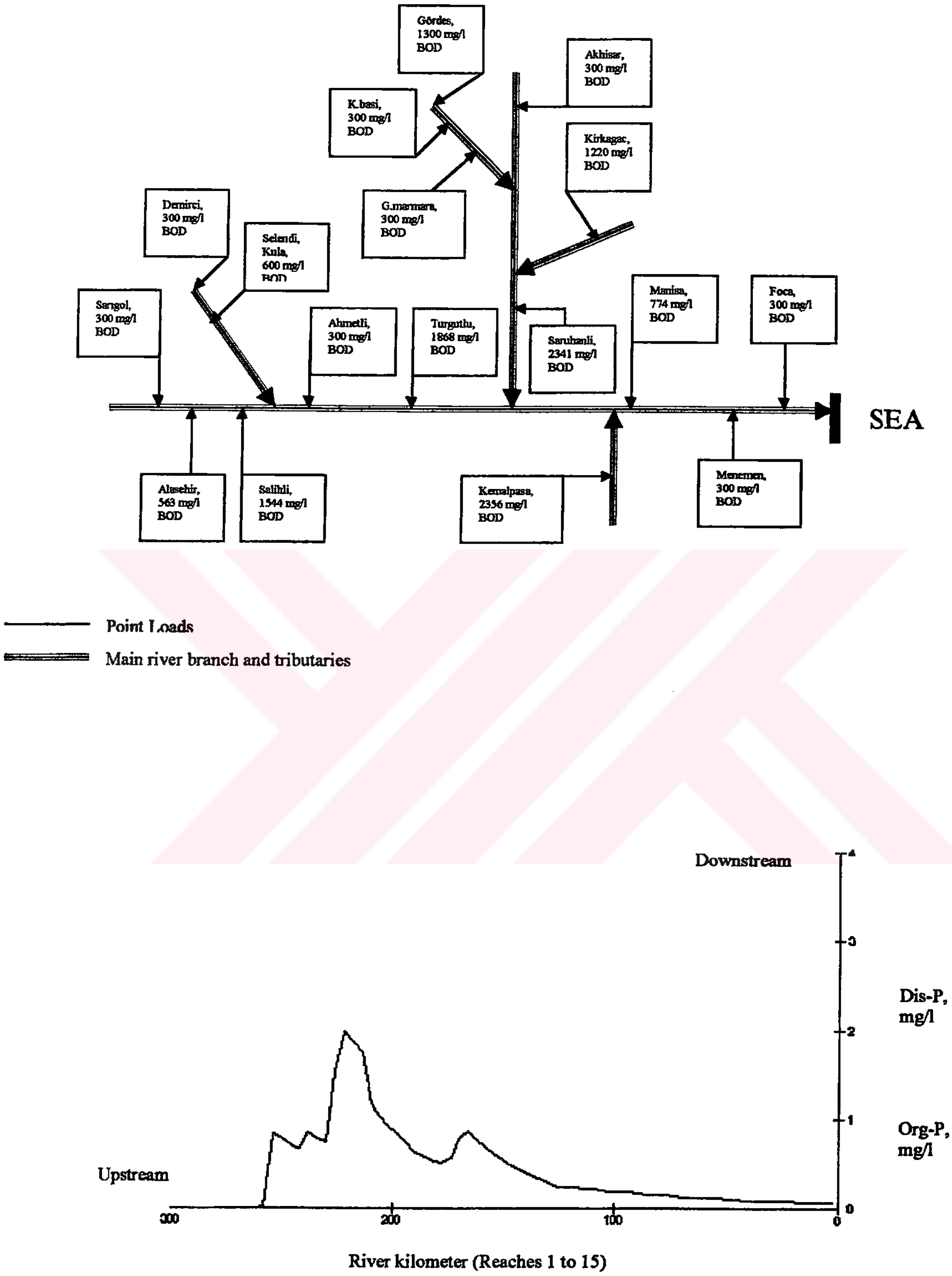


Figure 8.25 Total phosphorus cycle (mg/l) on the Main Stream.

CHAPTER NINE
CONCLUSIONS

In recent years, the importance of water has grown because of great increase in population and industrialization. This growth has led to serious water resources problems. Formerly, water use was determined majorly in terms of quantity. Due to increasing population and industrialization, demands have also increased. On the other hand, pollution occurred in great ratios, so that quality has also become important and a significant limiting issue besides quantity. By the increase in population and industrialization, water demand has increased quantitatively whereas water supply has decreased qualitatively. The main problem is to provide sufficient amount of water in desired water quality. Thus, as briefly indicated in the presented study, a new concept called "Integrated Water Resources Management", that concerns water users, polluters and managers, is needed and developed.

In the thesis, an approach is developed to integrated basin management to cover main three components as;

a. water allocation,
b. water distribution,
c. water quality.

Each component is assessed in terms of physical system identification, institutional and legal aspects. In the further step, a mathematical model is applied under conditions of a case basin. In the presented study, it is emphasized that models are effective tools in IWRM approach. It is possible to identify basin conditions clearly by a reliable, well calibrated and verified model. These issues all need data availability. By this end, water quality monitoring network that provides the required data for planners and decision-makers is the other important aspect of IWRM approach; however, it is not examined in the presented study.

By assessing the current status in the national scale; following issues can be concluded:

- There has been very limited planning at the basin level with respect to surface water and virtually none for groundwater and waste disposal. There is no integrated plan which considers both ground and surface water availability, and no existing planning that considers water quality, wastewater disposal.
- Water is allocated, in practice, by a variety of agencies and users operating independently of each other.
- Water quality monitoring takes place, but information is often not available in useful forms. The information collected, however, remains as pure data files and is not generally used as a basis for policy making or decision making for basin management.
- A single actor, the provincial governor's office, is empowered to authorize enforcement of breaches of wastewater discharge regulations by banning offending practices or imposing fines. In practice, attempts to process fines or prohibit industrial activities often leads to confrontation between industrialists and public administrators.
- No attention is paid to the quality of agricultural return flows. It is sometimes presumed that these flows contribute nitrates to groundwater and nitrates, phosphorus, and organic chemical residues, e.g. from pesticides to surface water.
- NGOs have no role in performing essential management functions but started to play an important role in recent basin management practices.

