INVESTIGATION OF EFFECTS OF LAND USE CHANGES IN TAHTALI RIVER BASIN ON WATER QUALITY

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“Whether or not the journey is the destination, no journey is undertaken alone.”

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ABSTRACT

INVESTIGATION OF EFFECTS OF LAND USE CHANGES IN TAHTALI RIVER BASIN ON WATER QUALITY

The rapid increase of population, industrial growth and disorganized urbanization have put considerable stress on the available water sources, which are already scarce, not only by the increased usage but also by deterioration of the quality of available resources. Both statistical and GIS analyses were adopted in this study to examine the changes in water quality parameters associated with the changes in landuse within a major watershed in the city of Izmir, Turkey. In this study, the satellite images containing the periods prior and after filling of the main pool of the Tahtali reservoir, were analyzed and the effects of the land use changes on the water quality were investigated. For this purpose, the aerial photos of the basin taken in 1995 (October) composed of 130 sections having a scale of 1/5000 were obtained and these images were compared with images of the Ikonos satellite taken in 2005 (November) with a resolution of 1 meter. New residential buildings, greenhouses and industrial buildings were presented in separate layers to document changes in basin activities since 1995. Later on, changes in all 130 sections were merged and the thematic maps of the basin were obtained. This analysis utilized several GIS techniques including manual digitizing, remote sensing and use of existing digital base maps for the preparation of input data. The data analysis included transformation between map projections and data formats, editing of attributes and use of query functions, use of spatial overlaying and also both retrieval and classification.

In order to investigate the effects of changes on the water quality, the water analysis values obtained from samples taken at 6 different reaches within the basin and at the main lake for the years of 1995-2005 were obtained. Seasonal Kendall and Mann Kendall tests were selected and applied to the water quality data to investigate which parameters increased/decreased and how these changes were related to the effects of urbanization and industrial development. This study also investigated and quantified soil erosion in the basin by the universal soil loss equation (USLE) for two different land use compositions and soil maps from two years: 1995 and 2005.

ÖZET

TAHTALI HAVZASI'NDA ARAZİ KULLANIMINDAKİ DEĞİŞİKLİKLERİN SU KALİTESİNE ETKİLERİNİN İNCELENMESİ

Hızlı nüfus artışı, sanayinin gelişimi ve kentleşme sınırlı olan su kaynaklarına olan ihtiyacı arttırarak, kalitesinin de bozulmasına neden olmaktadır. Su kaynaklarının sürdürülebilir yönetimi için ekosistem tüm özellikleriyle irdelenmelidir. Bu nedenle, su kaynaklarını çevreleyen arazi hakkında verilerin toplanması, sayısal ortamda depolanması ve analizlerin yapılması gerekmektedir. Coğrafi bilgi sistemleri (CBS) platformunda oluşturulan ve uydu görüntüleriyle desteklenen arazi modelleri, son zamanlarda yaygın olarak kullanılmaktadır. Bu çalışmada, Tahtalı Havzası için, baraj gölü dolum öncesi ve sonrası dönemleri içeren uydu görüntüleri analiz edilerek havzada arazi kullanımındaki değişikliklerin su kalitesine olan etkileri incelenmiştir. Bu amaçla, havzayı kapsayan ve 1995 yılı Ekim ayına ait hava fotoğraflarından elde edilen 1/5000 ölçekli 130 adet pafta, 2005 yılı Kasım ayına ait 1 metre çözünürlüklü 1/5000 ölçekli İkonos uydu görüntüleriyle karşılaştırılarak aralarındaki farklar özetlenmiştir. CBS platformunda yapılan analizde; 1995 yılında olan, 2005 yılında yapılan ve her iki yılda da görülen yerleşim birimleri, seralar ve sanayi binaları ayrı katmanlar olarak tanımlanmıştır. Daha sonra bu katmanlar sayısallaştırılarak vektörel formatta haritalara dönüştürülmüş, tablolar oluşturulmuş ve bütün paftalar birleştirilerek havzaya ait tematik haritalar elde edilmiştir.

Arazi kullanımındaki değişikliklerin su kalitesine etkisini incelemek amacıyla 1997 - 2005 yılları arasında baraj gölünde ve havzadaki 6 ayrı dereden alınan analiz değerleri irdelenmiştir. Bu zaman aralığında arazi kullanımında meydana gelen değişikliklerin başta toplam fosfor ve nitrat olmak üzere ölçülmüş olan su kalitesi parametrelerine etkileri incelenmiştir. Analizde, su kalitesi parametrelerinin değişiminde artan/azalan eğilim olup olmadığına Mevsimsel Kendall ve Mann Kendall testleri ile bakılmıştır. Eğilim analiziyle nitrat ve fosfor da artan bir eğilim görülmemesine karşın diğer parametrelerde artış olduğu görülmüş, bu artışta evsel ve endüstriyel atıkların önemli bir etkisinin olduğu saptanmıştır.

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CHAPTER 1

INTRODUCTION

1.1. The Water Resources of Earth

"Water, water, everywhere, nor any drop to drink" - Rhyme of the Ancient Mariner, by Coleridge.

Water is essential for human life, for agricultural and industrial production and for water-based recreation and transportation. With the population relatively small and concentrated in water-abundant areas and with the existence of adequate supplies, little need existed for conservation or careful water management in the past. Pollution was minimal, so there was not much need to worry about the quality of stream and lakes. As the world's population increased continuously, demand for the freshwater in the world's lakes, rivers, rainwater collection tanks, and groundwater rose. Eventually, water has become being used faster than nature can replace it. Already there is strong competition among water users such as individuals, farmers, factories, and cities. As water resources get scarcer, there is a danger that conflict could erupt among countries over available freshwater.

Water covers about two-thirds of the earth's surface,but surprisingly little is available for use as freshwater. On a global scale, the oceans are the biggest component of the earth's water system, leaving only 3 % as fresh water. Nearly 70% of the fresh water is frozen in the icecaps of Antarctica and Greenland; most of the remainder is present as soil moisture, or lies in deep underground aquifers as groundwater not accessible to human use. < 1% of the world's fresh water (~0.007% of all water on earth) is accessible for direct human use. This is the water found in lakes, rivers, reservoirs and those underground sources that are shallow enough to be tapped at an affordable cost. Only this amount is regularly renewed by rain and snowfall, and is therefore available on a sustainable basis (Gleick 2000).

A great deal of water use is non-consumptive, which means that the water returns to surface runoff. Usually that water is contaminated however, whether used for agriculture, domestic consumption, or industry. Fresh water is accepted to be a critical limiting resource for many regions in the near future. About one-third of the world's population lives in countries that are experiencing water stress. In Asia, where water has always been regarded as an abundant resource, per capita availability declined by 40-60 % between 1955 and 1990. Projections suggest that most Asian countries will have severe water problems by the year 2025. In summary water related problems are due to:

- Increased demand as a result of rapidly growing population
- Decreased supply as a result of contamination

Surface water is the water in stream channels and in lakes, reservoirs and wetlands. In periods without precipitation, the water in the streams (its base flow) derives from exfiltration of groundwater through aquifers. During and immediately after rainfall events, the base flow will be augmented by contributions from interflow, overland flow, and, of course, from rain falling directly on the stream channel. Hence, surface water can be seen as a mixture of emerging groundwater and direct inter and overland flow (see Figure 1.1.).

Throughout the course of the river, the total volume of water transported downstream will often be a combination of the visible free water flow together with a substantial contribution flowing through sub-surface rocks and gravels that underlie the river and its floodplain called the hyporheic zone. For many rivers in large valleys, this unseen component of flow may greatly exceed the visible flow. The hyporheic zone often forms a dynamic interface between surface water and true ground-water receiving water from the ground water when aquifers are fully charged and contributing water to ground-water when ground waters are depleted.

Sub-surface water, or groundwater, is fresh water located in the pore space of soil and rocks. It is also water that is flowing within aquifers below the water table. Sometimes it is useful to make a distinction between sub-surface water that is closely associated with surface water and deep sub-surface water in an aquifer

Several schemes have been proposed to make use of icebergs as a water source, however to date this has only been done for novelty purposes. Glacier runoff is considered to be surface water.

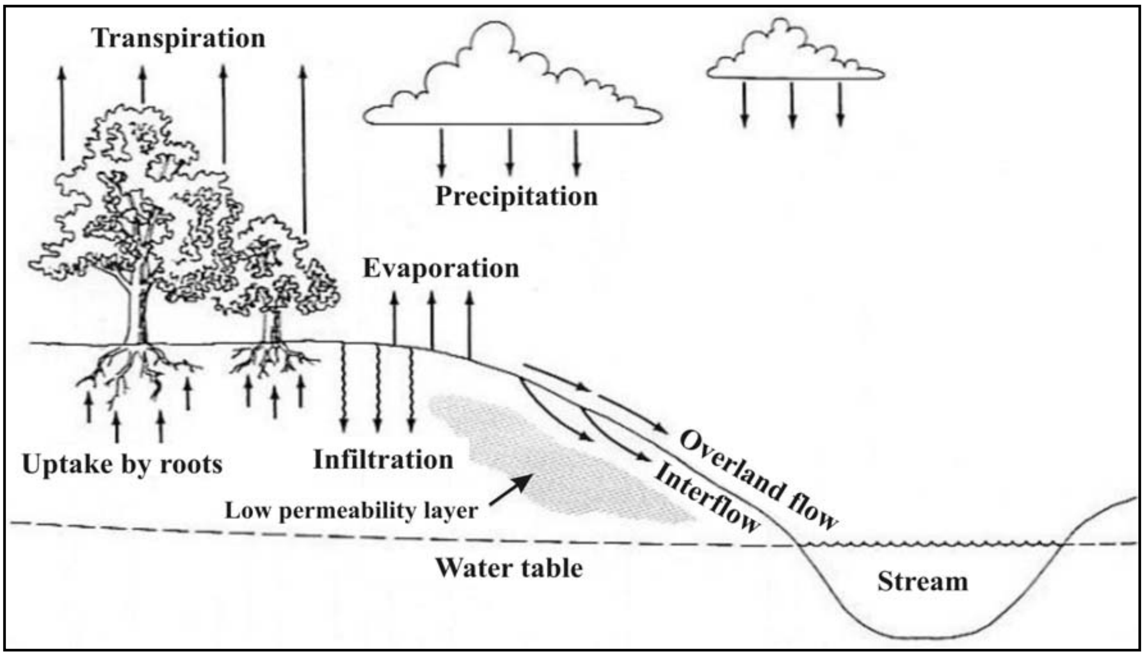


Figure 1.1. Near-surface hydrologic processes
(Source:Drever 1997)

Uses of fresh water can be categorized as consumptive and non-consumptive. Use of water is consumptive if that water is not immediately available for another use. Losses to sub-surface seepage and evaporation are considered consumptive, as is water incorporated into a product (such as farm produce). Water that can be treated and returned as surface water, such as sewage, is generally considered non-consumptive if that water can be put to additional use.

It is estimated that 69% of world-wide water is used for irrigation, with 15-35% of irrigation withdrawals being unsustainable. Recreational usage is usually non-consumptive. Recreational water use is usually a very small but growing percentage of total water use. Release of water from a few reservoirs is also timed to enhance whitewater boating, which could be considered a recreational usage. Other examples are anglers, water skiers, nature enthusiasts and swimmers. It is estimated that 15% of world-wide water use is industrial. Major industrial users include power plants, which use water for cooling or as a power source (i.e. hydroelectric plants), ore and oil refineries, which use water in chemical processes, and manufacturing plants, which use water as a solvent. The portion of industrial water usage that is consumptive varies widely, but as a whole it is lower than agricultural use. 15% of world-wide water is used for household purposes, such as drinking water, bathing, cooking, sanitation, and gardening. Environmental water usage, a very small but growing percentage of total water consumption, includes artificial wetlands, artificial lakes intended to create wildlife habitat, fish ladders around dams, and water releases from reservoirs timed to help fish spawn. Like recreational usage, environmental usage is non-consumptive but may reduce the availability of water for other users at specific times and places

Water is in constant motion on earth. The movement and endless recycling of water between the atmosphere, the land surface, and underground is called the hydrologic cycle. It describes the circulation of water throughout our environment. This movement, driven by the energy of the sun and the force of gravity, supplies the water needed to support life. Understanding the hydrologic cycle is a key to the proper management of water resources.

The portion of water which does not infiltrate the soil but flows over the surface of the ground to a stream channel is called surface runoff. Water always takes the path of least resistance, flowing downhill from higher to lower elevations, eventually reaching a river or its tributaries. All of the land which eventually drains to a common lake or river is considered to be in the same watershed. Watersheds are defined by topographic divides which separate surface flow between two water systems. Land use activities in a watershed can affect the water quality of surface water as contaminants are carried by runoff and of groundwater, especially through infiltration of pollutants. Understanding the factors which influence the rate and direction of surface water and groundwater flow helps to determine where quality of water supply is good and how contaminants migrate.

Land use and land cover have a direct relationship with environmental characteristics and processes, including the productivity of the land, species diversity, climate, biogeochemistry and the hydrologic cycle.Land cover refers to the type of feature present on the surface of the earth. Agricultural fields, lakes, rivers, pine forests, roads, and parking lots are all land cover types. Land cover may refer to a biological categorization of the surface, such as grassland or forest, or to a physical or chemical categorization such as concrete. Land use refers to the human purposes that are associated with the land cover (e.g. raising cattle, recreation, or urban living) and relates to human activities on the land (Meyer and Turner 1994).

Streams, rivers, and lakes are an important part of the landscape, as they provide water supply, recreation, and transportation for humans, and a place to live for a variety of plants and animals. As populations increase there is a greater need for food and clean water. These factors are linked with land use. Watersheds are developed and changed into urban, industrial, and agricultural areas. These land use changes may be more useful in terms of food production and provide extra space for human population growth, however, they put stress on the water. All land uses have an effect on water quality, whether positive or negative. Many physical, chemical, and biological parameters are measured to determine the overall quality of water. However, the quality of water is based not only on the concentration of substances but also on the intended use of the water. A person utilizing water for drinking would have a different set of criteria for determining the water quality compared with a person using the water for swimming. The following parameters are often used for monitoring water quality: dissolved oxygen, fecal coliform, ph, biochemical oxygen demand, temperature, total phosphates, nitrates, turbidity, total solids.

The changes of land use patterns certainly provide many social and economic benefits. However, they also come at a cost to the natural environment. One of the major direct environmental impacts of development is the degradation of water resources and water quality (USEPA 2001). Conversion of agricultural, forest, grass, and wetlands to urban areas usually comes with a vast increase in impervious surface, which can alter the natural hydrologic condition within a watershed.

The industrial and commercial land uses represent higher percentages of impervious surfaces and do result in higher runoff. Increased runoff has impacts on both our streams and ground water. First, there is an increased frequency and severity of flooding. Increased runoff also reduces ground water recharge. Continuous base flow in streams is vital to the health of fish and aquatic life in the stream. Increased runoff causes greater stream channel erosion, producing sediment that harms aquatic life. Another effect is the reduced natural filtration of the water.

1.2. Sources of Surface Water Pollution

Besides the effects on flow, land use directly affects the water quality. Point source pollution is contamination that enters the water directly, usually through a pipe. Some sources are sewage treatment plants and industrial sources. Nonpoint source pollution occurs when rainfall or snowmelt runs over land or through the ground, picks up pollutants, and deposits them into rivers, lakes, wetlands, and coastal waters or introduces them into groundwater. An example of a point source of water pollution is a pipe from an industrial facility discharging effluent directly into a river. An example of a nonpoint-source of water pollution is when fertilizer from a farm field is carried into a stream by rain.

Municipal sewage treatment plant discharges can contribute pollution in the form of oxygen-depleting nutrients and in the form of pathogens that cause serious health hazards in drinking water and swimming areas. Industrial point sources can contribute pollution in the form of toxic chemicals and heavy metals. Municipal point sources are the result of community sewage treatment systems. At the sewage treatment plant, wastewater is treated to remove solid and organic matter, disinfected to kill bacteria and viruses, and then often discharged to a surface water. During heavy rain, discharges from sewage treatment systems can be a serious problem. In many municipalities, storm-water runoff is combined with municipal sewage in a common system. The increased water volume leads to reduced treatment. Combined sewer overflows occur when water flow exceeds treatment plant capacity, resulting in untreated sewage being discharged directly to rivers or lakes. Industrial point sources are the result of industries using water in their production processes, and then treating the water prior to discharge. Some of the industries requiring process waters include pulp and paper mills, food processors, electronic equipment manufacturers, rare metal manufacturers, textile manufacturers, pharmaceutical manufacturers, forest product producers, leather tanners, and chemical manufacturers.

Some of the primary activities that generate nonpoint source pollution include farming and grazing activities, harvesting,construction, and recreational boating. Manure, pesticides, fertilizers, dirt, oil, and gas produced by these activities are examples of nonpoint source pollutants. Even individual households contribute to nonpoint source pollution through improper chemical and pesticide use, landscaping, and other household practices.

Sediment can be destructive for rivers and lakes. Sediments come from unvegetated, open space area. Modification of streams and wetlands, high-till farming, and dredging cause soil erosion. This sediment is posed as a problem because it destroys the aquatic habitat through the removal of riparian vegetation and alteration of a stream's natural hydrology.

Runoff is referred to as any liquid substance that runs from one area to another and is not absorbed by the ground. Urban runoff from buildings and streets include oil, grease, trash, road salts, lawn fertilizer, lead, metals, bacteria that run into surface and ground waters. Agricultural storm water runoff from rain and snow melt carries animal wastes, pesticides, nutrients, and sediments into surface and ground waters.

Another nonpoint source of pollution is leakage. Abandoned surface mines and waste piles may leak sediments, acids, and chemicals. Improper disposal of waste directly into or above an aquifer can cause serious ground water contamination.

Combined sewer overflows which consist of storm water and untreated sewage and sanitary sewer overflows are a problem when they overflow into lakes and rivers. They put trash, sewage, bacteria, wastes, and other pollutants into the water.

Poor land management, water use, and nonpoint source pollution remain the most significant threats to our water resources. Control of cropland and construction site erosion, urban runoff manure and industrial waste are needed to maintain quality of water resource.