On the other hand, the following conclusions of assessment of the major components have been extracted under conditions of the case basin:

In the Gediz River Basin, the major part of water is allocated for irrigation besides other purposes such as domestic, industrial, wetlands and hydropower generation. The only point where water is allocated to hydropower generation is the Demirkopru

Dam and Power Plant, which operates in conjunction with the irrigation schemes in the basin. Manisa District Office of the DSI 2nd Regional Directorate carries out activities related to the operation of the reservoir; on the other hand, operational decisions are made by the 2nd Regional Directorate jointly with the Regional Office of TEAS. Under normal conditions, inflows to the reservoir are reserved during the winter months and allocated to irrigation during the summer months. When allocating water to irrigation schemes, hydroelectric energy is also generated as a secondary benefit. This program is carried out by TEAS and DSI.

For the irrigation purposes, DSI allocates water from three reservoirs; Demirkopru, Afsar and Buldan. For this allocation, DSI is informed of the irrigation demands of farmers, which is realized through the IAs. There are 14 IAs in the basin dealing with irrigation operation. The transfer of operation and management responsibilities to IAs has been successful for irrigation purposes.

On the other hand, groundwater resources is used for mainly urban purposes, for industries or residential areas. Although DSI has the responsibility for management of groundwater resources; in practice, the exploitation of groundwater has been largely a private sector initiative and much of the investment has been private rather than public. There is no record of the precise number of wells that are installed because most are private investments. Normally, individuals are supposed to request permission from DSI before installing wells, but in reality most wells are not registered or registration is done once the well is installed. Some of the IAs keep a record of whether the land is irrigated by canal water or exclusively by private water sources, but these records are not consistent between IAs and may not be wholly accurate because DSI only requires data on area irrigated at least once using canal water. It is therefore impossible to know exactly how much water is used from wells and low-lift pumps.

The main actor for water allocation is DSI besides DPT, GDRS and TEAS; along with the great help of IAs and municipalities. The operation and management stage is more systematic than other components of IWRM.

Similar to water allocation, DSI plays the key role in water distribution to the major irrigation schemes in the Gediz River Basin. Again DSI, IAs and Village Irrigation Committee's are effective in water distribution. The general practice in water allocation and in the following distribution is based on the cooperation of IAs and DSI in assessing water demands and comparing these with reservoir water availability. DSI makes an allocation of available water supply among the units sharing the supply in proportion to their scheduled irrigated area. DSI then makes reservoir releases or river diversions in accordance with the planned schedule. IA technical staff distribute the water delivered to their main canal according to the IA's distribution plan.

Water quality is the main limiting issue in irrigation and other water uses. Water quality affects the amount of water that should be allocated for several purposes. Farmers and agricultural engineers often complain about this problem, stating that crops irrigated with such polluted waters have toxic effects. The normal operational mode in the determination and control of the quality of waters allocated to irrigation covers the following steps;

a. DSI determines the uses to which water may be allocated, considering the quality of these waters; then, in coordination with local governors, DSI prepares a basin water use plan,
b. In the beginning of each irrigation season, DSI determines the quality classes of irrigation waters in different parts of the basin,
c. The results are conveyed to IAs by DSI,
d. If the IAs accept the quality of waters specified; DSI makes the allocation of surface waters to irrigation.

At present, the general practice among farmers who are not satisfied with the quality of surface waters allocated to them is to use groundwater. Thus, they develop their own wells by permission from DSI and pump water for irrigation purposes.

Stating and briefly examining all these components show that there is a great need for IWRM, including institutional and legal aspects. In Turkey, the IWRM concept is applied in each institution only in their own framework; the concept is not applicable throughout the country to include all institutions. This is because of inadequate laws and regulations in Turkey. The existing laws do not allow to apply IWRM throughout the country. One of the reasons why integrated management is developed is the degraded water quality. High population increase and industrialization cause water pollution and limit water use throughout the basin. In a situation of a dam construction in the basin; for example, each institution or organization apply their own rules and decisions to the problem but do not decide together with other related institutions.

In an example in a foreign country; farmers determine the problem in the basin. A commission consisting of farmers determines the demand for that problem and asks for a solution to the water agency established in the basin. This agency develops the technical solution. In the next step, the commission and the agency decide together and make the final decision. Similar to this application, in order to establish an authority, there should be sufficient legal infrastructure. Unless the needed legal orders are not prepared, it is not possible to establish such a basin authority and carry out an orderly management process in a basin. Turkey has not yet established legal infrastructure in the country so that, when an organized district is constructed in a field by an authority, another authority can construct a residential area near that district. In the framework of environmental impacts, it is not possible to construct a residential area near an organized district; this is only possible where there is no related legal infrastructure or sanction to prevent this construction process.

In Turkey, the Ministry of Environment prevented the interference of such responsibilities by applying Environmental Impact Assessment. It may take such a time to apply IWRM to the country but some registration processes of several water purposes or water use may be a useful basis or a "data bank" for further studies. Unit identity may be the first step for this purpose. If the institutions that are related to the same process can use the same unit system, it may be useful for the institutions to talk on the same language.

In recent applications of decision making in water resources management in Turkey, political aspects play an important role. The responsibility includes social, economical and political issues. Among these issues, political aspects take the biggest portion so that integrated management concept is parallel to the concept of "sharing responsibility". The question of "who'll pay" always ends the task; in other words, financial responsibility becomes always the limiting factor.

The final aspect in IWRM is the technical aspect that relates to the evaluation of the current pollution status in the test basin. This may be possible by using mathematical models. Models are effective tools in IWRM to determine the pollution profile in the basin. The model represented in the thesis is one of these useful tools. The objective of the model application in the thesis is to emphasize the use of models in integrated management concept. Because the available information and data are not adequate, the obtained results are not reliable and do not reflect the current situation. Model application is not the objective of the thesis; it is only for the demonstrative purpose.

The purpose of the presented thesis is to determine the IWRM concept and its major components and its applicability to the daily problems. These issues are presented; on the other hand, it seems impossible to apply the approach to recent problems and situations. In further studies, the presented approach can be developed in presence of new laws, regulations and institutions.

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Appendix A

Water Quality Classification for Surface Waters

Water Quality Classification for Surface Waters (Uslu & Türkman, 1987).

Water Quality Parameters	Water Quality Classes			
	I	II	III	IV
A. Physical and inorganic chemical parameters				
1. Temperature (°C)	25	25	30	>30
2. pH	6.5-8.5	6.5-8.5	6.0-9.0	out of range 6.0-9.0
3. Dissolved oxygen (mg/l)	8	6	3	<3
4. Dissolved oxygen saturation (%)	90	70	40	>40
5. Chloride (mg/l)	200	200	400	>400
6. Sulphate (mg/l)	200	200	400	>400
7. Ammonium nitrogen (mg/l)	0.2[a]	1[a]	2[a]	>2
8. Nitrite nitrogen (mg/l)	0.002	0.01	0.05	>0.05
9. Nitrate nitrogen (mg/l)	5	10	20	>20
10. Total phosphorus (mg/l)	0.02	0.16	0.65	>0.65
11. Total dissolved solids (mg/l)	500	1500	5000	>5000
12. Color (Pt-Cu unit)	5	50	300	>300
13. Sodium (mg/l)	125	125	250	>250
B. Organic Parameters				
1. COD (mg/l)	25	50	70	>70
2. BOD_5 (mg/l)	4	8	20	>20
3. Organic Carbon (mg/l)	5	8	12	>12
4. Total Kjeldahl nitrogen (mg/l)	0.5	1.5	5	>5
5. Emulsified oil and gres (mg/l)	0.02	0.3	0.5	>0.5
6. Alkyl benzene sulphonate	0.05	0.2	1	>1.5
C. Inorganic industrial pollution parameters				
1. Hg (µg/l)	0.1	0.5	2	>2
2. Cd (µg/l)	3	5	10	>10
3. Pb (µg/l)	10	20	50	>50
4. As (µg/l)	20	50	100	>100
5. Cu (µg/l)	20	50	200	>200
6. Cr (total) (µg/l)	20	50	200	>200
7. Cr (+6) (µg/l)	*	20	50	>50
8. Co (µg/l)	10	20	200	>200
9. Ni (µg/l)	20	50	200	>200
10. Zn (µg/l)	200	500	2000	>2000
11. CN (total) (µg/l)	10	50	100	>100
12. F (µg/l)	1000	1500	2000	>2000
13. Free chlorine (µg/l)	10	10	50	>50
14. Sulfide (µg/l)	2	2	10	>10
15. Fe (µg/l)	300	1000	5000	>5000
16. Mn (µg/l)	100	500	3000	>3000
17. B (µg/l)	1000	1000[c]	1000	>1000
18. Se (µg/l)	10	10	20	>20
19. Ba (µg/l)	1000	2000	2000	>2000
20. Al (mg/l)	0.3	0.3	1	>1
21. Radioactivity (pCi/l)				
α-acitivity	1	10	10	>10
β-activity	10	100	100	>100
D. Organic industrial pollution parameters				
1. Phenolic matters (volatile) (mg/l)	0.002	0.01	0.1	>0.1
2. Mineral oil and derivatives (mg/l)	0.02	0.1	0.5	>0.5
3. Total pesticide (mg/l)	0.001	0.01	0.1	>0.1
E. Biological Parameters				
1. Fecal coliform (MS/100ml)	10	2000	20000	>20000

(a) The concentration of free ammonium nitrogen should not be exceeded 0.02 mg NH3-N/l related to the value of pH.

(b) One of the value between concentration and saturation of dissolved oxygen is enough to satisfy.

(c) The concentration of B should be lowered to 300 μg/l for irrigation of conscientious plants.

(d) The concentration limits should be lowered against chloride for irrigation of conscientious plants.

* Excessive amount

Appendix B

Model limitations
and
default values

Model limitations and the default values can be given as following tables.

Parameter	Minimum	Maximum	Default
CONTROL DATA			
Time step (h)	0.0	none	0.0
5D-ULT BOD Conversion Coefficient	none	none	0.23
Maximum route (h)	0.0	none	0.0
Time for RPT2 (h)	0.0	none	0.0
Maximum iterations	1.0	none	30.0
Latitude of basin (°C)	0.0	90.0	34.0
Longitude of basin (°C)	0.0	180.0	85.0
Standard meridian (°C)	0.0	180.0	75.0
Start day	1.0	366.0	180.0
Evaporation coefficient (AE)	4.9E-6	0.00006199999	9.4E-6
Evaporation coefficient (BE)	3.2E-6	5.49999E-6	3.2E-6
Elevation of basin (m)	-120.0	3650.0	305.0
Dust attenuation coefficient	0.05	0.15	0.06
ALGAL, NITROGEN AND PHOSPHORUS PARAMETERS			
NH3OXYUP	3.0	3.5	3.43
NO2OXYUP	1.0	1.2	1.14
AGYOXYPR	1.4	1.8	1.6
AGYOXYUP	1.6	2.3	2.0
AGYNCON	0.08	0.09	0.085
AGYPCON	0.012	0.015	0.014
AGYGROMX	1.0	3.0	2.5
AGYRESPR	0.05	0.5	0.05
NHALFSAT	0.02	0.4	0.2
PHALFSAT	0.002	0.1	0.04
AGYEXTLN	0.0	0.003	0.0007499999
AGYEXTNL	0.0	0.003	0.0
LFNOPTN	1.0	3.0	1.0
LSATCOEF	0.0	0.04	0.03
DIURNOPT	1.0	4.0	2.0
LAVGFACT	0.85	1.0	0.92
NUMBDLH	4.0	18.0	14.0
TDYSOLAR	0.0	400.0	350.0
AGYGROPT	1.0	3.0	2.0
APREFNH3	0.1	0.9	0.9
A/TFACT	0.4	0.5	0.44
NHIBFACT	0.0	10.0	10.0
THETA VALUES			
TC/BODDC	1.0	1.1	1.047
TC/BODST	1.0	1.1	1.024
TC/REAER	1.0	1.1	1.024
TC/SOD	1.0	1.1	1.060
TC/NH2DC	1.0	1.1	1.047
TC/NH2ST	1.0	1.1	1.024
TC/NH3DC	1.0	1.1	1.083
TC/NH3SC	1.0	1.1	1.074
TC/NO2DC	1.0	1.1	1.047
TC/PRGDC	1.0	1.1	1.047
TC/PRGST	1.0	1.1	1.024
TC/PO4SC	1.0	1.1	1.074
TC/ALGRO	1.0	1.1	1.047
TC/ALRES	1.0	1.1	1.047
TC/ALSET	1.0	1.1	1.024
TC/CLIDC	1.0	1.1	1.047
TC/ANCDC	1.0	1.1	1.0