Flow regime (the quantity of water in a stream and how it changes over time) is a major determinant of the biological integrity of stream and river resources. Land cover has a significant effect on the water cycle, which in turn affects stream and river flow regimes. Water quality is strongly influenced by land use. Nonpoint source pollution from rural and urban land use activities reduces water quality by adding sediment, nutrients, toxics, organic materials, and pathogens to surface and ground waters. Inputs of phosphorus from manure and commercial fertilizers may cause an excess of nutrients (eutrophication) in streams, rivers, or lakes, which often results in excessive aquatic plant growth and algal blooms. High nitrate levels resulting from excessive or improperly applied manure and chemical fertilizers may leach into the ground water reducing drinking water quality. Increased surface runoff, water turbidity, and reductions in riparian vegetation all act to warm surface waters. Warming and eutrophication of surface waters reduces the amount of dissolved oxygen (DO) in water. DO is an important regulator of aquatic life and a good indicator of stream health.

Riparian and instream habitat quality are major determinants of water resource quality that are influenced by land use. Reductions in riparian vegetation by cropping, grazing, and urban development affects aquatic and terrestrial habitat and the animal communities that occur there. Sedimentation reduces the quality and quantity of instream habitat for insects and fish by covering a diverse stream bottom with a uniform layer of sediment (Miller 1999).

1.3. Land Use and Land Cover

Water quantity and water quality in watersheds are directly influenced by changes in land use and the application of agricultural and urban best management practices. Human activities frequently challenge the quantity and quality of water in rivers. These include activities that use river water directly - such as power generation and irrigation and land-based activities that generate nutrients and pollutants, while also changing the runoff patterns of their catchments. A growing population with growing expectations places increasing pressure on our rivers, stretching their ability to handle extraction and to absorb wastes and runoff while still maintaining the standards of water quantity and quality required for healthy rivers.

Land use and land cover information have become important for land use planning and resource management, yet currently used mapping and monitoring methods cannot address the needs of forest managers and environmentalists. Using or relying on ground surveys and sampling alone requires man power, expenditure and time. Recent developments in remote sensing technology indicate that, if these methods are carefully combined with reliable ground based data, it is possible to compile detailed inventories and to monitor natural resources. Such analyses include the relationships between changes in forest zones and socio-economic development factors. Geographic Information Systems (GIS) are used for more detailed analysis of collected land use information (Roy, et. al. 1985, Unni, et. al. 1985, Jadhav, et. al. 1987).

1.4. Study Objectives

The objective of this study is to investigate the impacts of land use changes in Tahtalı Basin on water quality through GIS techniques. In this thesis, effects of landuse changes in 1995 (before the dam construction in Tahtali basin) and 2005 (after the dam construction) on water quality (including BOD, COD, boron, total phosphorus and nitrate) have been investigated. For this purpose water quality measurements conducted by Izmir Water and Sewage Authority (IZSU) at the dam site and at 6-different stream monitoring stations within the basin were obtained. All data gathered were collected in a database and the results were evaluated in combination with landuse changes determined from aerial photos belonging to October-1995 and IKONOS satellite images taken in November-2005. Data existence, availability and the scale of 1/5000 were considered during the selection of dates for images. Radiometric resolution of the satellite images of Tahtalı Basin which were taken on October 3 rd, 2005, is 11 bit. Spatial resolution of the images is 1 meter of which projection type is UTM with ED50 datum. Digital elevation model was prepared using vector elevation data of the study area to ortorectify the 1/5000 scale satellite images. Water quality affected from different land uses such as residential areas, greenhouses and industrial zones were analyzed using Microstation software to determine their changes in time. After determining the changes occured in landuse between 1995 and 2005, database for water quality data was created using data obtained from IZSU for lake and 6 different monitoring stations in the basin . Water quality data were available starting from 1996.

This study aims to provide backround information for sustainable management of water resources in the basin. Sustainable management of water resources requires controlling and minimizing the incidence of pollutant-oriented problems, and to provide water of appropriate quality to serve various purposes such as drinking water supply, irrigation water, etc. The quality of water is identified in terms of its physical, chemical and biological parameters, and ascertaining its quality is crucial before use for various intended purposes such as potable water, agricultural, recreational and industrial water uses.

A major objective of water quality assessment is to determine whether or not the water quality meets previously defined objectives for designated uses, to describe water quality at regional, national or international scales, and also to investigate trends in time. Traditional approaches to assess water quality are based on a comparison of experimentally determined parameter values with existing guidelines. In many cases, the use of this methodology allows proper identification of contamination sources and may be essential for checking legal compliance. However, it does not readily give an overall view of the spatial and temporal trends in the overall water quality in a watershed (Debels, et al. 2005).

One of the difficult tasks facing environmental managers is how to transfer their interpretation of complex environmental data into information that is understandable and useful to technical and policy individuals as well as the general public. This is particularly important in reporting the state of the environment. Internationally, there have been a number of attempts to produce a method that meaningfully integrates the data sets and converts them into information. (Sargaonkar and Deshpande 2003).

Since 1965, when Horton (1965) proposed the first water quality index (WQI), a great deal of consideration has been given to the development of 'water quality index' methods to simplify the presentation of water quality data.

There are several water quality indices that have been developed to evaluate water quality in the world. All of these indices have eight or more water quality variables. The National Sanitation Foundation Water Quality Index (NSFWQI), standardized method for comparing the relative quality of various bodies of water, was used in this study to evaluate the water quality within the basin.

In order to asses water quality changing trends within the basin, trend analysis was also utilized. In this study statistical methods were applied to water quality data sets including five parameters obtained at seven stations . These parameters are; boron, total phosphorus, nitrate, biological oxygen demand (BOD), and chemical oxygen demand (COD). Non-parametric trend analysis methods including Mann Kendall test and Seasonal Kendall Test statistics were performed to determine temporal trends. These tests were utilized in this study because, the tests can be applied to limited and deficient values of water quality data and internal dependence of water quality data can be taken into consideration.

Watershed erosion is a cause of non-point source pollution that can have an adverse effect on the ecosystem and downstream water quality. Consequently, the estimation of runoff and soil loss from small watersheds is becoming more and more important as concerns about surface water quality increase. Beside these analysis, soil erosion was investigated and quantified in the basin by the Universal Soil Loss Equation (USLE) for two different land use compositions and soil maps from two years: 1995 and 2005. Thus the effect of changes in landuse in ten years could be quantified via computation of soil erosion rate in the basin.

This thesis includes 5 chapters. First; common indicators of water quality were examined and related to land use in Tahtalı basin. Previous relevant studies discussing effects on landuse change on water quality and application of statistical methods in water quality assessment are reviewed in Chapter 2. In Chapter 3, the study site is described. The methodologies applied for landuse analysis, water quality analysis and erosion prediction are discussed in Chapter 4. Finally, in Chapter 5, the main results and the conclusions of the study are summarized.

CHAPTER 2

LITERATURE REVIEW

Natural processes and both direct and indirect effects of human activities are major drivers of land use and land cover change .Land-use change is a primary factor causing water-quality and habitat degradation (USGS 2005). Change in land-cover influence soil quality, water runoff, sedimentation rates, earth-atmosphere interactions, biodiversity, the hydrological cycle, and biogeochemical cycling of carbon, nitrogen and other elements at regional to global scales. There have been several investigations in recent years on the effect of land use on water quality.

Different studies showed that the unplanned urban and industrial expansions and domestic and industrial waste discharge are having a direct impact on the water quality of the lakes. Landuse changes are directly affected on water quality (Fachrul 2007; Raumann 2001, Gümrükçüoğlu ve Baştürk 2007, Demirci ve Mcadams 2006). A study conducted in Turkey revealed that Sakarya river was mainly polluted by discharges in automotive and textile firms (Gümrükçüoğlu and Baştürk 2007). Johnson, et. al. (1997) showed that landscape characteristics explain some water quality variations in some seasons, but that catchment land use was just as important in predicting water quality. Uncontrolled, discharges made Çark Stream (Adapazarı) polluted the stream, which was used for drinking water and other aims in 1988. In the same study, effects of waste waters of food and chemical industries are lower than the industries mentioned above.

Not only unplanned cities and industrial development but also home waste and industrial wastes which infiltrated to the lake in Küçük Çekmece Basin, made the water polluted (Demirci and Mcadams 2006). Smart (2004) used remote sensing to determine the land use in the Upper Little Miami River Watershed and then used data from waste water treatment plants to relate the water quality to land use. France (2005) focused on the effects of urban sprawl on water quality in the Mid-Ohio River Watershed using remote sensing data and data from the United States Environmental Protection Agency's STORET water quality database. The major limitation of these studies was that the data collected may not be representative of the actual watershed. Also, the water quality data used in these studies may only represent the current land use and not necessarily reflect the change in land use.

Binford, et. al. (2000) evaluated the drivers of land use change and they stated that demography, technology, economy, political and social institutions cause changes in landuse. Consequently, they concluded that, there is a need to develop a framework for modeling land use change and hydrological impacts.

Agarwal, et. al. (2000) discussed land use change as an important and complex environmental issue that needs "many eyeballs" working together. They stated that there are water quality parameters including temperature, dissolved oxygen, pH, total suspended solids, nutrients, and heavy metals are crucial to the survived habitat and critical to the quality of water resources.

Randall (2000) studied nitrate in surface waters as influenced by climatic conditions and agricultural practices. Subsurface drainage from row-crop agricultural production systems has been recognized as a major source of nitrate entering the surface waters of Mississippi River basin. They authors pointed out that uncontrollable factors such as precipitation and mineralization of soil organic matter had a great effect on drainage losses, nitrate concentrations, and nitrate loadings in subsurface drainage water. The researchers emphasized that cropping system and nutrient management inputs are controllable factors that have an unstable control on nitrate losses. They observed that improving nitrogen management by applying the correct dosage of N at the optimum time can lead to reduced nitrate losses.

Karakoç,et.al. (2003) conducted a study about water quality of Lake Eymir and Lake Mogan. In this study, potential impacts from extensive agriculture, recreation, incomplete infrastructure and other human activities were investigated. It was found that the most polluted creeks were Yavrucak, Gölcük and Mogan Canal. In the summer months, there were heavier pollution loads due to lower flow rates and heavier land use, human activities and agricultural activities. It was observed that Eymir Lake had heavy pollution originating from Mogan Lake. It was also found that the pollution loads did not worsen after the study in 1995.

Andraski and Larry (2002) studied the relationship between phosphorus levels in soil and runoff from corn production systems. Runoff enriched with phosphorus from cropland can accelerate eutrophication of surface waters. Long-term fertilization is one of several potential sources of increased P losses in runoff from agricultural systems. In this research, the scientists conducted several field experiments at locations representing three major soil regions in Wisconsin. They aimed to determine the effect of tillage and soil P extraction method on the relationship between soil test P level and P concentrations in the runoff. Runoff from simulated rainfall (75 mm) was collected from 0.83-m^2 areas for 1 h after rainfall initiation and analyzed for dissolved phosphorus (DP), total phosphorus, and sediment. For most of the tests and sampling depths used in 213 observations across a variety of soils and managements, there were good relationships between soil test P level and DP concentration in runoff.

Greene and Cruise (1995) applied urban watershed modeling using geographic information system to direct a hydrologic modeling effort for watershed management in Baton Rouge, Louisiana. The GIS identified hydrologic response units (HRUs), and the locational information (coordinates) of the HRU boundaries were used to guide and direct the model. In this study, the curve number method was used to determine rainfall events.

Pohlert (2007) modeled point and non-point source pollution of nitrate in the river Dill, Germany. They used the Soil and Water Assessment Tool (SWAT) to simulate point and non-point source pollution of nitrate in mountainous catchments. The results showed that the internal fluxes and cycles of nitrogen pointed out considerable weaknesses in the model's conceptualization of the nitrogen modules, which should be improved in future research. Additional research by Scott, et. al. (1992) analyzed the geographical and statistical relationships between landscape parameters and water quality indices in the Muddy Fork Watershed in Washington County, Arkansas also by utilizing remote sensing and GIS modeling techniques. The impetus of their research stems from the fact that this particular watershed contains many of the key elements involved in rural water quality issues: a high density of farm animals located on well-drained soils over carbonate terrain. Such terrain is considered to be highly susceptible to infiltration of pollutants and can often result in non-point source contamination of water resources. Similar conditions and terrain also occur in Carroll County as well as many areas of Northwest Arkansas. The results of their research indicated that increased levels of nitrates and phosphorus contamination in both ground water and soil could be linked to pastures characterized by well-drained soils and proximity to chicken houses as a result of applied chicken litter for soil amendment or fertilizer.

Several studied showed that a change in land use can alter the nutrient content of surface and groundwater, most notably nitrogen (N) and phosphorus (P) levels. Deforestation can lead to high nitrate (NO_3) concentrations in water due to decomposition of plant material and a reduced nutrient uptake by the vegetation. Nitrate concentration in runoff in deforested catchments can be 50 times higher than in a forested control catchment over several years (Falkenmark and Chapman 1989).

Allen, et. al. (1999) applied GIS-based methodologies for analysis, modeling and prediction of coastal land-use change. They took a micro approach to examine the parcel-based land-use change at the local scale. A spatial multivariate logistic regression model was developed and 20 variables were selected for predicting the possibilities of land-use change for Murrells Inlet. The results indicated the advantages of GIS in land-use change studies due to its ability to perform spatial analysis, model spatial processes, and map the results. The results also indicate that the Murrells Inlet has experienced rapid land-use change over the last thirty years.

Tong and Chen (2002) used both statistical and GIS analyses to examine the effect of land use on water quality. A statistical approach of non-parametric correlation analysis and variance analysis was used to examine the general association of land use and flow and water quality and then identity areas with contaminant enrichment and correlate that to land use. They found that most of the nitrogen loading in the system came from agricultural lands followed by impervious-urban then pervious-urban, forest and finally barren. In storm events forests exported more nitrogen then pervious-urban land use. A similar pattern was observed for phosphorus loading and fecal coliform. Agricultural areas have higher nutrient inputs which allows for higher amounts of loading of nitrogen, phosphorus and fecal coliform. This study have had limitations in the high amount of data required or a high degree of knowledge required to setup the model.

Hannon (2003), generated an updated Land Use/Land Cover (LULC) map that could be used by city planners in Grand Haven to get a visual representation of the growth patterns that are occurring in the community. To determine the trend of land use change in the township as opposed to the loss of actual green space. In other words, the BSRSI research finds that the township is developing underutilized non-forested and non-farmed areas instead of developing farms and forests.

Smith, et. al. (1996) used the Seasonal Kendall test to detect trend for 14 physical and chemical parameters at 77 river sites distributed across New Zealand's North and South Islands. Their justification for using the Seasonal Kendall test was that, firstly, water quality data were often not normally distributed, thus casting doubt on the use of regression techniques. Secondly, the seasonality aspect of water quality data would not be accounted for in regression analyses. The results of their analysis revealed that there was a general improvement in water quality, especially in the South Island. This was seen in decreasing trends of biological oxygen demand, nitrogen and phosphorus.

In another study of long term trends in surface water quality, Zipper, et. al. (1998), employing the Seasonal Kendall test for trend, analysed time series data for dissolved oxygen (DO), biological oxygen demand (BOD), pH, total residue (TR), non filterable residue (NFR), total Kjeldahl nitrogen (TKN), total phosphorus (TP) and faecal coli form (FC) accumulated for 187 monitoring stations in Virginia's rivers, from 1966 to early 1997. They observed that significant trends indicating improvements in water quality exceeded those indicating deterioration for BOD, TP, FC, NFR, and DO across the state of Virginia. Increasing trends for TKN outnumbered the decreasing trends, suggesting deteriorating water quality in that regard.

Harned,et.al. (1995) used Seasonal Kendall trend analysis to detect trends in water quality in the Neuse River from its headwaters to Kinston for the period 1980-90. Several sites analyzed for this report coincide with sites analyzed by Harned and others (1995). Decreasing trends in total phosphorus in North Carolina streams were attributed to the 1988 phosphate-detergent ban. A decreasing trend in total nitrogen below Falls Lake was probably due to the 1983 impoundment that formed Falls Lake. An increasing trend in total nitrogen was detected in the middle part of the Neuse River Basin and was probably due to increased development and changing agricultural practices.

Hunter (1990) conducted a study for the comparison of GIS, remote sensing with the USLE model using factors calculated in the field. His methodology incorporated several assumed constant values, such as R (R is the rainfall erosivity factor), P (P is the supporting practice factor) and slope length. He concluded that the USLE model was capable of identifying the same areas of high erosion potential as those identified by a Soil Conservation Service survey, plus additional areas of concern.

Study by Endreny and Wood (2003) used the export coefficient method to quantify the impact of land use on water quality. The export coefficient model is a model that attempts to predict nutrient loading at any location in a watershed based on land use, fertilizer application, livestock and human spatial distribution and other nutrient inputs . This method however only allows for a load or weight amount of a certain chemical that is exported from the watershed for the year.

In all these studies mentioned above, either landuse changes were investigated in the river basins alone, or effects of landuse changes on water quality were investigated through indexing methods. In some studies, statistical tests were applied to water quality monitoring parameters, and trends were investigated in time where effects of landuse were not considered. Widely used USLE equation have been applied to different basins in the world for quantification of soil loss. However, an analysis for application of USLE for comparison of soil loss due to different landuse compositions in time has not been encountered in the literature. Therefore, this study utilized two different land use compositions and soil maps from two years: 1995 and 2005 and investigated impacts of landuse through water quality indexing, trend analysis and erosion prediction analysis.

CHAPTER 3

STUDY SITE

The third largest city in Turkey, in terms of population and industrial development İzmir has appropriate climatic conditions enabling the growth of various crops, and constitutes a commercial bridge between Turkey and the Europe. The city is rapidly developing and the current infrastructure is getting less sufficient for the residential and industrial zones that are attached to the city year by year. The rapid expansion of the city is being accelerated by the domestic population movement to the city from other parts of the country, especially due to its warm climatic properties. On the other hand, the city is not rich in water resources. The current water supply system includes several surface water resources and groundwater developments. The most important surface water resource is Tahtali reservoir (Figure 3.1) which provides around 40 % of city supply, located approximately 40 km away from the city. The Tahtali reservoir has started operation in 1998 and is expected to be the major source of domestic water supply for Izmir. The Sarikiz-Göksu wells (Figure 3.1), whose resources require a 50 km pipeline to reach the city, are the other important water resources. Groundwater resources to the north of the city have long been the only source of drinking water supply; yet, they are degraded both in quantity and quality due to excessive use by the rapidly increasing population.The Tahtali reservoir is prone to significant levels of environmental pollution originating from domestic, industrial and agricultural discharges which feed its catchment area. These discharges are drained through the catchment area of 550 km^2 and are further transported via 44 creeks and their tributaries to the Tahtali reservoir. Although protection zones are defined around the reservoir, the safety of drinking water supplies is threatened by pollution originating in the basin. Consequently, the Tahtali reservoir and its catchment area have attained top priority among all other problems relevant to the city of Izmir in terms of environmental protection (Gürses 2002).