	Minimum	Maximum	Default
THETA VALUES (Continued)			
TC/ANCST	1.0	1.1	1.024
TC/ANCSC	1.0	1.1	1.0
REACH IDENTIFICATION DATA			
Reach order	0.0	50.0	none
Begin location (km)	0.0	none	none
End location (km)	0.0	none	0.0
FLOW AUGMENTATION DATA			
Number of available sources	0.0	100.0	0.0
Target level (mg/l)	0.0	15.0	5.0
Order of available sources	0.0	100.0	0.0
COMPUTATIONAL ELEMENTS FLAGS			
Number of elements	1.0	20.0	none
Comp. elements flags	0.0	7.0	0.0
HYDRAULIC DATA			
DISPSN-K	6.0	6000.0	60.0
COEFQV-A (m/s)	0.0	none	0.0
EXPOQV-B (m/s)	0.0	1.0	0.0
COEFQH-C (m)	0.0	none	0.0
EXPOQH-D (m)	0.0	1.0	0.0
MANNINGS	0.001	0.05	0.0
TRAP-SS1	0.0	1000.0	0.0
TRAP-SS2	0.0	1000.0	0.0
TRAP-WTH	0.0	none	0.0
TRAP-SLP	0.0	1.0	0.0
TEMPERATURE/LOCAL CLIMATOLOGICAL DATA			
ELEVATIN (m)	-120.0	3650.0	305.0
DUSTATTN	0.01	0.15	0.06
CLOUD	0.0	1.0	0.0
DRYBULB (°C)	2.0	55.0	20.0
WETBULB (°C)	2.0	55.0	15.0
ATMPRES (mbar)	900.0	1100.0	1017.0
WINDVEL (m/s)	0.0	36.0	0.0
BOD/DO COEFFICIENTS			
BOD DECA	0.0	10.0	0.0
BOD SETT	0.0	10.0	0.0
SOD RATE	0.0	10.0	0.0
K2-OPT1	0.0	100.0	0.0
N AND P COEFFICIENTS			
NH2 DECA	0.0	10.0	0.0
NH2 SETT	0.0	10.0	0.0
NH3 DECA	0.0	10.0	0.0
NH3 SRCE	0.0	none	0.0
NO2 DECA	0.0	10.0	2.0
PORG DECA	0.0	10.0	0.0
PORG SETT	0.0	none	0.0
DISP SRC	0.0	none	0.0
ALGAE COEFFICIENTS			
CHLA/ART	1.0	100.0	10.0
ALG SETT	0.0	1.0	1.0
LTEXTNCO	0.0	3.0	0.0
COLI DEC	0.0	24.0	0.0
ANC DECA	0.0	none	0.0
ANC SETT	0.0	none	0.0
ANC SRCE	0.0	none	0.0
INITIAL CONDITIONS			
Temperature (°C)	2.0	55.0	21.0

	Minimum	Maximum	Default
INITIAL CONDITIONS (Continued)			
DO (mg/l)	0.0	15.0	0.0
BOD (mg/l)	0.0	1000.0	0.0
Cons 1,2,3	0.0	none	0.0
ANC	0.0	none	0.0
Coliform (no/100 ml)	0.0	none	0.0
Chl-a (μg/l)	0.0	none	0.0
Org-N (mg/l)	0.0	none	0.0
NH3/N (mg/l)	0.0	none	0.0
NO2-N (mg/l)	0.0	none	0.0
NO3-N (mg/l)	0.0	none	0.0
Org-P (mg/l)	0.0	none	0.0
Dis-P (mg/l)	0.0	none	0.0
INCREMENTAL FLOW			
INCRFLOW	none	none	0.0
The limits for other parameters are the same with Initial Conditions' parameters.			
STREAM JUNCTION DATA			
Number of element upstream	1.0	100.0	0.0
Number of element downstream	1.0	100.0	0.0
Number of element on tributary	1.0	100.0	0.0
HEADWATER DATA			
HWTRFLOW	0.0	none	0.0
The limits for other parameters are the same with Initial Conditions' parameters.			
POINT LOAD/WITHDRAWAL DATA			
PTLDTFCT	0.0	1.0	0.0
PTLDFLOW	none	none	0.0
The limits for other parameters are the same with Initial Conditions' parameters.			
DAM REAERATION COEFFICIENTS			
Element number below dam	1.0	20.0	none
DAMACOF	0.5	2.0	1.0
DAMBCOF	0.01	1.5	1.0
DAMSFRAC	0.0	1.0	0.0
Height of dam (m)	0.0	none	0.0
DOWNSTREAM BOUNDARY 1/2			
The limits for other parameters are the same with Initial Conditions' parameters.			
LOCAL CLIMATOLOGICAL DATA			
Cloud cover	0.0	1.0	0.0
Dry bulb air temperature (°C)	1.0	38.0	15.0
Wet bulb air temperature (°C)	1.0	38.0	15.0
Barometric pressure (mbar)	900.0	1100.0	1017.0
Wind speed (m/s)	0.0	36.0	0.0
DO/BOD PLOT DATA			
Number of plots desired	1.0	5.0	1.0
Number of starting reach number	1.0	13.0	1.0