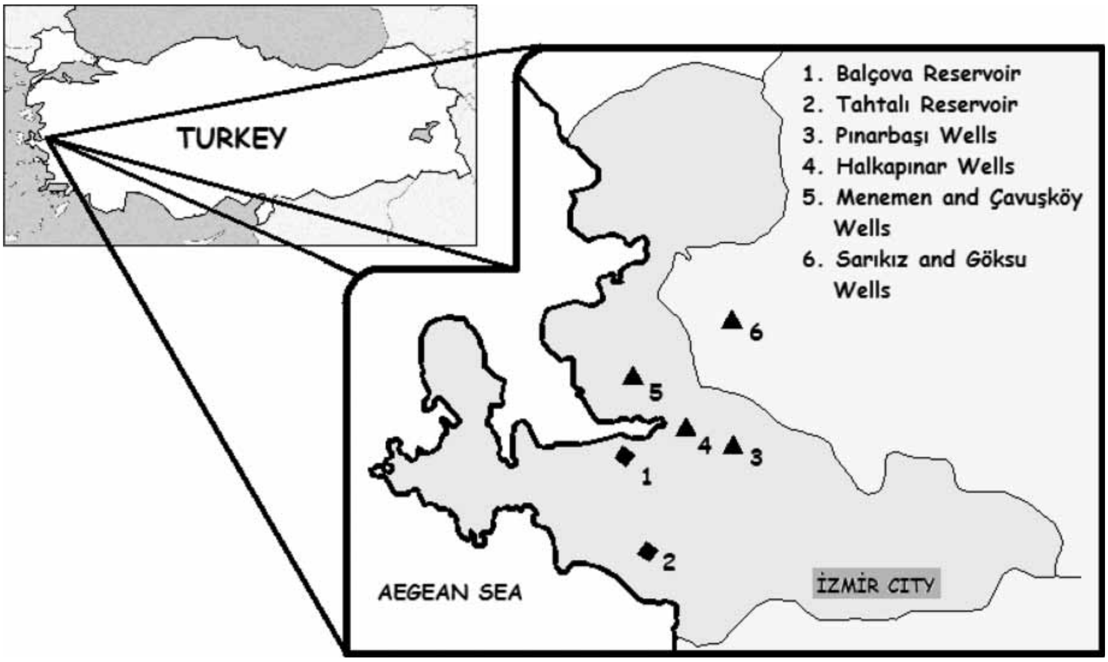


Figure 3.1. Location of the city of Izmir and water resources.

Tahtalı Dam was projected as a rockfill dam and completed in 1996 to supply fresh water to Izmir. The capacity of the dam is 175 million cubic meters and it generates monthly 5 million cubic meters of water. The dam is currently operated by IzmirWater and Sewage Administration (IZSU). The main tributaries contributing to the rerservoir are Tahtalı and Sasal Rivers merging downstream of the basin where the reservoir is located. In Tahtali Basin, there are 17 villages, where approximately 75000 people live in this area (by 2005).

An Environmental Organization Plan has been issued in 1996 by the Ministry of Housing and Public Works, which foresees the development of master plans for organization of settlements and their infrastructures. The climate of the region is typical Mediterranean: hot and dry in summers and temperate and rainy in winters. Illegal housing has become a major problem,particularly due to continuous migration to the basin. A significant number of settlements do not have access to sewage systems nor to treatment facilities. Projects are prepared to complete the construction of infrastructures for such areas. Vegetables and dairy products are the basic outputs of agricultural activities. Plain fields which are generally located in the middle of the study site, are used for agricultural purposes. Dry arable fielding, vine growing and fruit growing, orcharding in greenhouses, and flower production are made in agricultural fields.

Within the basin %60 at the area is composed forestry and scrub areas, agricultural areas cover % 30 of the area. Farmers are encouraged to shift to ecological agriculture to reduce the use of artificial fertilizers and pesticides that lead to significant levels of nonpoint pollution in surface waters. Water quality of the Tahtali basin has been monitored on an irregular basis by IZSU. Since monitoring commenced in 1996, about 40 physical, chemical and biological water quality variables have been recorded at 7 river monitoring stations (Figure 3.2). As a result of the above activities, the quality of surface waters and hence that of reservoir contents, has been degraded, (Gok 1998).

Currently, authorities apply restrictions on collective settlements, industrial and agricultural developments particularly in the protection zones of the reservoir. Such restrictions have a direct impact on the social and economical activities of the population residing in the basin. In a report by IZSU, the following actions are foreseen to assure the safety of drinking waters supplied by the Tahtali reservoir (IZSU 1997),

1. management of the basin should be realized by a single authority in the form of a “basin management administration”;
2. controlled agricultural policies should be adopted;
3. permits for stock-breeding should be issued according to regulations;
4. new industries and new settlements should not be permitted;
5. the use of fertilizers and pesticides should be prevented;
6. farmers should be trained for ecological agriculture;
7. as the basin has a dynamic social and economic character, all activities in the basin should be monitored along with water quality; results of monitoring should be transformed into a database (information system) and assessed through a computerized system of database and models.

Table 3.1. Water quality monitoring stations

Station	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Name	Tahtalı Lake	Şaşal Bridge	Menderes Şehitoğlu	Tahtalı River	İstasyon District	Mersinli Kahve	Aydın Motorway

The names of the stations are provided in Table 3.1.

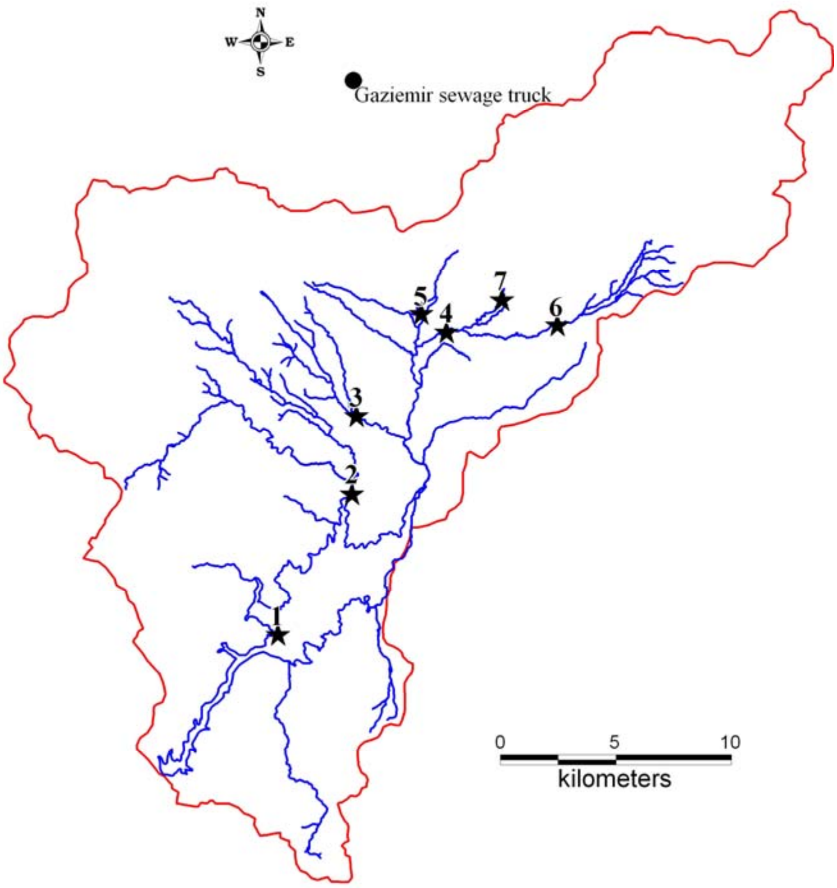


Figure 3.2. River network and water quality monitoring stations within Tahtalı Basin

In 1992, IZSU issued a Regulation on Watershed Protection, based on the Law of Establishment of ISKI (Law No: 2560 and its revised from numbered 3009), Environmental Law (Law No: 2872), Water Pollution Control Regulation of 1988 and the Law on Natural Waters (Law No: 831). IZSU, Regulation on Watershed Protection (Law No: 2560 and its revised from numbered 3009; date of issue: 21/10/1992) The purpose of this Regulation is to prevent domestic, industrial and agricultural pollution in watersheds that feed domestic water sources. It further defines measures to be taken in absolute, short distance, medium distance and long distance protection zones. The Regulation has been revised a number of times in 1993, 1994, 1995, 1997,2000. IZSU has recently updated its Regulation on Watershed Protection (updated; Reg. No: 05/16; date of issue: 12/03/2002). In this recent Regulation Protection Zones are determined as follows (Figure 3.3).

- -0-300 meters absolute protection zone from maximum water level (15 km^2),
- -300-1000 meters short distant protection zone (28 km^2),
- -1000-2000 meters medium distance protection zone (33.5 km^2),
- ->2000 meters long distance protection zone (452.5 km^2) and
- -River protection zone of 0-100 meters (28 km^2).

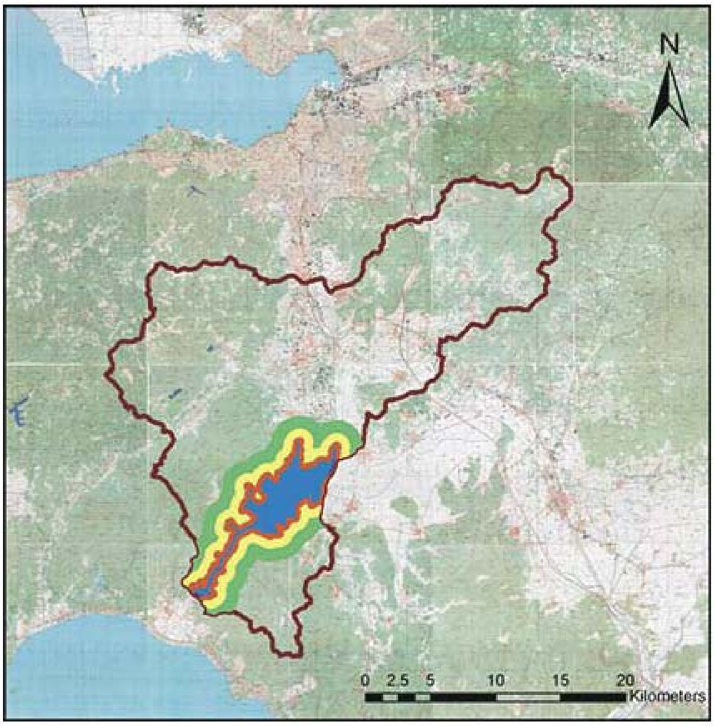


Figure 3.3. Regulation protection zones in Tahtalı Basin.

Absolute protection zone, is strictly prohibited for building construction except for that of treatment plants. Touristic activities, settlements, agriculture, mining and discharge of all types of wastes are forbidden. There are industrial activities including forestry production, furniture, marble, detergent, chicken farms, dairy farms, rendering plants, oil stations, stock farming and meat farming. These industries are located in Kısıkköy, Oğlananası, Menderes, Dereköy, Akçaköy, Develiköy, Görece, Gölcükler, Yeşilköy sites (Figure 3.4).

In short distant protection zone, touristic and industrial activities are forbidden. Solid or liquid wastes can neither be stored nor discharged. Settlements are permitted provided that the population density is kept at 5 persons/ha in regions with an area of

10000 m^2 or more Agricultural practices using fertilizers and pesticides are prohibited. Stock farming, chicken farms are located in Bulgurca, Değirmendere, Şaşal and Küner sites (Figure 3.4).

Industrial activities, green housing and stock farming activities are not allowed in medium distance protection zone settlements are permitted for a population density of 10 persons/ha in parcels with an area of 5000 m^2 or more.. Similarly, agriculture that uses fertilizers and pesticides is not permitted. Discharge of solid and liquid wastes is forbidden as well. Industrial firms, stock farming, mining, water and machine industries are active in this zone. These firms are located in Develiköy, Bulgurca, Degirmendere and Şaşal sites (Figure 3.4).

Settlements are permitted for a population density of 20 persons/ha in parcels with an area of 2500 m^2 or more in long distance protection zone. Industrial and touristic establishments are prohibited. Again, the use of fertilizers and pesticides is forbidden. Long Distance Protection Zone covers of stock farming, wood-metal works, cooperative apartment housing, chicken forming, machine industry, oil stations, egg production, polyester production, automotive industry, freezer depot, box industry, migrant buildings which are about 2000. These buildings are mostly located in Görece, Gölcükler, Gaziemir, Kısık, Oglananası, Kaynaklar, Belenbaşı, Kırıklar, Sarnıç, Develiköy, Menderes, Akçaköy, Küner, Yeşilköy, Karaagaç sites. Some of them took necessary precautions about contaminations. In this obligatory plan, no stock farming is accepted in such areas but there are stock farms in the dam protection sites.

Organic substance, hazardous wastes and droppings which come from these industries, are the main source of contaminants which threat surficial and underground water supplies. Aside from these, water coming from agricultural irrigation, drainage water contaminated from not only sewage water from solid wastes and droppings like wastes but also rainfall supported drainage water, continue to flow to the dam site.

Green housing and agricultural applications have been made in absolute, short and medium distant protection zones. Fertilizer and pesticide usage in agricultural field must be limited, instead of chemical fertilizer usage, usage of biologic methods should be encouraged.

IZSU has been controlling and decreasing works for sources of contamination by doing many measurements and studies. These measurements basically control sources which are points. Contamination resources which are not points rather originated from agricultural activities and rainfall-flow properties. As a result, basin has been exposed to some contaminants. 1/25000 scale environmental regulation plan prepared in 2002 to prevent the contamination source of domestic, industrial, agricultural and animal breeding activities and to protect community's health and to evaluate natural potential of water basin ideally.

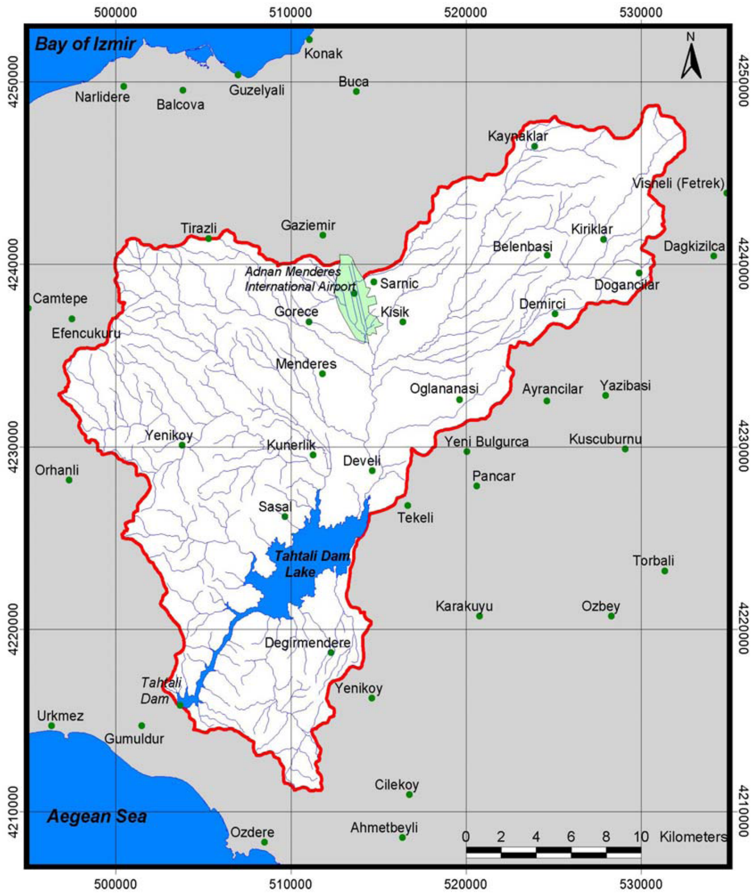


Figure 3.4. Settlements within the Tahtalı Basin
(Source: Barış 2008)

Tahtalı Reservoir is controlled firmly, and the industrial plants around are not allowed to be discharged to the reservoir. They are discharged to Gaziemir with a sewage truck. Sewage water is pumped to the treatment plant near Gaziemir through the pipes designed and built by IZSU. The location of the treatment plant is given in Figure 3.2.

CHAPTER 4

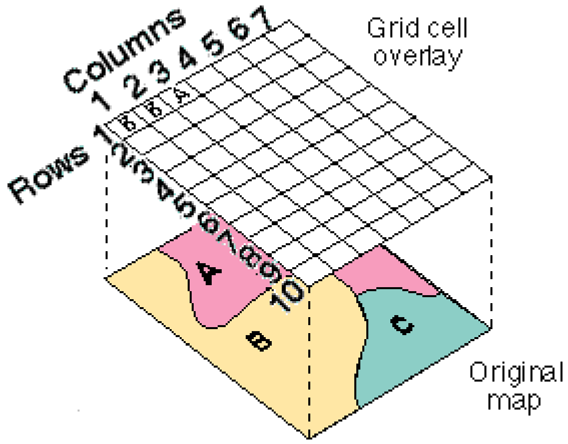
METHODOLOGY

This section is divided into three parts. The first part describes analysis of land use changes using GIS. The second part describes analysis of water quality by water quality indexing and statistical testing. The third part involves quantification of erosion in the basin by the Universal Soil Loss Equation (USLE).

4.1. Land Use Analysis

Geographic Information System (GIS) is an arrangement of computer hardware, software, and geographic data that people utilize to integrate, to analyze and to visualize data, to identify relationships, patterns, and trends; and to find solutions to problems. The system is designed to capture, store, update, manipulate, analyze, and display data and used to perform analyses. GIS have been used in various environmental applications since the 1970s; however, extensive application of GIS to hydrologic and hydraulic modeling and flood mapping and management did not begin until the early 1990s (Moore, et. al. 1991, Maidment and Djokic 2000).