Appendix C

Water Quality

Observation Stations

Data Sets

05-GEDİZ HAVZASI

BÖLGESI : II. Bölge-İZMİR

İSTASYON ADI VE YERİ : Alaşehir Çayı-Baklacı

İSTASYON NO : 05-02-00-001

AKIM GÖZLEM İSTASYONU : 526 (EIE)

1981 YILI KALİTE GÖZLEMLERİ

PARAMETRE	n	MİNİMUM	ORTALAMA	MAKSİMUM	OCAK	ŞUBAT	MART	NİSAN	MAYIS	HAZİRAN	TEMMUZ	AĞUSTOS	EYLÜL	EKİM	KASIM	ARALIK
Q	11	0,250	361,628	2120,000		1060,000		2120,000		400,000		355,000		20,000		
T	15	3,0	16,4	30,0		11,3		11,5		30,0		21,0		18,0		11,0
pH	16	7,1	8,0	8,5		7,8		8,5		7,8		7,9		8,1		7,1
EC	16	320	696	1190		900		320		790		600		990		590
TDS	9	187	430	730												
SS	10	22	469	2029		2029		309		213		350		823		814
TS																
Turb																
Col																
M-Al	10	140,0	252,8	440,0		385,0		140,0		160,0		205,0		440,0		295,0
P-Al	6	0,0	10,8	60,0		0,0		5,0		0,0		0,0		60,0		0,0
Cl	16	17,7	43,4	99,3		99,3		17,7		53,2		39,0		39,0		42,5
NH_3-N	6	0,00	0,00	0,00		0,00		0,00		0,00		0,00		0,00		0,00
NO_2-N	8	0,000	0,418	2,000				0,026		0,010		0,004		0,250		0,030
NO_3-N	11	0,50	1,92	12,00		0,50		1,60		0,95		0,25		0,70		1,99
DO	10	6,5	8,3	10,6				10,6		6,5		7,8				10,6
pV	16	2,40	3,76	5,80		5,60		2,56		4,32		4,00		3,12		5,20
BOD_5	3	0,9	1,5	2,4												
TH	5	210	308	500				210		290		210		500		330
o-PO_4	4	0,05	0,08	0,12						0,05		0,05		0,12		0,10
SO_4																
CO_2																
Fe	1									4,26						
Mn																
Na	11	14,70	29,46	55,20		30,82		14,70		55,20		23,00		23,10		23,10
K	11	0,80	1,93	2,70		2,00		0,80		2,70		1,80		1,80		1,80
Ca	14	20,0	51,6	80,2		56,1		56,1		60,0		50,1		66,1		50,1
Mg	14	17,0	49,6	110,0		77,8		17,0		32,8		34,0		80,3		54,7
T-Coli																
T-Germ																

05-GEDİZ HAVZASI

BÖLGESİ : II.Bölge-İZMİR

İSTASYON ADI VE YERİ : Gediz Nehri-Urganlı

İSTASYON NO : 05-02-00-002

AKIM GÖZLEM İSTASYONU : -

1983 YILI KALİTE GÖZLEMLERİ

PARAMETRE	n	MİNİMUM	ORTALAMA	MAKSİMUM	OCAK	ŞUBAT	MART	NİSAN	MAYIS	HAZİRAN	TEMMUZ	AĞUSTOS	EYLÜL	EKİM	KASIM	ARALIK
Q	5	5,200	15,860	32,000		18,500		32,000		5,200		18,000		5,600		
T	13	8,0	17,2	25,0		10,0		13,0		23.0		22,0		14,5		10,5
pH	16	7,6	8,1	8,7		7,8		8,0		7,8		8,0		8,3		7,7
EC	16	213	502	900		415		290		900		595		620		435
TDS	9	36	224	397												
SS	15	1	148	561		1		253		167		392		561		227
TS																
Turb																
Col																
M-Al	16	122,5	196,9	275,0		205,0		122,5		170,0		230,0		247,5		240,0
P-Al	10	0,0	18,5	75,0		0,0		0,0		0,0		0,0		25,0		9,0
Cl	16	17,7	32,6	49,6		15,5		21,3		49,6		46,1		46,1		33,0
NH_3-N	6	0,00	0,00	0,00		0,00		0,00		0,00		0,00		0,00		0,00
NO_2-N	5	0,004	0,025	0,050				0,020		0,050		0,004		0,040		0,012
NO_3-N	15	0,00	0,94	1,80		1,30		0,40		0,95		1,70		1,00		1,66
DO	11	6,3	8,5	11,9		11,9		10,4		8,0		6,8		9,6		
pV	16	1,68	3,16	5,16		4,10		3,04		3,04		4,80		3,90		5,34
BOD_5	2	1,3	1,5	1,8												
TH	5	170	238	330				.170		240		230		330		220
o-PO_4	2	0,20	0,25	0,30						0,20		0,30				
SO_4																
CO_2																
Fe	2	4,75	4,79	4,82						4,75		4,82				
Mn																
Na	16	15,20	23,56	48,80		23,00		15,20		48,80		27,60		15,20		15,70
K	16	0,40	1,64	2,70		1,60		0,80		2,70		2,40		1,80		0,40
Ca	16	20,0	40,8	60,1		40,0		32,1		36,0		44,1		58,1		48,1
Mg	16	7,3	26,5	45,0		24,3		9,7		35,3		30,4		45,0		24,3
T-Coli																
T-Germ																

05-GEDİZ HAVZASI

BÖLGESİ : II. Bölge-İZMİR

İSTASYON ADI VE YERİ : Kum Çayı-Killik

İSTASYON NO : 05-02-00-003

AKIM GÖZLEM İSTASYONU : 510 (BİZ)