GIS data represents real world objects (roads, land use, elevation) with digital data. Data are stored in two different formats, as raster and vector data. Raster data are used to store images such as aerial photographs, and are extremely demanding on computer systems in terms of storage and processing requirements It consists of rows and columns of cells (or pixels). Figure 4.1. shows the essential steps involved in converting a map to a raster format. First, a gridded matrix is registered to and overlaid on the original map manuscript. Location in the grid is defined by the row and column coordinates of each cell. To encode the map data for each cell in the raster format, three pieces of data are recorded: the row coordinate, the column coordinate, and the attribute. (Congalton and Green 1992)



Raster data file

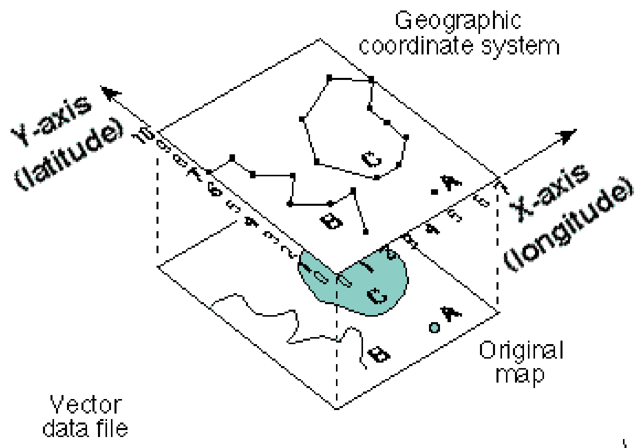
ROW	COLUMN	ATTRIBUTE
1	1	B
1	2	B
1	3	A

Figure 4.1. Raster data and its attribute table

Vector data presents features using three basic shapes: points, lines, and polygons. It is useful in representing maps those have boundaries, such as landmarks, highways, countries, lakes, and watersheds (Figure 4.2). Features have a geographic location and are stored as coordinates. Latitude and longitude, or another system of measurement, are used to locate features. Location coordinates also define the feature shape. A single coordinate defines a point. Features have four properties: Shape, location, symbol, and attributes.

Data to build a GIS dataset usually come from three sources: paper-based maps, aerial or satellite photographs, and/or global positioning system (GPS) receivers. (Congalton and Green 1992).

GIS convert traditional (usually paper) maps into a computer-compatible form. In order to get the spatial data stored in the GIS accurate, the map maker and the GIS user must consider issues of coordinate systems, projections, and scale. Every GIS analysis requires that data must be compatible with these basic issues used in compiling mapped data. Traditional maps are static and fixed with respect not only to the data, but also with respect to projection, scale, and coordinate system. When a user needs to integrate maps of different scales, for example, it is often necessary to re-draft the maps, (Falbo, et. al. 1991). Table 4.1. summaries the advantages and disadvantages of Traditional maps compared with GIS.



ENTITY	X,Y COORDINATES	NAME
A	5,1	well
B	0,7; 1,7; 1,6; 2,5; 1,4; 2,3; 3,3; 2,1	stream
C	4,3; 5,3; 6,4; 6,5; 6,6; 7,7; 6,8; 4,7; 3,5; 4,3	lake

Figure 4.2. Vector data and its attribute table

The primary requirement for the source data in GIS analysis is that the locations for the variables are known. Location may be annotated by x, y, and z coordinates of longitude, latitude, and elevation, or by such systems as ZIP codes. Any variable that can be located spatially can be fed and different kinds of data in map form can be entered into a GIS. If the data to be used are not already in a digital format , there are various techniques and technologies available to capture the visible features. The simplest technique is digitizing, hand-tracing the paper map by a computer mouse. Electronic scanning devices may be employed to convert map lines and points to digits (Bianchin 2001).

During the analyses of land use changes in Tahtalı Basin, aerial photographs of the basin taken in October-1995 and Ikonos Satellite Images taken in November-2005 were used. Both aerial photos and satellite images must be geometrically and radiometrically corrected, in order to eliminate distortions. Using digital image processing techniques, different information layers were developed and imported to the GIS software (MapInfo) which was used for the comparative spatial and quantitative analysis of all map layers with attributes.

Table 4.1. Advantages and disadvantages of traditional maps compared with GIS (Source: Falbo, et.al. 1991)

TRADITIONAL MAPS	GEOGRAPHIC INFORMATION SYSTEMS
Data are static	Data easy to update
Fixed projection, scale, coordinate system	Can convert to new, scale, scale or coordinate system
Quantitative analyses often tedious	Many manipulation options for analyzing maps
Difficult to combine multiple map sheets	Easy to combine multiple map layers
Overlays are restricted to a few layers	Can overlay as many maps as contained in database
Updates require re-drafting	Tools allow for map updates without re-drafting
Difficult to copy and share between many users	Multiple, simultaneous user access available
Lower overhead costs	Higher overhead costs
Paper maps usable in present form	Must convert map data to a digital environment
Few Changes in technology	Technology changes

4.1.1. Aerial Photographs

Aerial photographs recorded with standard mapping cameras must be scanned and converted to raster format before they can be used in digital image processing/mapping environments. Decisions made concerning the scanning process will determine, in large part, the geometric accuracy of the scanned photographs, the amount of information that can be extracted and the speed with which the images can be processed. Aerial photographs are recorded with photogrammetric mapping cameras from altitudes of approximately 300 m to over 20,000 m.

Photogrammetry is the technique of measuring objects (2D or 3D) from photogrammes. It is referred commonly to photographs, but it may also be imagery stored electronically on tape or disk taken by video or CCD cameras or radiation sensors such as scanners. The results can be:

- coordinates of the required object-points
- topographical and thematical maps
- and rectified photographs (orthophoto)

Its most important feature is the fact that the objects are measured without being touched. Aerial photogrammetry is mainly used to produce topographical or thematical maps and digital terrain models (Heipke C., 2004).

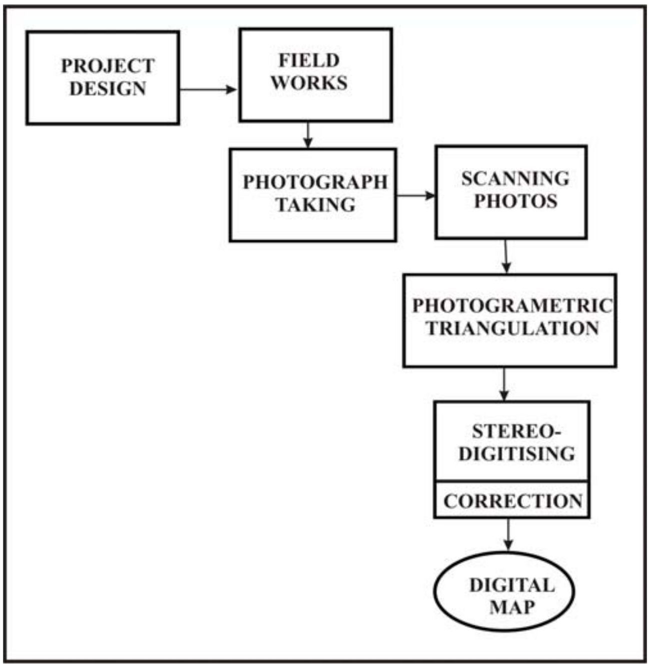


Figure 4.3. Flow chart of photogrametric map production system
(Source: Sethian 1998)

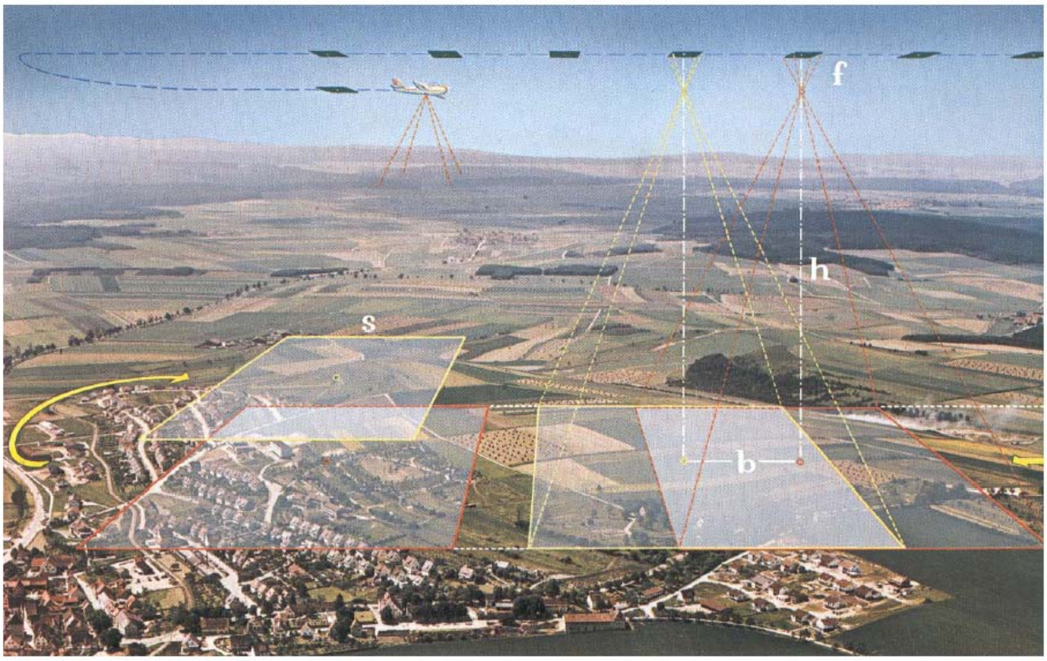


Figure 4.4. Taking aerial photograph from plane

Figure 4.5. Example of taken from plane

4.1.2. Overview of Ikonos Imagery

Applications of satellite imagery on Geographic Information Systems (GIS) are quite important in future of GIS. Resolutions of satellite images are increasing with developing technology. Since the first commercial high-resolution satellite, IKONOS, meaning image in Greek, was successfully launched in September 1999. Several similar high-resolution satellites will be launched in a few years. Ikonos data records 4 channels of multispectral data at 4 meter resolution and one panchromatic channel with 1 meter resolution. Ikonos was the first commercial satellite to deliver near photographic high resolution satellite imagery of anywhere in the world.

Ikonos was launched on September 24, 1999 from Space Launch Complex 6 (SLC-6) at Vandenberg Air Force Base in California. The imaging sensors are panchromatic and multispectral. This satellite has a polar, circular, sun-synchronous 681-km orbit and both sensors have a swath width of 11 km. Its weight is 1600 pounds (720 kg). Space Imaging was acquired by ORBIMAGE to form GeoEye. Satellite Operation Engineers use appropriate passes according to the priority of the product orders in the system. After getting 10 days cloud forecast information for the whole communication cone from the meteorological service the relevant satellite pass is requested depending on cloud cover. Planning is made on the timeline where imaging windows and angles are specified. Final optimized collection plan is saved along with the 15 minutes basis updated meteosat data (Collins and Kliparchuk 2004).

Prepared command packet is sent to satellite from ground station located in Golbasi Ankara. Imaging is done and downloaded to ground station in real time. Raw image data is stored on the robotic archive machine within the tapes (Breuning 1996).

Ikonos has both cross and along track viewing instruments which enable flexible data acquisitions and frequent revisiting capabilities - 3 days at 1 meter resolution and 1 to 2 days at 1.5 meter resolution,(IKONOS Product Guide 2004). Ikonos satellite details are shown in Table 4.2.

Tablo 4.2. Details of IKONOS data

	BAND WIDTH	SPATIAL RESOLUTION
Panchromatic	0.45 - 0.90m	1 m
Band 1	0.45 - 0.53m (blue)	4 m
Band 2	0.52 - 0.61m (green)	4 m
Band 3	0.64 - 0.72m (red)	4 m
Band 4	0.77 - 0.88m (near infra-red)	4 m

4.1.3. Comparison of Digitized Aerial Photos with Ikonos Images

When comparing satellite imagery to conventional aerial photography, often it is questioned which one is more appropriate. Satellite imagery is ideally suited to a number of projects, particularly projects that are more "block" as opposed to "linear" in nature. This is primarily because satellite images are collected in rather large blocks (a nominal image from IKONOS is 11 km by 11 km). Since the resolution and accuracy of satellite images cannot match the accuracy of traditional aerial photography, conventional aerial images are still used for projects where high accuracy and resolution are important. Other factors must be considered in comparing satellite to aerial images. Aerial photography projects can be tasked at a particular time of the year with very specific requirements like a cloud-free day. Satellites are only able to capture imagery of a certain area when the satellite is overhead. Each satellite has a revisit frequency the amount of time that passes between successive orbits over a certain area. For IKONOS, this revisit frequency is 2.9 days for the 1 m product. An otherwise perfect day for image collection can be missed if the satellite does not pass overhead while the weather is good. Table 4.3. summarizes differentiation between satellite images and aerial photos.

Before the advent of high-resolution satellite, the disadvantage of using satellite imagery has been the relatively low resolution of the imagery available (Barnsley, et.

al. 1996). For example, Landsat imagery was captured with a ~30m pixel, therefore the smallest picture unit that could be discerned was 30m x 30m (900 m²), and thus was most commonly used for catchment, state-wide, and continental mapping. Up until 1999, the only source that provided data on-demand, with a resolution of less than one meter, was aerial photography. However, in September 1999, this all changed with the successful launch of the IKONOS satellite. IKONOS imagery is also able to be merged after capture to produce 1m Colour imagery, thus enabling satellite imagery, for the first time, to be used for urban or highly detailed mapping. Afterwards, in 2001, the Quickbird satellite was launched and is able to capture 0.6 m black and white and 2.4 m multispectral imagery. The SPOT5 satellite was then launched in 2002, and captures black and white imagery as 5 m pixels (and can be post-processed to produced 2.5 m pixels) and 10 m multispectral pixels. These satellites can therefore produce, after processing, 1 m Colour imagery (IKONOS), 0.6 m Colour imagery (Quickbird) and 2.5 m Colour imagery (SPOT5).

Table 4.3. Satellite images versus aerial photos

ADVANTAGES OF SATELLIT IMAGERY	CHARACTERISTICS OF AERIAL PHOTOGRAPHS
Greater areal extent	Higher resolution
Digital data	Analogue photos
Repetitive coverage	Lower cost of launch
Regular (predictable) distortion	3D stereo effect
Greater wavelength range	Higher understanding
Analysis / GIS	Easier interpretation

Number of attempts have been made to identify informal settlements from remotely sensed data. Sliuzas (2001) studied the citywide estimation of development density in informal settlements from SPOT satellite images of Dar es Salaam. Malcolm, et. al. (2001) identified the location of areas of poverty using an integration of RADARSAT and Landsat imagery of Rosario, Argentina. The result of the study outlined that the characteristics of these areas and misclassification results in over estimation for locating likely areas of urban poverty. Thus, the use of highresolution satellite data is a necessity for mapping and monitoring these areas. Dare and Fraser (2001) mapped informal settlements using IKONOS satellite data. The variations in texture and radiometry of the 4-m image are sufficient to classify different types of urbanization, and hence separate formal from informal settlements. As a summary IKONOS has 1 m resolution on the ground where as Landsat has 30 m. And Spot has 20 m resolution respectively.

A simple comparison of the different space images available from any area gives a good impression about the information contents. The Synthetic Aperture Radar (SAR) image from JERS with 18 m pixel size includes only some rough information about the area. The information contents of Radar images cannot be compared with optical images having the same pixel size. Also based on other data there is approximately the relation of 5 between them – 18m pixel size of a SAR images includes approximately the information of an optical image with 90 m pixel size. But this is only a rough figure because some details can be identified very well in SAR images. For example in the JERS-image in Figure 4.6. the white spot in the upper left corner is a ship which can be seen more clear in Radar images than in optical images. The Landsat TM image (Figure 4.7. includes with the 30 m pixel size quite more topographic details like the JERS image (Topan, et. al. 2004).

A comparison between the colour image of Landsat 7 TM (bands 432) and the panchromatic Landsat image with 15 m pixel size shows more or less no advantage of the higher resolution of the panchromatic band, but in general, the quality of the panchromatic Landsat image is not so good in relation to other space images with 15 m pixel size like for example ASTER. ASTER images do have usually a very good contrast. The combination of the green, red and near infrared band includes the advantage of a very good differentiation also in the forest areas. The colour images in the visible spectral range (red, green, blue) are influenced by the low contrast of the blue channel caused by the stronger atmospheric scattering of the shorter wavelength. In addition the blue and green band do have a stronger correlation, that means in addition to the green and red band the blue band includes quite less information like the near infrared. By this reason also the visible and near infrared (VNIR) combination of Landsat is shown in Figure 4.7 (Topan, et. al. 2004).

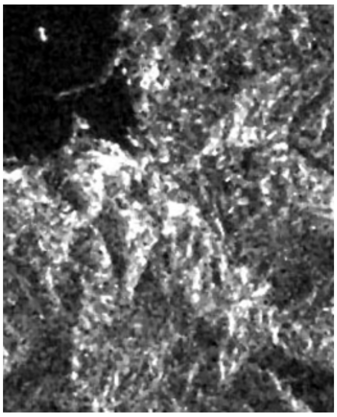


Figure 4.6. Lansat satellite images

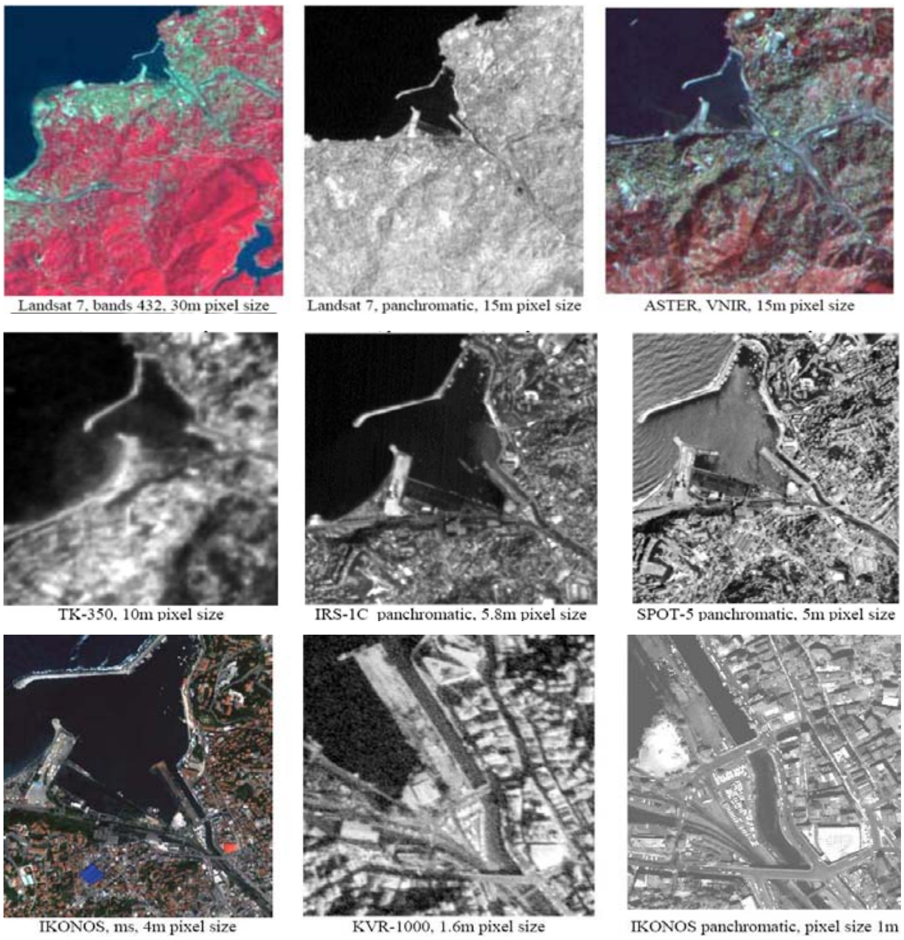


Figure 4.7. Comparison of different space images in the city of Zonguldak
(Source: Topan, et. al. 2004).

Table 4.4. Effective pixel size determined by edge analysis.

	NOMINAL PIXEL SIZE (M)	EFFECTIVE PIXEL SIZE (M)
ASTER	15	16.5
TK 350	10	13
IRS-1C	5.8	6.9
SPOT 5	5	5
KVR 1000	1.6	2.2
IKONOS pan	1	1

Landsat TM images are optimal for the classification of the land use. The large pixel size of 30 m is averaging the details which are causing problems for an automatic classification based on images with a small pixel size. But only few details required for the generation of a topographic map can be identified. Highways, especially in forest and agricultural areas can be seen, but no more details. Under the condition of a geometric mapping accuracy not better than 1 pixel and a requirement of 0.3mm for the map, this would be sufficient for a map scale 1:100000, but the details required for this scale cannot be seen. ASTER images do show quite more details like Landsat. Wide roads can be seen but not the details usually shown in topographic maps. The panchromatic TK-350 photos available from the Zonguldak area with an effective pixel size of 13m (Table 4.4) do not show all the details visible in the ASTER VNIR image. At first the ASTER image includes the advantage of the colour, but also the contrast of the TK-350 photos is not so good. TK-350 photos have been flown together with the KVR-1000. The concept for the use of both together is the generation of a digital elevation model (DEM) based on the stereoscopic coverage by the TK-350 and a monoplotting of the not stereoscopic KVR-1000 photos based on such a DEM. So the real use of the TK-350 was not directly for mapping purposes. IRS-1C with a nominal ground pixel size of 5.8 m includes quite more information like TK-350. On the first view the details usually included in a topographic map 1:50000 can be seen. Nevertheless the effective pixel size in the Zonguldak area was just 6.9 m. This may be caused by the limited contrast of the original images resulting on the 6 bit radiometric resolution (64 different grey values) but of cause also on the atmospheric conditions at the day of imaging. The panchromatic SPOT-5 images with a ground pixel size of 5m include quite more the details like the preceding SPOT images with just 10m pixel size. In comparison to the IRS-1C it has the advantage of a quite better contrast and the individual details can be seen clearer. The nominal relation of IRS-1C to SPOT-5 and SPOT-5 to multispectral IKONOS is approximately the same, but in comparison to SPOT-5 the multispectral IKONOS image has the advantage of the colour information. The colour improves the potential of object recognition and interpretation. Especially the interpretation is quite better based on colour images than just with black and white, (Topan, et. al. 2004).

4.1.4. Orthorectification and Orthophotos

Digital satellite images and aerial photographs play an important role in general mapping, as well as GIS data acquisition and visualization. First, they provide a solid visual effect. Many people are more able to put spatial concepts into perspective when they see photos. In addition, the secondary and perhaps more vital role is to provide a basis for gathering spatial information. Examples of this are features such as roads, vegetation, and water. Before this information can be gathered in a manner that is useful for a mapping or GIS system, the satellite image data or aerial photographs must be prepared in a way that removes distortion from the image. This process is called orthorectification. Without this process, you wouldn't be able to do such functions as make direct and accurate measurements of distances, angles, positions, and areas.

Orthophotographs are produced after orthorectification process. Orthophotographs are scaled aerial photographs from which displacements due to tilt and terrain relief have been removed and which have the geometric characteristics of a map with all of the information content of the original photo. Required inputs to the digital process include aerial photographs, ground control points and a DEM. The DEM can be generated from the aerial photograph by photogrammetric techniques and automated stereocorrelation, derived from contours digitized from existing maps or, perhaps, acquired from government or commercial sources (Welch 1990).

4.1.5. Digital Elevation Model (DEM)

In order to accurately remove the image distortions, a digital elevation model (DEM) is used to perform image orthorectification. The required DEM is generated by semi-automatic DEM extraction software from stereo satellite scenes acquired by the QuickBird, IKONOS, SPOT-5, or ASTER satellite sensors, and stereo aerial photography.

When vector data is to be extracted from satellite or aerial image data by raster-to-vector translation, Satellite Imaging Corporation performs the orthorectification of the remotely sensed image data and rectifies all digital images of environmental, geological, topographic, or any source maps that will be used in the GIS mapping environment.

In this study aerial photos (Orthophotos) which are total of 130 sheets, were opened using Microstation software separately. Three different map layers such as settlement areas, industrial buildings and green houses were digitized using the orthophotos. Digitized maps were then transformed to MapInfo TAB format using Universal Translator patch in MapInfo Professional 8.0 software. Data were entered to related database using MapInfo software. Finally, thematic maps were prepared using 1/5000 scale sheets of digital maps (total of 130) such as greenhouses, settlement areas and industrial zones seperately. In this thesis the digital elevation model of the Tahtalı Basin was created by using MapInfo Professional 8.0 software. Figure 4.8 shows flow chart for creation of digital data from aerial photos.

4.1.6. Digitizing for GIS Analysis

To determine the effect of landuse changes on water quality, the aerial photos of the basin taken in 1995 (October) composed of 130 sections (Figure 4.9) having a scale of 1/5000 were obtained and these images were compared with images of the Ikonos satellite taken in 2005 (November) with a resolution of 1 meter. IKONOS Satellite image Metadata for Tahtalı Basin is given in Table 4.5.

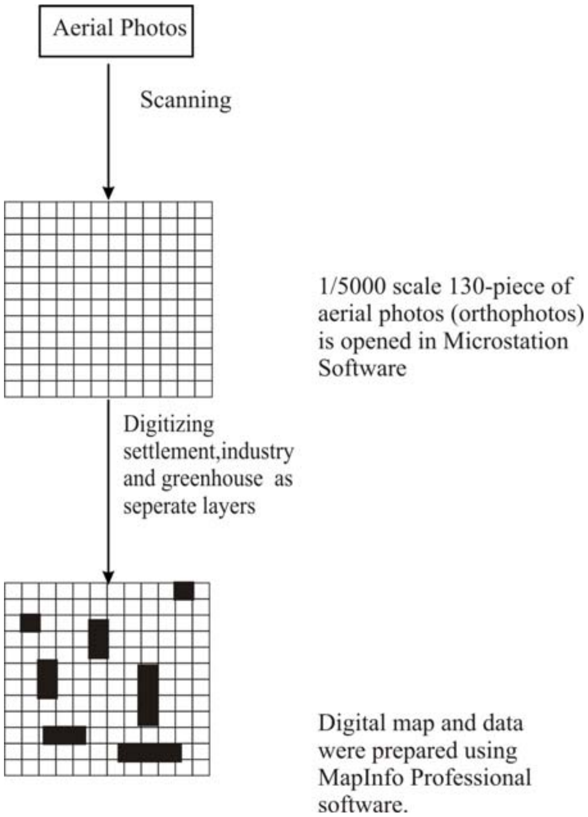


Figure 4.8. Flow chart of creating digital data from aerial photos

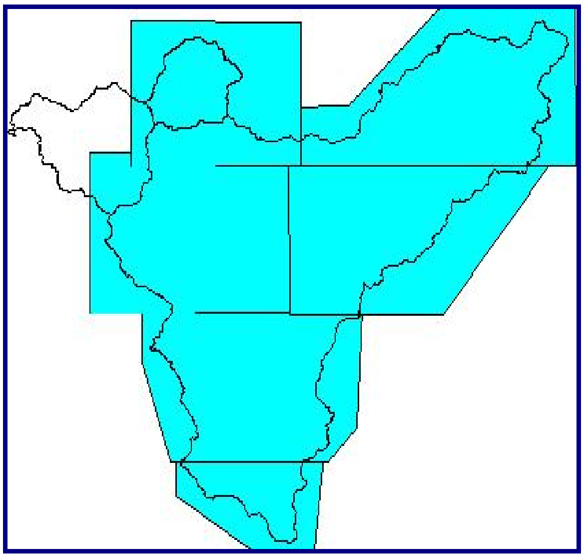


Figure 4.9.Vector data and border of Tahtalı Basin digitized from 6-sheets of IKONOS satellite images.

Table 4.5. IKONOS satellite image for Tahtalı Basin

NOMINAL PIXEL SIZE (M)		
	IKONOS satellite image metadata for Tahtalı basin	Metadata of orthorectıfied image for Tahtalı Basin
Radiometric Resolution:	11bit/8 bit	11bit/8 bit
Spatial Resolution:	1 meter	1 meter
Projection Type :	Transverse Mercator	UTM
Datum Name :	European 1950	WGS 84
Longitude of Central Meridian :	27:00:00.000000 E	North or South :North
False Easting :	500000. 0 meters	500000. 0 meters
False Northing :	0.000000 meters	0.000000 meters
Total area:	600 km2	910 km2
Date of taking:	3 November 2005	3 November 2005
Angle:	≥ 77	≥ 77
Cloudiness:	0%	0%
Format :	TIFF	TIFF
Band combination:	Natural Color (Red, green, blue, 3 bands, one file)	Natural Color (Red, green, blue, 3 bands, one file)

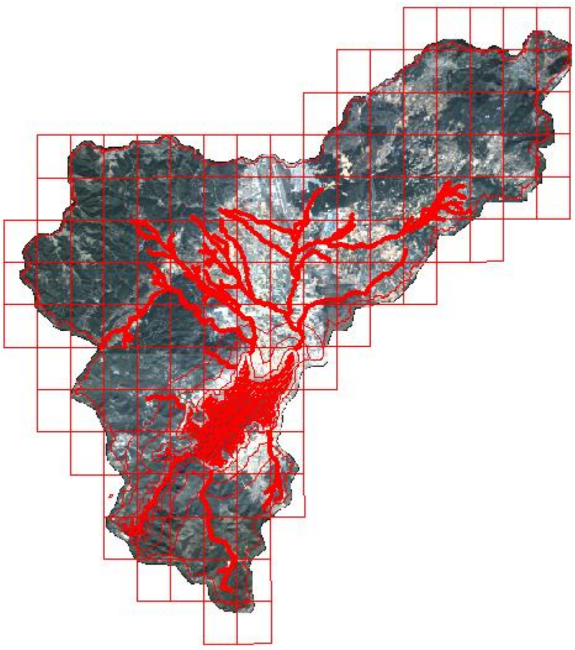


Figure 4.10. Orthorectified IKONOS image of Tahtali dam site bearing of 1 meter resolution and its basin border.

IKONOS IMAGES

↓

ORTHORECTIFICATION

↓

1/5000 SCALE DIGITAL MAPS

Figure 4.11. Creation of digital data with a scale of 1/5000 from IKONOS images.

Digital elevation model (DEM) was prepared using vector data supplied by IZSU to use orthorectification process. IZSU also produced 1/5000 scale 130-sheets of orthorectified maps.

Layers are seen in 1/5000 scale map of L18d13b. Levels of 2, 3, 5 and 21 is open. Elevation data is seen in number-2 map layer. Drawings which are orange color show residential area in the year 1995 .(Figure 4.12.-4.13.)

Figure 4.12. Microstation software window showing aerial photo

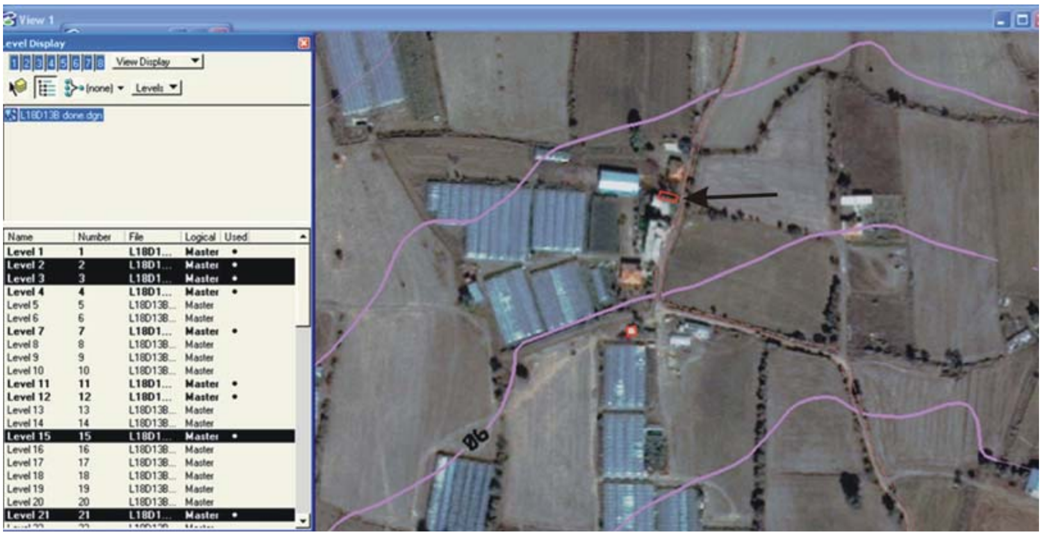


Figure 4.13. Microstation software window showing IKONOS image

Since water quality was affected mostly from discharges of settlements , greenhouses and industrial areas, Microstation software was used to quantify changes in these zones from 1995 and 2005. Maps were transformed to raster format and region calculations and spatial analysis were conducted.

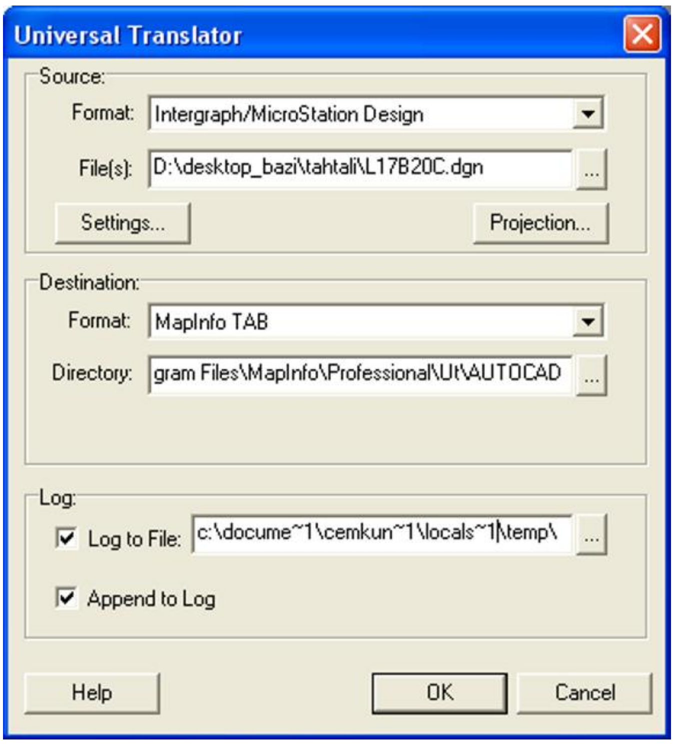


Figure 4.14. Menu for universal translator.

Digitizing of maps using MapInfo Professional 8.0 software involved several steps.

1)Conversion of Microstation dgn. file to mapinfo tab" file by Universal Translator.

2) Selection of "dgn" file format for Microstation software.in Source part.

3) "tab" file format for MapInfo software is chosen in Destination part.

4) All digital maps (130 maps with 1/5000 scale) are combined with each other and thematic maps were prepared.

5) Using "Select" function from Query menu, settlement, industry and green house areas are differentiated from each other. Then, they were classified as years 1995 and 2005 .

4.2. Water Quality Analysis

After determining the changes occured in landuse in 1995 and 2005, database was created using IZSU data obtained from 6 different streams in the basin and dam lake in year 1997 and later.

Since the digitized maps of Lake Tahtali were taken from IZSU (Izmir Water and Sewage Administration) prior to the study, the coordinates of the measurement sites were determined in GIS (Geographic Information Systems).

Initially, polyline features shape file was available in the digitized map and there were no information about the coordinates in the attributes table of the related shape file. Since the coordinates of the measurement sites were to be presented as point features on the map, attribute table was required. So, the attribute table listing the station names was tabulated.

Water quality is a term used to describe the chemical, physical, and biological characteristics of water. There are many different factors and processes that control water quality. The main factors influencing water quality are land cover, land use, soil type, geology, vegetation and precipitation. When the rain hits the land it can loosen soil particles and chemically react with them. Land use alters the texture and composition of the land surface and therefore influences water quality. Initial human influence upon water quality was the dumping of human and animal wastes into the water supply.

Advances in agriculture, such as use of fertilizers can also change the water quality. (Boyd 2000) .

4.2.1. Water Quality Parameters

Water quality parameters provide important information about the health of a water body. These parameters are used to find out if the quality of water is good enough for drinking water, recreation, irrigation, and aquatic life. Some commonly used parameters are briefly described in the following paragraphs.

Temperature is one of the most important water quality parameters. Temperature affects water chemistry and the functions of aquatic organism and also tells about the health of a river. As temperature goes up, the rate of photosynthesis and plant growth also goes up and more plants die. So when the rate of photosynthesis increases, the amount of oxygen needed by aquatic organisms increases. Wastes often raise water temperature. In the summer, the sun heats up sidewalks, parking lots and streets. Rain falls on these areas, warms up, and runs into the river. Factories and stations that generate electricity to cool their processes also use water. Warm water enters the river, raises the temperature of the downstream area and changes oxygen levels. This form of thermal pollution is one of the most serious ways of effects caused by humans. Cutting down trees along the bank of a river also raises water temperature. When they are cut down, the sun shines directly on the water and warms it up. Cutting down trees also leads to erosion. When soil from the riverbank washes into the river the water becomes turbid. The darker, turbid water captures more heat from the sun than clear water does (Leib and Frank 2002).

Measurement of dissolved oxygen (DO) is important for the estimation of water quality, because like people, aquatic organisms need oxygen to survive and stay healthy. The main reason DO levels might fall is the presence of organic waste.The time of year and many other factors affect the amount of DO in water. DO levels also can fall due to any human activity that heats the water. Oxygen enters water as a result of two processes:

- Diffusion - diffusion of oxygen into water is accelerated when the water turbulence is increased .Oxygen will diffuse into cold water at a higher rate than it will into warm water.
- Photosynthesis - during daylight hours, aquatic plants use the sun's energy to create energy they can use for growth.