1983 YILI KALİTE GÖZLEMLERİ

PARAMETRE	n	MİNİMUM	ORTALAMA	MAKSİMUM	OCAK	ŞUBAT	MART	NİSAN	MAYIS	HAZİRAN	TEMMUZ	AĞUSTOS	EYLÜL	EKİM	KASIM	ARALIK
Q	12	1,150	1310,583	7860,000		7860,000		3250,000		2590,000		268,000		1350,000		383,000
T	13	7,0	17,2	23,0		10,5		16,5		23,0		21,0		16,5		11,0
pH	14	7,6	8,0	8,4		8,0		8,1		7,9		8,0		8,1		7,6
EC	14	310	497	688		390		485		520		455		460		310
TDS	7	219	265	323												
SS	13	209	200	680		680		417		419		237		322		209
TS																
Turb																
Col																
M-Al	14	142,5	210,7	300,0		300,0		225,0		210,0		215,0		205,0		200,0
P-Al	9	0,0	20,0	70,0		0,0		5,0		0,0		0,0		60,0		0,0
Cl	14	17,7	30,1	49,6		28,4		21,3		21,3		35,5		24,8		21,3
NH_3-N	6	0,00	0,00	0,00		0,00		0,00		0,00		0,00		0,00		0,00
NO_2-N	5	0,020	0,029	0,040				0,027		0,028		0,040		0,030		0,020
NO_3-N	14	0,80	1,888	4,15		1,50		1,35		1,80		4,15		1,25		1,28
DO	11	6,5	9,3	11,9		11,9		9,2		9,4	—	8,7		10,8		10,6
pV	14	0,72	2,37	7,00		4,10		1,60		1,44		1,44		0,72		3,20
BOD_5																
TH	5	210	254	290				260		290		210		250		260
o-PO_4	4	0,28	0,36	0,44						0,28		0,36		0,44		0,36
SO_4																
CO_2																
Fe																
Mn																
Na	8	13,80	20,35	43,20				18,90		18,40		13,80		14,70		14,30
K	8	0,80	1,49	3,50				0,80		1,20		1,20		0,80		1,20
Ca	14	24,0	49,1	70,1		54,1		60,1		60,0		44,1		40,1		54,1
Mg	14	8,5	31,6	47,4		30,4		26,8		32,8		21,9		47,4		30,4
T-Coli																
T-Germ																

05-GEDİZ HAVZASI

BÖLGESİ : II. Bölge-İZMİR

İSTASYON ADI VE YERİ : Medar Çayı-Medar Köprüsü

İSTASYON NO : 05-02-00-004

AKIM GÖZLEM İSTASYONU : 5-15 (DSİ)

1983 YILI KALİTE GÖZLEMLERİ

PARAMETRE	n	MİNİMUM	ORTALAMA	MAKSİMUM	OCAK	ŞUBAT	MART	NİSAN	MAYIS	HAZİRAN	TEMMUZ	AĞUSTOS	EYLÜL	EKİM	KASIM	ARALIK
Q	16	0,000	2,128	6,800		3,800		0,900		0,090		0,000		0,000		
T	15	3,0	14,0	24,0		8,0		16,0		24,0						9,5
pH	16	7,2	7,9	8,5		8,1		8,4		8,1						7,4
EC	16	295	521	873		295		400		485						295
TDS	10	104	224	305												
SS	7	6	134	374		42		374		287						194
TS																
Turb																
Col																
M-Al	7	165,0	206,1	243,0		215,0		180,0		195,0						165,0
P-Al	4	0,0	7,5	15,0		0,0		15,0		15,0						0,0
Cl	16	14,2	24,4	39,0		24,8		17,7		17,7						17,7
NH_3-N	4	0,00	0,00	0,00		0,00		0,00		0,00						0,00
NO_2-N	3	0,007	0,016	0,023				0,023		0,007						0,018
NO_3-N	15	0,20	1,20	2,50		1,25		0,56		1,20						1,00
DO	9	6,1	9,8	13,0		13,0		10,2								12,0
pV	16	0,40	2,11	4,16		4,16		2,24		1,20						3,92
BOD_5																
TH	3	210	233	270				220		270						210
o-PO_4	2	0,10	0,27	0,44						0,10						0,44
SO_4																
CO_2																
Fe																
Mn																
Na	10	15,20	20,24	26,20		19,30		19,80		17,00						15,20
K	10	0,70	1,46	3,10		1,20		1,20		0,80						0,70
Ca	7	21,9	44,3	60,1		46,1		42,1		40,0						42,1
Mg	7	21,9	29,1	41,3		21,9		28,0		41,3						24,3
T-Coli																
T-Germ																

05-GEDİZ HAVZASI

BÖLGESİ : II.Bölge-İZMİR

İSTASYON ADI VE YERİ : Gediz Nehri-Muradiye Köprüsü

İSTASYON NO : 05-02-00-005

AKIM GÖZLEM İSTASYONU : 5-25 (DSİ)

1983 YILI KALİTE GÖZLEMLERİ

PARAMETRE	n	MİNİMUM	ORTALAMA	MAKSİMUM	OCAK	ŞUBAT	MART	NİSAN	MAYIS	HAZİRAN	TEMMUZ	AĞUSTOS	EYLÜL	EKİM	KASIM	ARALIK
Q	26	14,500	183,250	2200,000		72,000		85,000		2200,000		23,500		14,500		
T	28	7,5	16,1	28,0		10,5		14,0		26,5		23,5		21,0		10,0
pH	29	7,0	7,7	8,4		7,6		7,8		7,9		8,2		8,4		7,4
EC	28	58	562	967		390		350		675		650		735		410
TDS	20	220	340	514												
SS	24	14	127	518		27		319		291		326		406		518
TS																
Turb																
Col																
M-Al	29	150,0	218,6	290,0		215,0		162,5		210,0		227,5		270,0		220,0
P-Al	23	0,0	5,4	40,0		0,0		0,0		0,0		25,0		40,0		0,0
Cl	29	17,7	32,6	56,7		53,2		21,3		31,9		42,5		28,4		31,9
NH_3-N	29	0,00	0,06	1,50		0,00		0,00		0,00		0,00		0,00		0,00
NO_2-N	29	0,000	0,180	5,000		0,000		0,028		0,025		0,014		0,034		0,012
NO_3-N	26	0,00	1,78	10,00		1,25		1,10		2,05		0,00		1,92		1,45
DO	19	6,5	8,3	10,4				8,3		7,7		6,8		9,4		
pV	28	0,40	2,72	6,00		4,16		4,00		3,60		1,60		1,68		3,92
BOD_5	15	0,8	2,1	5,4												
TH	5	220	266	330				220		300		230		330		250
o-PO_4	9	0,10	0,61	1,20						0,36		0,96		0,42		0,48
SO_4	5	15,0	33,4	40,0				15,0		38,0		40,0		40,0		34,0
CO_2																
Fe																
Mn																
Na	16	17,00	22,16	31,30		22,50		19,30		26,20		31,30		19,80		22,50
K	16	0,80	1,84	3,50		1,20		1,60		2,30		2,40		1,60		1,20
Ca	12	40,1	53,4	80,2		50,1		44,1		50,0		62,1		80,2		46,1
Mg	12	13,4	27,4	41,3		18,2		13,4		41,3		26,8		31,6		32,8
T-Coli																
T-Germ																
TKN	16	1,20	2,13	4,30												