PH is defined as the negative common logarithm of the hydogen ion (H+) activity. It is one of the most important operational water quality parameters. Chemical reactions and biological activity in water depend highly on their level. The pH of natural water is usually between 6.5 and 8.2. At extremely high or low pH levels (for example 9.6 or 4.5), the water becomes unsuitable for most organisms.It can vary from its normal levels due to pollution from automobiles and coal-burning power plants. These sources of pollution help form acid rain. Acid forms when chemicals in the air combine with moisture in the atmosphere. It falls to earth as acid rain or snow. Europe are becoming acidic because they are downwind of polluting industrial plants.

Fecal coliform bacteria may occur in ambient water as a result of the overflow of domestic sewage or nonpoint sources of human and animal waste. High levels of fecal coliform bacteria should be considered as a warning sign that water can make you sick, rather than as a cause of illness. Some examples of diseases and illnesses that can be contracted in water with high fecal coliform counts include typhoid fever, hepatitis, gastroenteritis, dysentery and ear infections.

Biochemical oxygen demand, or BOD is a measure of how much oxygen is used by microorganisms in the aerobic oxidation, or breakdown of organic matter in the streams. The harder the microorganisms work, the more oxygen they use, and the higher the measure of BOD, leaving less oxygen for other life in the water. A high BOD measure harms stream health in the same ways as low dissolved oxygen: aquatic organisms become stressed, suffocate, and die. As more organic matter enters a stream, the BOD will rise. Organic matter may include leaves and woody debris; dead plants and animals; animal manure; effluents from pulp and paper mills, wastewater treatment plants, failing septic systems; and urban storm water runoff. In case of BOD, it indicates organic pollution due to municipal wastes or industrial wastes (Mallari 2006).

Generally COD & BOD are used while referring to waste waters, either sewage or industrial waste water . Chemical oxygen demand (COD) does not differentiate between biologically available and inert organic matter, and it is a measure of the total quantity of oxygen required to oxidize all organic material into carbon dioxide and water. Briefly COD is o a measure of the organicmaterial are essential for the growth of algae and other plants. Aquatic life is dependent upon these photosynthesizers, which usually occur in low levels in surface water. Excessive concentrations of nutrients, however, can overstimulate aquatic plant and algae growth. Bacterial respiration and organic decomposition can use up dissolved oxygen, depriving fish and invertebrates of available oxygen in the water (eutrophication). Fertilizers, failing septic systems, waste water treatment plant discharges, and wastes from pets and farm animals are typical sources of excess nutrients in surface waters.

Scientists believe that when too much phosphorus enters a river or lake, plants grow more. Plants that live on the surface and bottom of a river or lake use phosphorus. They use up most of the oxygen in the water. In surface waters, phosphorus is usually present as phosphate (chemical compounds containing the element, phosphorous) They enter surface waters from both point and nonpoint sources. The primary point source is sewage treatment plants. Additional phosphorus originates from the use of industrial products, such as toothpaste, detergents, pharmaceuticals, and food-treating compounds. Nonpoint sources of phosphorus include both natural and human sources. Natural sources such as phosphate deposits and phosphate-rich rocks which release phosphorus during weathering, erosion and sediments in lakes and reservoirs which release phosphorus during seasonal overturns. The primary human nonpoint sources of phosphorus include runoff from;

- land areas being mined for phosphate deposits,
- agricultural areas, and
- 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 (Csuros 1994).

Nitrate-nitrogen is water soluble and can move readily through the soil profile into ground water.(Nitrate is composed of one atom of nitrogen (N) and three atoms of oxygen (O)). Nitrate is a major ingredient of farm fertilizer and is necessary for crop production. When it rains, varying nitrate amounts wash from farmland into nearby waterways. Nitrates also get into waterways from grass fertilizer run-off, leaking septic tanks, manure from farm livestock, animal wastes , and discharges from car exhausts. Home septic systems in rural areas (cesspools) leak waste into the ground. This waste should be filtered by the soil around the septic system. However, this does not always happen. Therefore, groundwater can become polluted by nitrogen in the wastewater.

Boron (B) is chemical element in nature and has a high affinity for oxygen (Wyness, et. al. 2003). So far, over 150 boron minerals have been found all over the world, but only about ten of them have industrial value. Both natural and anthropogenic factors can lead to the release of boron into air, water, or soil resulting in boron contamination in ambient environment. It is essential for plant growth and deficiency studies in animals and humans have provided some evidence that low intakes of boron affects cellular function and the activity of other nutrients an essential nutrient for plants and an essential element for many organisms (USEPA 1994). The boron concentration depends on the type of soil, the amount of organic matter, which contains boron, and the amount of rainfall, which can remove boron from the soil. Boron is used in a variety of products including glass and glass products, cleaning products, agrochemicals, insecticides, flame-proofing compounds, corrosion inhibitors and antiseptics. Boron compounds are also used in treating skin cancer resulting in complete disappearance of melanoma without substantial side.. Boron enters the environment mainly through the weathering of rocks, boric acid volatilization from seawater, and volcanic and geothermal activity.

4.2.2. Water Quality Index

Water quality index provides a single number that expresses overall water quality at a certain location and time based on several water quality parameters. The objective of an index is to turn complex water quality data into information that is understandable and useable by the public. A single number cannot tell the whole story of water quality; there are many other water quality parameters that are not included in the index. A water index based on some very important parameters can provide a simple indicator of water quality. It gives the public a general idea the possible problems with the water in the region (Brown, et. al. 1970).

All of these indices have eight or more water quality variables. However, most watersheds do not have long-term and continuous data for these variables. Basic environmental variables used to construct WQI include DO, fecal coliform, turbidity, total phosphorus, and specific conductance. The effects of these variables are reflected to a certain degree by the basic variables. For example, the temperature effect can be captured if the dissolved oxygen is measured as percent saturation. The colder the water, the more oxygen it can hold. The oxygen consumption from degradation of organic material is normally measured as BOD and COD, so there is an important relation between them (Apha 1998, Basin 2001).

Most water quality indices rely on normalizing, or standardizing, data parameter by parameter according to expected concentrations and some interpretation of 'good' versus 'bad' concentrations. Parameters are often then weighted according to their perceived importance to overall water quality and the index is calculated as the weighted average of all observations of interest (Stambuk and Giljanovic 1999; Sargaonkar and Deshpande 2003; Liou, et. al. 2004).

Indices make the transfer and utilization of water quality data enormously easier and lucid. Water quality indices help in:

1) Resource allocation :Indices may be applied in water-related decisions to assist managers in allocating funds and determining priorities.
2) Ranking of allocations : Indices may be applied to assist in comparing water quality at different locations or geographical areas.
3) Enforcement of standards : Indices may be applied to specific locations to determine the extent to which legislative standards and existing criteria are being met or exceeded
4) Trend analysis : Indices may be applied to water quality data at different points in time to determine the changes in the quality (degradation or improvement) which have occurred over the period
5) Public information : Index score being an easy to understand measure of water quality level, indices can be used to keep the public informed of the overall water quality of any source.
6) Scientific research : The inherent quality of an index which translates a large quantity of data to a single score, is immensely valuable in scientific research.

The following four steps are most often associated with the development of any WQI; parameter selection, transformation of the parameters of different units and dimensions to a common scale, assignment of weightages to all the parameters, aggregation of sub-indices to produce a final index score.

The National Sanitation Foundation Water Quality Index NSFWQI is the most respected and utilized water quality index in the world. To convert the rating into weights, a temporary weight of 1.0 was assigned to the parameter which received the highest significance rating. All other temporary weights were obtained by dividing each individual mean rating by the highest rating. Each temporary weight was then divided by the sum of all the temporary weights to arrive at the final weight. The calculation of the index value is illustrated in Table 4.6.

Table 4.6. Illustrative example of a calculation of Brown's (NSF) WQI

Parameters	Example of a Measured Values	Individual Quality Rating ($q_{i)}$	Weights ($w_{i)}$	Overal Quality Rating (w_ix $q_{i)}$
Dissolved Oxygen	100	98	0.17	16.7
Fecal Coliform density	10	100	0.15	15
Ph	7	92	0.12	10.1
BOD (5-day)	0	100	0.10	11
Nitrates	0	98	0.10	9.8
Phosphates	0	98	0.10	9,8
Temperature	0	94	0.10	9.4
Turbidity	0	98	0.08	7.8
Total solids	25	84	0.08	6.7
			WQI = w_i q_i	96.3

The index is given by;

$$NSFWQI = \sum_{i=1}^{n} w_i - q_i \tag{1}$$

Where,

q_i=the quality of the i^{th} parameter (a number between 0 and 100 read from the appropriate subindex graph)

w_i=the weight of the i^{th} parameter

The NSFWQI describes water quality based on nine water quality parameters. While it lacks the ability of directly determining whether water quality objectives are met, it does not depend on how comprehensive the objectives setting process is. This allows for a much wider use of the index for water bodies for which no objectives have been established. Since the NSFWQI is calculated using a strictly additive, weighted formula of one-dimensional scores, the index for multiple samples (from different times or locations) is simply the average of the index values of the individual samples. The results across different water bodies with different monitoring program will therefore be more comparable.

The WQI ranges have been defined as :90-100: Excellent, 70-90: Good, 50-70: Medium, 25-50: Bad, 0-25: Very Bad ((Brown, et. al. 1970) Parameters used in the estimation of water quality and quality value graphs are shown below (Figure 4.15.a–b)

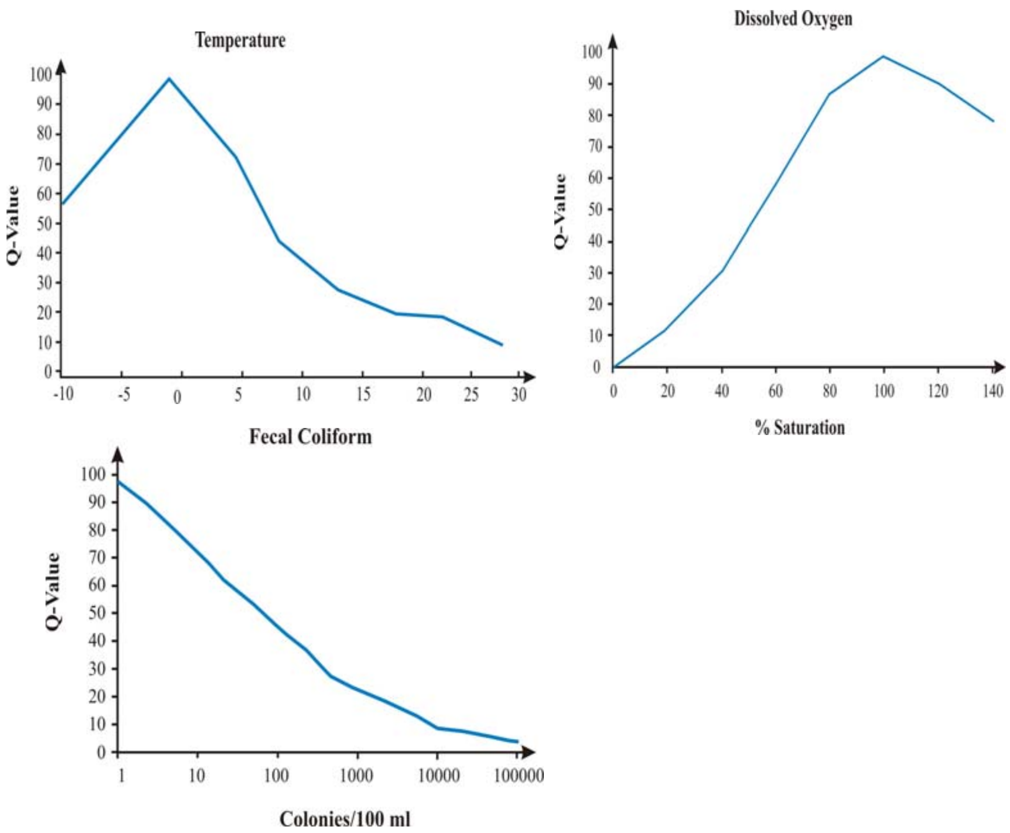


Figure 4.15.a. Q values of water quality parameters used in the NSFWQI calculations

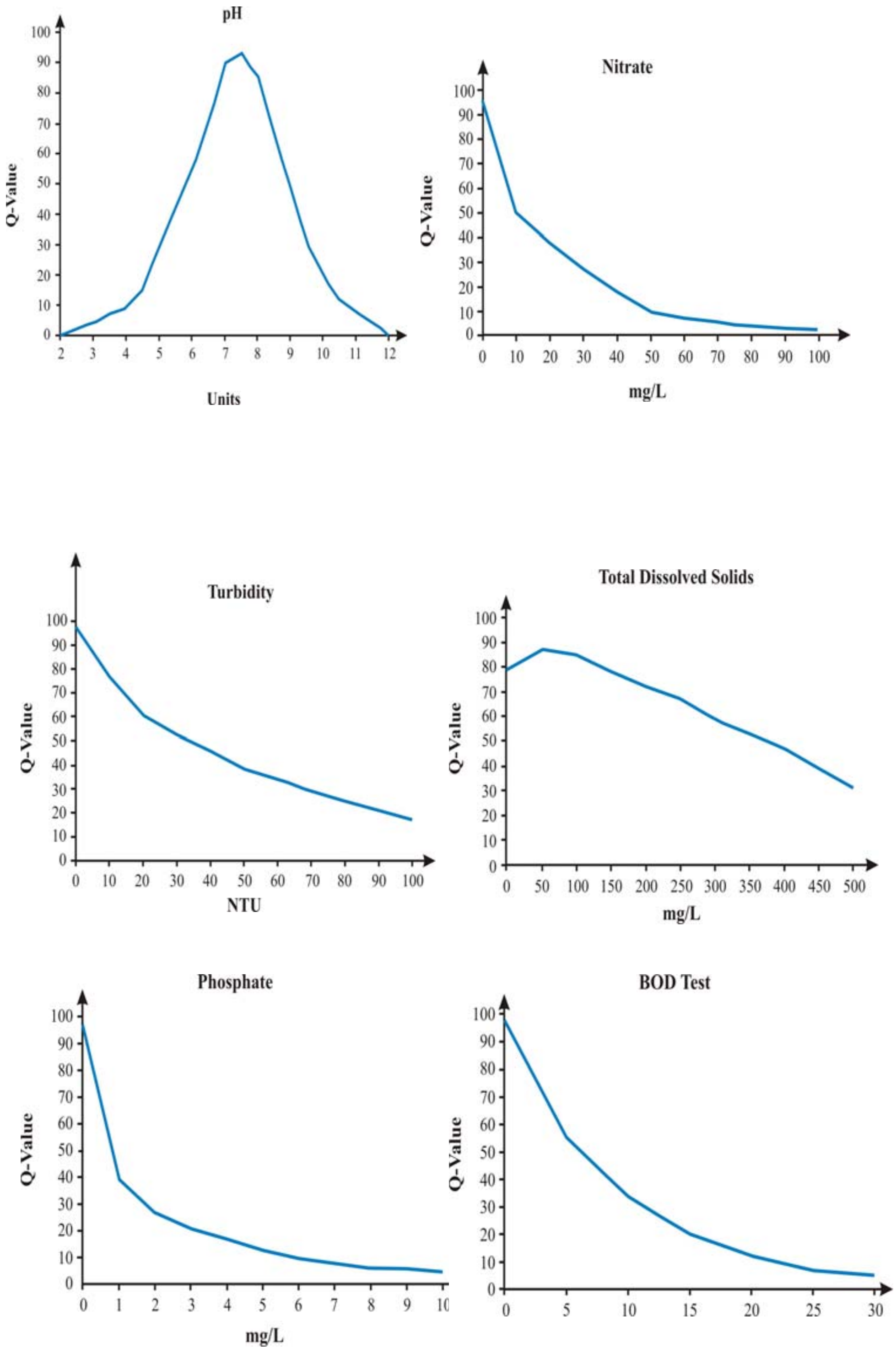


Figure 4.15.b. Q values of water quality parameters used in the NSFWQI calculations

If there is a missing parameter;

Step 1 If one to three test results are missing, the adjustment formula is used. The adjustment formula provides an overall water quality value that is relative to the value are would get if nine water quality tests have been performed.

Step 2 From the results of the tests overall water quality is calculated.

Step 3 The weighting factor number(s) for the test(s) not performed are added up.

Step 4 97 is subtracted it from weighting factor total.

Step 5 97 is divided by the value from Step 4.

Step 6 Original overall water quality is multipled by the value from Step 5, which will give the overall water quality adjustment.

4.2.3. Trend Analysis

During the last decades, there has been an increasing demand for monitoring water quality of many rivers by regular measurements of various water quality variables. The result has been the gradual accumulation of reliable long-term water quality records and the examination of these data for long-term trends.

Time series of water quality variables typically possess many of several characteristics which complicate analysis. Of interest to researchers is often the trend over time of the water quality variable. Trend analysis determines whether the measured values of a water quality variable increase or decrease during a time period.Numerous statistical techniques are available to analyze trends in time series like those presented here. Due to limitations of the dataset, parameters for trend analysis were selected that provided the most consistent understanding of water quality trends. In this study water quality parameters that were examined as monthly averages for 7-different stations included total phosphorus, nitrate, boron, COD, and BOD. These parameters were examined Two types of trend are commonly considered in the water quality literature, monotonic and step. A step trend occurs when the time series experiences a change point in location. In that case, it is assumed that the water-quality variable changes at one point in time from one constant level to another constant level. Hirsch, et. al. (1991) said that step trend procedures should only be used when the data are separated into two groups by a relatively large gap in time or when the time of an event suspected to have an effect on water quality is known. Step trend techniques include the two-sample t-test with the associated estimates of change in magnitude based on the difference in sample means. The alternative is the Mann-Whitney-Wilcoxon Rank sum test and the Hodges-Lehmann estimator of trend magnitude.

Monotonic trend occurs when a response variable changes with a concurrent change in the explanatory variable. The change is unidirectional over time and the hypothesis in this case does not specify whether this shift is continuous, linear, in one or more discrete steps, or in any particular pattern. If no prior hypothesis of a time change is known, or if records from multiple stations are being analysed in a single study, then monotonic trend procedures are appropriate. For monotonic trend, the hypothesis that the data shifts monotonically is often tested with regression analysis of the water quality variable as a function of time. The alternative test is the nonparametric Mann-Kendall test for trend. A number of variations of the Mann Kendall test are currently in use, these include the Seasonal Kendall Test with its variations, the covariance sum test, or the covariance (Mann 1945, Hirsch and Slack 1984).