05-GEDİZ HAVZASI

BÖLGESİ :II.Bölge-İZMİR
İSTASYON ADI VE YERİ :Gediz Nehri-Menemen Köprüsü
İSTASYON NO :05-02-00-006
AKIM GÖZLEM İSTASYONU : -

1983 YILI KALİTE GÖZLEMLERİ

PARAMETRE	n	MİNİMUM	ORTALAMA	MAKSİMUM	OCAK	ŞUBAT	MART	NİSAN	MAYIS	HAZİRAN	TEMMUZ	AĞUSTOS	EYLÜL	EKİM	KASIM	ARALIK
Q	7	14,500	14,515	85,000		72,000		85,000		17,100		23,500		14,500		
T	14	6,0	17,4	27,0		9,0		16,0		20,0		27,0		18,0		10,0
pH	15	7,7	7,9	8,3		7,7		7,8		7,9		8,0		8,2		7,7
EC	15	330	566	730		330		440		650		700		730		400
TDS	8	219	308	350												
SS	14	22	233	606		407		120		309		356		604		606
TS																
Turb																
Col																
M-Al	10	187,5	218,0	265,0		215,0		187,5		190,0		265,0		215,0		187,5
P-Al	6	0,0	0,0	0,0		0,0		0,0		0,0		0,0		0,0		0,0
Cl	15	24,8	37,1	49,0		46,1		24,8		35,5		49,0		39,0		28,4
NH_3-N	6	0,00	0,00	0,00		0,0		0,0		0,0		0,0		0,0		0,0
NO_2-N	5	0,010	0,017	0,036				0,036		0,010		0,010		0,017		0,012
NO_3-N	14	0,00	1,50	3,00		1,35		1,40		0,10	-	0,00		0,95		1,20
DO	10	7,4	9,1	13,0		8,4		8,2				8,5		9,6		13,0
pV	15	1,76	6,76	26,80		5,20		4,60		1,76		2,40		7,68		4,32
BOD_5																
TH	5	130	248	350				130		270		270		350		220
o-PO_4	4	0,10	0,35	0,46						0,10		0,40		0,45		0,46
SO_4																
CO_2																
Fe																
Mn																
Na																
K																
Ca																
Mg																
T-Coli																
T-Germ																

Appendix D

Meteorological Data Sets

of

DMI (State Meteorological Works)

Station Name: ALAŞEHİR

Parameter	Observation Period (year)	Months 1	2	3	4	5	6	7	8	9	10	11	12	Annual Average
A	There is no observations of pressure at this station.													
B	20	6.6	8.1	10.5	15.5	20.7	25.0	27.8	26.8	23.0	16.5	12.3	7.9	16.7
C	25	23.0	25.0	30.9	35.6	39.2	41.0	42.2	42.0	39.3	37.0	31.1	23.1	42.2
D	25	-7.5	-7.5	-5.1	-0.9	3.1	7.8	11.5	10.0	6.5	0.0	-3.5	-8.0	-8.0
E	22	4.4	4.2	5.5	6.8	9.3	15.0	22.9	24.0	19.5	12.9	7.2	5.2	136.9
F	22	15.4	14.1	15.8	16.0	18.1	13.7	7.8	7.0	9.8	14.3	14.5	15.3	161.8
G	22	11.2	9.9	9.7	7.0	3.5	1.3	0.2	0.0	0.7	3.8	8.3	10.4	66.0
H	22	1.9	1.9	1.9	1.9	1.7	1.8	1.7	1.5	1.4	1.6	1.7	1.9	1.7
I	30	8 SE	8SW	8NW	8SW	7 W	8NW	8NW	8SW	7NW	7NW	8SE	8NE	8 NW
J	20	N	N	NW	W	W	W	W	NW	W	N	N	N	N
K	50	73.0	74.6	57.0	31.8	36.9	18.5	8.2	4.7	9.6	32.1	57.0	84.4	487.5

A: Average actual pressure (mbar)
B: Average temperature (°C)
C: Maximum temperature (°C)
D: Minimum temperature (°C)
E: The number of days that have minimum cloudiness
F: The number of days that have average cloudiness
G: The number of days that have maximum cloudiness
H: Average wind speed (m/s)
I: Maximum wind and its direction
J: Dominant wind drection
K: Average height of rain (mm)