Parametric-Statistics for normally distributed data includes regression of parameter against time or spatial measure, like heights, weight and depth.. When the data do follow a normal distribution and are independent, parametric methods are seen to be the most powerful tests, far more powerful than their nonparametric counterparts at any significance level (Darken 1999). However, if the data do not follow normal distribution, the parametric tests tend to lose their power to detect trends, (Hirsch, et. al. 1991). Examples of parametric tests include the ordinary least squares also known as linear regression, the t-test and the rank sum test.

Nonparametric-Statistics that are not as dependent on assumptions about data distribution. Generally the safer statistics to use, but are not as readily available. Common nonparametric tests used in trend analysis of water quality include the Seasonal Kendall Test and the Mann-Kendall Test. The Seasonal Kendall Test compares measures of water quality at different time periods or seasons of the year to determine the presence of a trend. The Mann-Kendall is a test for correlation between water quality and time. Both statistics can determine the existence and the magnitude of a trend.

Non-parametric tests are thought to be more powerful than parametric tests useful in water resources data. Siegel and Castellan (1988) list the following advantages of nonparametric tests:

1. If the sample size is very small, there may be no alternative to using a nonparametric statistical test unless the nature of the population distribution is known exactly.
2. Nonparametric tests typically make fewer assumptions about the data and may be more relevant to a particular situation.
3. Nonparametric tests are available to analyze data which are inherently in ranks as well as data whose seemingly numerical scores have the strength of ranks.
4. Nonparametric methods are available to treat data which are simply classificatory or categorical, i.e., are measured in a nominal scale.
5. There are suitable nonparametric statistical tests for treating samples made up of observations from several different populations. Parametric tests often cannot handle such data without requiring us to make seemingly unrealistic assumptions or requiring cumbersome computations.
6. Nonparametric statistical tests are typically much easier to learn and to apply than are parametric tests.

4.2.5. Mann-Kendall Test

The test is generally used for the detection of trend in time series data (Hess, et. al. 2001). According to Helsel and Hirsch (1991), this test may generally be stated as a test for monotonic change, where the central values (mean or median) tend to either increase or decrease with time.

The basic principle of the Mann-Kendall test is to examine the signs of all pair wise differences of the observed values, ranked in chronological order (Libiseller and Grimvall 2002). Since the test uses the relative magnitude of data (based on rank order) and not the actual values of the data, they have the advantage that they are able to cope with outliers, missing values and values below detection limits (Onoz and Bayazit 2003, Helsel and Hirsch 1991).

The data values are evaluated as an ordered time series. Each data value is compared to all subsequent data values. The initial value of the Mann-Kendall statistic, S, is assumed to be 0 (e.g., no trend). If a data value from a later time period is higher than a data value from an earlier time period, S is incremented by 1. On the other hand, if the data value from a later time period is lower than a data value sampled earlier, S is decremented by 1. The net result of all such increments and decrements yields the final value of S. The test procedure is as follows:

• Calculate S by the following equation:

Let $_1x$, $_2x$, … $_nx$ represent n data points where $_jx$ represents the data point at time j. Then the Mann-Kendall statistic (S) is given by :

$$S = \sum_{k=1}^{n-1} \sum_{j\_k+1}^{n} sign(x_j - x_k) \tag{2}$$

$$sign(x_j - x_k) = 1 \quad \text{if} \quad x_j - x_k > 0 \tag{3}$$

$$= 0 \quad \text{if} \quad x_j - x_k = 0 \tag{4}$$

$$= -1 \quad \text{if} \quad x_j - x_k < 0 \tag{5}$$

A very high positive value of S is an indicator of an increasing trend, and a very low negative value indicates a decreasing trend. However, it is necessary to compute the probability associated with S and the sample size, n, to statistically quantify the significance of the trend.

• Calculate the variance of S, VAR(S),

$$VAR(S) = \frac{1}{18}\left[n(n-1)(2n+5) - \sum_{p=1}^{g} t_p (t_p - 1)(2t_p + 5) \right] \tag{6}$$

where n is the number of data points, g is the number of tied groups (a tied group is a set of sample data having the same value), and t_p is the number of data points in the p^{th} group. In the sequence {2, 3, non-detect, 3, non-detect, 3}, we have n=6, g =2, t_1=2 for the non-detects, and t_2 =3 for the tied value 3.

• Compute a normalized test statistic Z as follows:

$$Z = \frac{S-1}{\sqrt{[VAR(S)]}} \quad \text{if} \quad S > 0 \tag{7}$$

$$= 0 \qquad \text{if} \quad S = 0 \tag{8}$$

$$= \frac{S+1}{\sqrt{[VAR(S)]}} \qquad \text{if} \quad S < 0 \tag{9}$$

•The trend is said to be decreasing if Z is negative and the computed probability is greater than the level of significance. The trend is said to be increasing if the Z is positive and the computed probability is greater than the level of significance. If the computed probability is less than the level of significance, there is no trend.

4.2.6. Seasonal Kendall Test

The Seasonal Kendall Test is a modified version of the non-parametric Mann-Kendall test for monotonic trend, developed by Hirsch and others in 1982. It carries all the robust statistical properties offered by its predecessor and can be performed on raw data; or on residuals of the time series before and after the effects of flow have been removed (Zipper et al, 1992). This test is founded on the rationale that water quality is cyclical, varying with the seasons in the year. Therefore, to eliminate the possibility of seasonality invoking trend, and also to reduce variability when there is a seasonal effect, comparisons are made strictly between data from similar seasons, blocking out the other seasons (Darken 1999, Schertz. Et. al. 1991**).**

If a month is considered as a season, then for example, one January value is compared to the January value of the following year and so on in an iterative manner, no comparisons are made across months. If the later value is larger than the one before it, a plus is recorded, if on the other hand the later value is smaller, then a minus is recorded. The plus sign is then converted to +1, the negative sign to -1 and the zero left as a 0. The statistic (S_i) for each month is then computed as the difference between the total number of +1 and the total number -1 for each season (Helsel and Hirsch 1991, Schertz, et. al. 1991). The variance of the individual test statistics (S_i) is then computed (Darken 1999). The information from all the seasons is then aggregated by summing the individual monthly statistics (S_i) and their variances to give the overall statistic (S) and the overall variance (Darken 1999, Helsel and Hirsch 1991). The trend hypothesis is then tested by invoking a normality approximation of the standardized test statistic (Darken 1999, Helsel and Hirsch 1991, Zipper, et. al. 1992). A positive Mann-Kendall statistic means an increasing trend, and a negative one means a decreasing trend. The p value associated with the statistic describes the significance of the trend (Schertz, et. al. 1991).

"Z" standard normal variable is calculated and compared with "$Z_{1-\alpha/2}$" value in the Standard Normal distribution Table, in order to decide whether there is a trend in a determined "α" significant value. If $|Z| \geq Z_{1-\alpha/2}$, "Ho" hypothesis which shows that there isn't a trend in a determined "α" significant value, is rejected (it means that there is a trend). If Z<0, there is a decreasing trend, if Z>0, there is an increasing trend. Trend analysis is applied with Kendall tests in 90% confidence intervals which is written by U.S. Geological Survey (USGS, 2005).

$$S' = \sum_{i=1}^{12} S_i \tag{10}$$

$$\mathrm{Var}(S') = \sum_{i=1}^{12} \mathrm{Var}(S_i) + \sum_{i=1}^{12}\sum_{j=1}^{12} \mathrm{Cov}(S_i, S_j) \tag{11}$$

Si=f(Xi) and Sj=f(Xj) , i and j monthly data.

It is applied in formula 7,8,9, as S= S' , and also again the trend is said to be decreasing if Z is negative the trend is said to be increasing if the Z is positive. If the computed probability is less than the level of significance, there is no trend.

4.3. Prediction Of Erosion With Respect To Land Use Change

Soil erosion is the detachment of particles from the soil mass and their transport through the watershed system. In general, the heavier the rainfall, the larger the drops are. When rain hits vertically on a flat surface, the splash is equal in all directions. On a slope, more of the splash goes downhill than uphill. In a wind-driven rainfall, splash movement depends on slope and wind direction (McCullah 1994).

If water could always filter into the soil, the splashing of particles would be of minor concern. In many cases, however, water collects in low places, eventually overflows, and then begins to travel downhill, carrying soil particles with it. A raindrop falling on a thin sheet of water detaches soil particles more readily than one falling on dry soil. Splash erosion increases with surface water depth, but only up to a depth about equal to the raindrop diameter. Once the water becomes deeper, the splash effect is reduced. Water flowing off the soil surface described as sheet flow provides the mechanism for transporting particles loosened by rainfall. This transport ability is influenced by the energy level of the flow, which in turn is dependent on the depth of flow and slope of the land. Flat areas have little or no runoff; consequently, no transport occurs. Runoff from steeper areas flows at greater velocities and may have considerable transport capability (McCullah 1994).

Sedimentation of soils carried by moving water resulting from rill, gully, and stream bank forms may occur in rivers. In natural or artificial dams large particles tend to settle due to reduced velocity in the pool. When the water is slowly released, much of the material is left behind as sediment. Dense vegetation can reduce the flow velocity, thereby allowing soil material to be deposited. All three processes of detachment, transport, and sedimentation occur during an erosive rainfall event. The degree of erosion depends on the amount and intensity of rainfall, topography of the land surface, vegetative cover, and character of the soil.

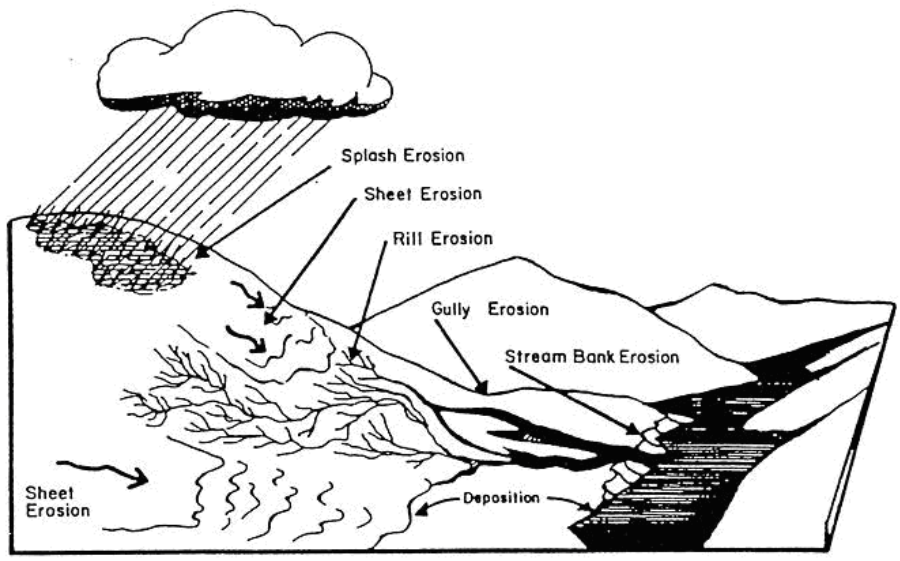


Figure 4.16 The mechanisms of soil erosion

(Source: USACE 1985)

Each type of soil has its own inherent susceptibility to the forces of erosion, in large part because of chemical composition and organic matter content. Although large-grained materials are easily detached by raindrop splash or flowing water, they are not easily transported. On the other hand, fine soils such as clays and fine silts that bond together tightly are not easily detached, but once free they are transported with little difficulty. For this reason, fine materials can be carried considerable distances, whereas larger particles are deposited somewhere along the flow path (SCS 1986).

The vulnerability of soil to erosion, known as its erodibility, is affected by several factors such as soil structure, surface cover, topography, and climatic factors. A stable, sharp, granular structure absorbs water readily, resists erosion by surface flow, promotes plant growth. Clay soils or compacted soils have slow infiltration capacities that increase runoff rate and create severe erosion problems. Soils with high permeability rates reduce runoff by allowing more water to infiltrate. Well-graded gravels and gravel sand mixtures typically have high permeability rates and are less susceptible to erosion from rainfall and surface runoff (McCullah 1994).

Vegetation is the most effective means of stabilizing soils and controlling erosion. Vegetation controls erosion by intercepting rainfall and shields the soil surface from the impact of falling rain, by providing a rough surface that reduces the velocity of surface runoff, promotes infiltration, forces deposition of suspended soil particles, and disperses flow; by holding soil particles in place thus resisting detachment by raindrops or surface runoff, by removing water from the soil via transpiration thus increasing the soil's capacity to absorb water.

Topographic features directly affect erosion potential. Watershed size and shape, for example, affect runoff rates and volumes. As slope length and degree of slope increase, runoff velocity and the potential for sediment transport increase. Slope orientation can also be a factor in determining erosion potential (USEPA 1989).

Climatic factors affecting erosion are precipitation, temperature, wind, humidity, and solar radiation. Temperature and wind affect evaporation and transpiration rates and therefore, indirectly, the water holding capacity of soils. The frequency, intensity, and duration of rainfall and the size of the area on which the precipitation falls are fundamental factors in determining the amount of runoff produced.

Humans alter the environment from its natural vegetation to any other use. Disruptive activities accelerate the natural erosion process because they expose soils to precipitation and surface runoff. Tremendous soil losses can be expected from untreated disrupted areas. Land use/disturbance activities that fostering erosion includes:

- Removal and loss of topsoil during construction or site preparation expose underlying less previous and more erodible material that critically hinders natural colonization or revegetation of the site.
- Establishment of heavily used training areas on sites with steep slopes, highly erodible soils or sites subject to flooding will inevitably lead to severe erosion problems.
- Construction of roads and tank trails that run up and down slopes rather than conforming to the contours of the land.
- The absence of properly prepared and maintained waterways along roadways and the routine scraping of road shoulders promotes erosion by destroying soil structure and eliminating vegetation.

4.3.1 Universal Soil Loss Equation (USLE)

Universal Soil Loss Equation (USLE) predicts the long term average annual erosion rate on a field slope based on the rainfall regime, soil type, cropping system and the management practices. The Universal Soil Loss Equation (USLE) is used to predict the amount of gully sheet and rill erosion. It does not, however, predict the amount of eroded sediment reaching downstream areas. Much of the eroded sediment will be deposited (in other areas of the same field or in areas with more level slopes) before reaching the stream.

Soil erosion is affected by the spatial topography, vegetation, soil properties, and land use. A GIS is a very useful tool to deal with the large number of spatial data and the relationship from various sources in the erosion modeling process. There are some advantages of linking soil erosion models with a GIS such as the following:

1. The possibility of rapidly producing input data to simulate different scenarios.A GIS provides an important spatial/analytical function performing the time consuming georeferencing and spatial overlays to develop the model input data at various spatial scales (Sharma, et. al. 1996).

2. The ability to use very large catchments with many pixels, so the catchment can be simulated with more detail (De Roo 1996).
3. The facility of displaying the model outputs. Visualization can be used to display and animate sequences of model output images across time and space. Therefore, visualization enables objects to be viewed from all external perspectives, and to invoke insight into data through manipulable visual representations (Tim 1996).

The Universal Soil Loss Equation (USLE) model was suggested first based on the concept of the separation and transport of particles from rainfall by Wischmeier and Smith (1965) in order to calculate the amount of soil erosion in agricultural areas. The equation was modified in 1978. It is the most widely used and accepted empirical soil erosion model developed for sheet and rill erosion based on a large set of experimental data from agricultural plots. In USLE method; The average annual erosion rate is calculate as follows ;

$$A = RKLSCP \tag{12}$$

where;

A is the average annual soil loss in ton/ha/year ;

R is the rainfall erosivity factor in MJ-m m/h^{-}ha^{-}year;

K is the soil erodibility factor in t^{-}ha^{-}h/ha^{-}MJ^{-}mm;

L is the slope length factor (unitless);

S is the slope steepness factor (unitless);

C is the cropping management factor (unitless);

P is the supporting practice factor (unitless).

An important evolution of the USLE model is its application based on spatially distributed input data (geology, soil and land use) in a Geographic Information Systems (GIS) environment (Fanetti and Vezzoli 2007).

Slope length is the horizontal distance between the starting and the ending point of a land slope. The more slope length means the more erosion in the area. Different equations are available for the calculation of slope length factor (L). In this study, the equation used for Tahtalı Basin is;

$$L = \left(I/22.1\right)^{0.5} \tag{13}$$

I is the slope length

Slope steepness factor is the effect of slope on soil erosion. If the slope of the land is high, more erosion occurs in the area. Slope steepness factor affects the rate of erosion more than the slope length. In the analysis, distributed slope values for each polygon were calculated and implemented to the USLE equation.

Soil erodibility factor (K) is the average soil loss in a particular soil land and changes due to the characteristics of soil. The infiltration rate of the soil type and the reflection of soil under different rain events are important to understand K factor. K value ranges between 0 and 1 where high K value means the more sensitive soil type to erosion. K values for different soil types were assumed as;

- 0.15 for low or non erosive ,
- 0.28 for medium erosive,
- 0.45 for high erosive,
- 0.60 for very high erosive soils.

Using GIS technique is based on calibrated values of basic factors which influence erosion rate. For the calibraton of these factors, data consisting of field surveys, map digitizated and procesed maps, should be prepared. The process of erosion estimation and sediment transport would be significantly simpler by using aerial photographs and satellite data, digital and thematic maps. In this study , soil erosion was investigated and quantified in the Tahtalı Basin for two different land use compositions and soil maps from two years: 1995 and 2005.

The data used in the erosion prediction analysis belonged two different dates: 1995 and 2005. The landuse maps of study area were obtained from “General Directive of Rural Services”. Paper map prepared available from 1995 was converted into the GIS database so that they could be compared with the satellite imagery taken in 2005. Some of the steps used in the analysis are listed below:

1. Land use paper map prepared in 1995 was scanned into Adobe Photoshop at a high resolution.
2. The scanned images were matched, aligned, joined and fitted together manually to form a complete map coverage. These images were transformed to compensate for distortions and minute differences in scale.
3. Scanned images were cleaned up by removing extraneous information and marginal data.

4. The final cleaned and enhanced images were saved in TIFF format and then brought into Mapinfo GIS for further processing. The digital versions of the land use paper map prepared in 1995 was georeferenced to the same projection
5. (UTM-ED50, zone 35), grid system, and datum as the landuse map prepared for the year 2005 and the field notes were added as attribute tables to the polygon layer Finally, the mentioned method was used in Mapinfo software to gain an optimized land use for the study area.