Station Name: AKHİSAR														
Prt.	Obsvtn. Period (year)	Months												Annual Average
		1	2	3	4	5	6	7	8	9	10	11	12	
A	54	1005.9	1005.0	1004.2	1002.4	1001.8	1000.7	998.8	999.3	1003.1	1006.0	1006.9	1006.4	1003.4
B	54	6.1	7.2	9.5	14.4	19.6	24.2	26.6	26.2	22.2	16.6	11.4	7.8	16.0
C	54	22.3	24.7	30.3	33.6	39.2	42.8	44.3	44.6	40.7	37.5	30.7	26.2	44.6
D	54	-13.6	-9.2	-7.4	-3.0	2.0	4.0	9.2	8.4	4.8	-3.0	-10.7	-10.8	-13.6
E	54	4.6	4.5	5.6	6.0	7.3	14.3	24.1	25.0	20.2	12.5	6.5	5.0	135.6
F	54	14.9	15.4	17.2	18.3	20.1	14.8	6.7	5.8	9.1	15.1	17.0	16.4	170.8
G	54	11.5	8.4	8.1	5.6	3.3	0.7	0.1	0.2	0.6	3.4	6.4	9.6	57.9
H	47	2.1	2.4	2.4	2.0	2.0	2.4	3.3	3.2	2.5	2.0	1.4	1.6	2.3
I	47	29.2 W	32.2 W	32.5 WNW	28.6 WSW	27.3 NNW	25.2 SW	24.8 N	26.0 SSE	24.0 WNW	27.1 SSE	25.7 SSW	32.2 WSW	32.5 WNW
J	42	N	N	N	N	N	N	N	N	NNE	N	NNE	NE	N
K	61	104.1	81.7	64.7	47.8	34.6	14.1	4.0	4.3	11.4	38.8	73.9	115.4	594.8

A: Average actual pressure (mbar)
B: Average temperature (°C)
C: Maximum temperature (°C)
D: Minimum temperature (°C)
E: The number of days that have minimum cloudiness
F: The number of days that have average cloudiness
G: The number of days that have maximum cloudiness
H: Average wind speed (m/s)
I: Maximum wind and its direction
J: Dominant wind direction
K: Average height of rain (mm)

Station Name: SALİHLİ

Prt.	Obsvtn. period (year)	Months												Annual Average
		1	2	3	4	5	6	7	8	9	10	11	12	
A	23	1005.5	1003.8	1002.8	1000.9	1001.1	999.6	998.2	998.9	1002.3	1005.4	1006.1	1005.9	1002.5
B	26	6.4	7.5	10.4	15.3	20.4	24.6	26.7	26.0	22.2	16.1	11.2	7.9	16.2
C	26	24.2	24.1	31.0	37.2	38.6	41.0	43.2	41.6	38.7	36.4	29.8	24.5	43.2
D	26	-8.0	-10.2	-5.3	0.0	2.4	9.4	10.7	9.8	6.0	-0.3	-5.2	-6.0	-10.2
E	26	5.9	5.0	6.9	6.3	10.7	17.6	24.2	24.8	21.6	13.7	8.8	6.2	151.7
F	26	17.8	16.7	17.3	18.5	18.4	11.7	6.7	6.1	8.0	14.4	16.4	17.8	169.9
G	26	7.3	6.5	6.7	5.2	1.8	0.8	0.1	0.1	0.3	2.9	4.8	7.4	44.0
H	22	1.5	1.7	1.7	1.8	2.0	1.9	2.1	2.0	1.6	1.3	1.2	1.4	1.7
I	22	26.0 SSW	27.0 SSW	32.0 WSW	27.6 SSW	20.6 SSW	28.0 SSW	24.3 NW	16.8 WSW	26.7 SSW	19.9 ESE	26.9 SSW	31.6 SSW	32.0 WSW
J	22	W	WSW	WSW	W	WSW	W	WSW	W	W	W	W	ESE	W
K	51	79.5	67.9	59.2	39.2	33.5	17.3	5.8	4.4	10.6	34.9	55.8	82.5	490.7

A: Average actual pressure (mbar)
B: Average temperature (°C)
C: Maximum temperature (°C)
D: Minimum temperature (°C)
E: The number of days that have minimum cloudiness
F: The number of days that have average cloudiness
G: The number of days that have maximum cloudiness
H: Average wind speed (m/s)
I: Maximum wind and its direction
J: Dominant wind direction
K: Average height of rain (mm)

Station Name: MANİSA

Prt.	Obsrvtn period (year)	Months												Annual Average
		1	2	3	4	5	6	7	8	9	10	11	12	
A	61	1009.0	1007.6	1007.0	1005.3	1004.9	1003.7	1002.0	1002.5	1006.2	1009.0	1009.8	1009.3	1006.4
B	61	6.8	8.0	10.4	15.1	20.1	25.0	27.6	27.2	23.1	17.6	12.3	8.4	16.9
C	61	23.3	24.8	33.5	34.6	39.5	41.8	44.0	44.5	40.1	36.0	29.9	26.4	44.5
D	61	-17.5	-10.9	-6.7	-2.7	2.0	7.4	10.5	11.2	3.3	-0.9	-7.3	-9.9	-17.5
E	61	3.8	3.6	5.3	5.4	7.4	14.2	23.0	24.1	19.4	11.1	5.1	4.0	126.4
F	61	15.5	15.9	17.1	19.2	20.3	15.1	7.6	6.8	9.7	16.2	18.6	16.6	178.6
G	61	11.6	8.8	8.6	5.5	3.3	0.6	0.1	0.0	0.7	3.9	6.2	10.4	59.7
H	56	2.3	2.5	2.5	2.3	2.0	2.1	2.4	2.4	2.0	1.8	1.8	1.9	2.2
I	56	39.1 S	35.5 S	38.4 SW	34.6 S	26.4 SW	29.0 SSW	27.2 SW	20.4 SW	26.4 SW	29.6 SW	32.7 S	41.2 S	41.2 S
J	40	E	E	E	E	E	E	E	E	E	E	E	E	E
K	61	128.8	106.2	78.6	55.8	40.0	15.1	6.4	4.6	15.8	50.0	90.9	147.8	740.0

A: Average actual pressure (mbar)
B: Average temperature (°C)
C: Maximum temperature (°C)
D: Minimum temperature (°C)
E: The number of days that have minimum cloudiness
F: The number of days that have average cloudiness
G: The number of days that have maximum cloudiness
H: Average wind speed (m/s)
I: Maximum wind and its direction
J: Dominant wind direction
K: Average height of rain (mm)