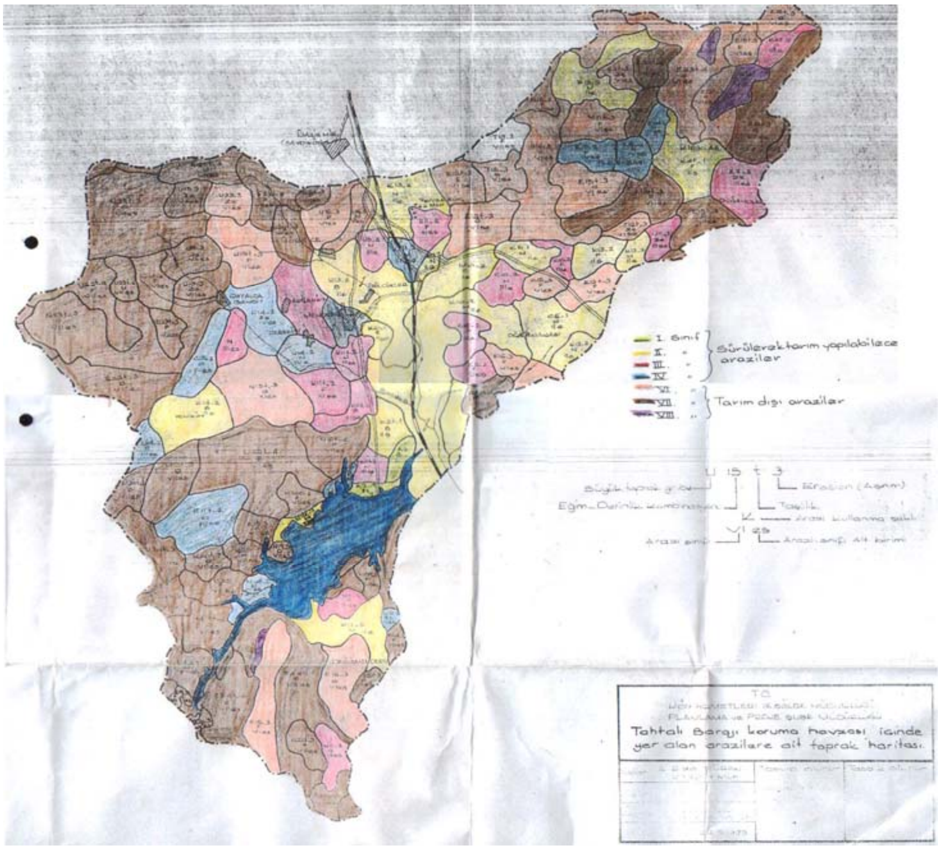


Figure 4.17. Land use paper pap prepared in 1995

Each factor which consists of a set of logically related geographic features and attributes is used as data input for analysis. The factor layers were collected from existing information and extracted from IKONOS imagery .Each of the above mentioned USLE factors, with associated attribute data, was digitally encoded in a GIS database to eventually create five thematic layers. Simultaneous overlay operation on these five layers produces a resultant polygonal layer, each polygon of which is a homogeneous area with respect to each of the five factors.

CHAPTER 5

DISCUSSION OF RESULTS

In this study, the effects of landuse changes in Tahtalı Basin between 1995 and 2005, were summarized and the effects of these changes on water quality, the main pool of the reservoir and at 6-different stream monitoring stations in the basin site, were discussed together. For assessment of the water quality, indexing suggested by NSF was utilized. Increasing or decreasing trend in water quality parameters was seeked through Seasonal Kendall Test. This study also investigated soil erosion rate in Tahtalı Basin for two different years. The universal soil loss equation (USLE) was utilized for prediction of soil erosion considering two different landuse compositions (1995 and 2005) within the basin.

5.1. Land Use Change Analysis

Since water quality is most affected by discharge from residential areas, industrial areas and greenhouses; changes in these zones were compared for two different years 1995 and 2005. Results indicated that in 2005; 0,819 km² of the basin was occupied for industrial activities, 2,972 km² of the area was composed of greenhouses and 5,284 km² of the area was used for settlement. These numbers reflect a 61% increase in industrial land, a 350 % increase in greenhouse land, and a 5 % decrease in residential land use.

Figure 5.2. shows newly constructed and existing residential buildings in both years, Figure 5.3. presents the changes in landuse for greenhouse between 1995 and 2005, and Figure 5.4 shows the recently built and existing industrial facilities. Figure 5.5 shows closed industrial buildings and greenhouses and damaged residential buildings .

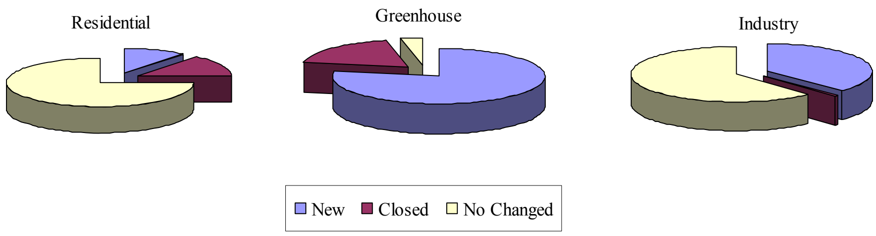


Figure 5.1. Summary of the landuse changes

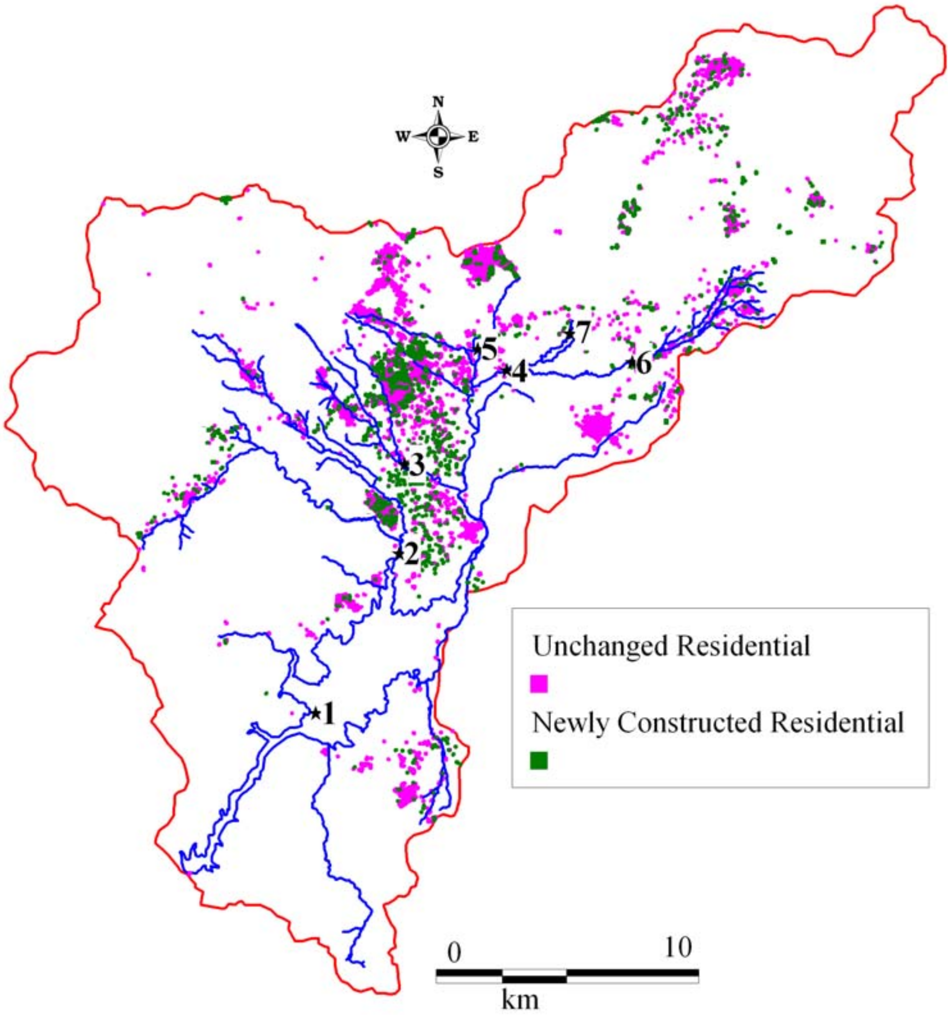


Figure 5.2. Results of the landuse analysis for residential usage in the basin

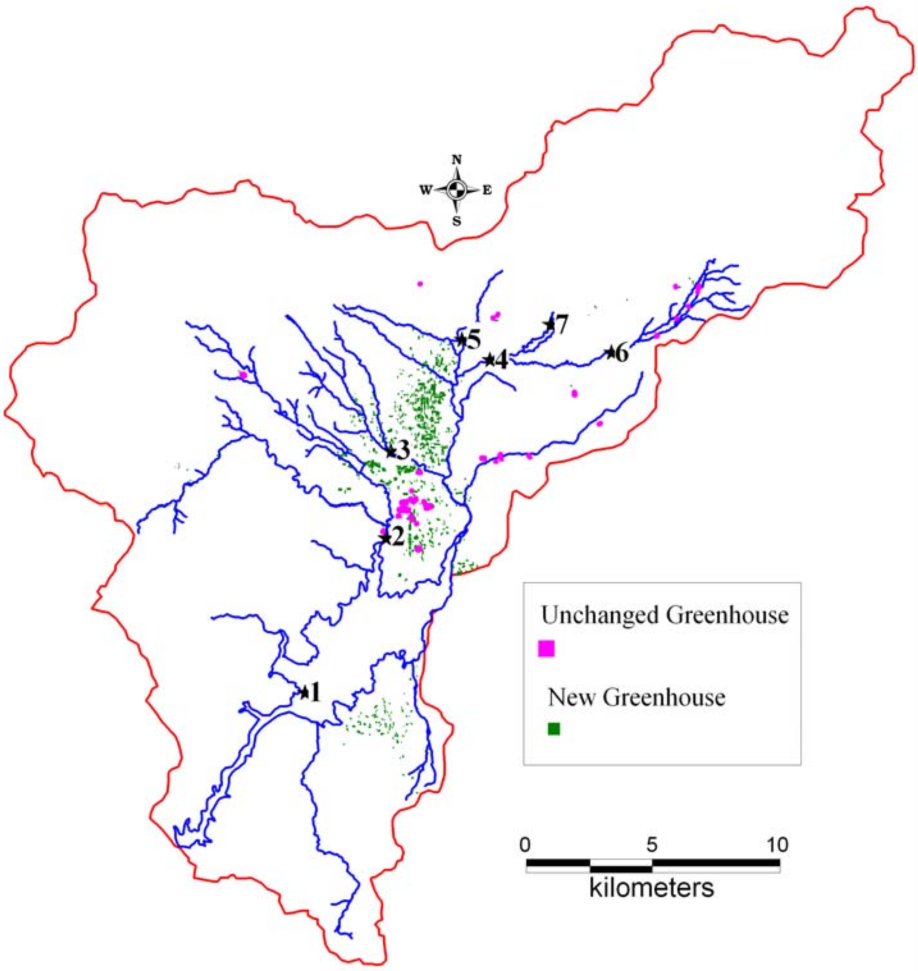


Figure 5.3. Results of the landuse analysis for greenhouse usage in the basin.

5.2. Water Quality Analysis

Upon quantifying the changes in landuse, the changes in water quality parameters were investigated. For this purpose, first available measurements were obtained from IZSU for the duration of the landuse analysis. The water quality data were monitored monthly on 6 different streams within the basin and at the merging point of Tahtali and Sasal Rivers which was located in the reservoir. The corresponding names and locations of the stations are listed in Table 5.1.

Table 5.1. The coordinates of the water quality data monitoring stations.

Number	Station Name	X	Y
1	Tahtalı Lake	509048,53	4223350,78
2	Sasal Bridge	511776,94	4229439,45
3	Menderes Sehitoglu	511863,10	4233124,25
4	Tahtalı Stream	515797,77	4236541,95
5	Istasyon District	514763,84	4236795,97
6	Mersinli Kahve	520852,52	4236939,57
7	Aydın Motorway	518468,74	4238490,46

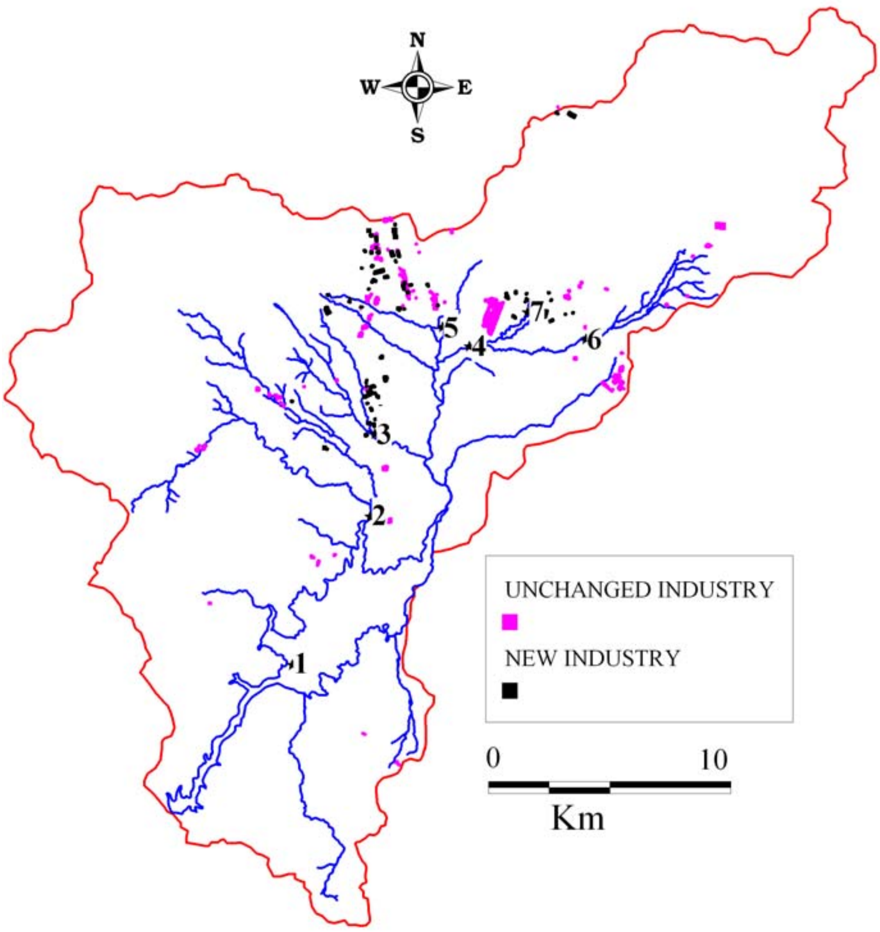


Figure 5.4. Results of the landuse analysis for industry usage in the basin.

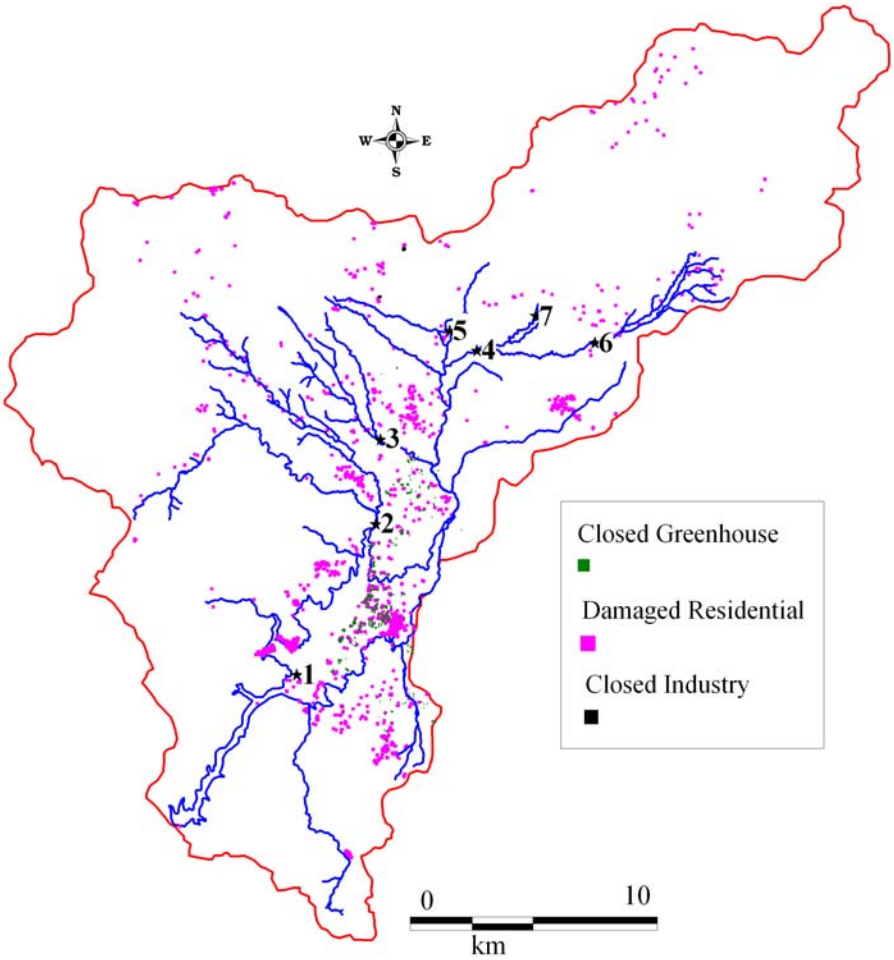


Figure 5.5. Greenhouses,industrial buildings and residential buildings those exixting in 1995 and no longer exist in 2005

Water quality parameters monitored at seven stations including boron, total phosphorus, nitrate, biological oxygen demand (BOD), and chemical oxygen demand (COD) were compared for two different years . When the landuse changes and the water quality observation results were gathered and examined together, at station # 1 located within the dam lake, the demolishing effect of houses and greenhouses were obsereved and total phosphorus, nitrate and boron values decreased. In spring period, at the stations # 2, 4 and 5, and in winter period, at all stations except lake, the amount of total phosphorus increased slightly. This increase in the stations, can be relatedto detergents coming from domestic wastes due to increasing settlement ratio. Although greenhouses increased at station # 3, total phosphorus ratio decreased as a result of controlled use of agricultural drug. In spite of increase of the settlement areas and greenhouses, in spring season, in all stations except Şaşal bridge station # 2, general decreasing trend of nitrate values were determined because of the controlled drug usage and new water treatment plants in operation.

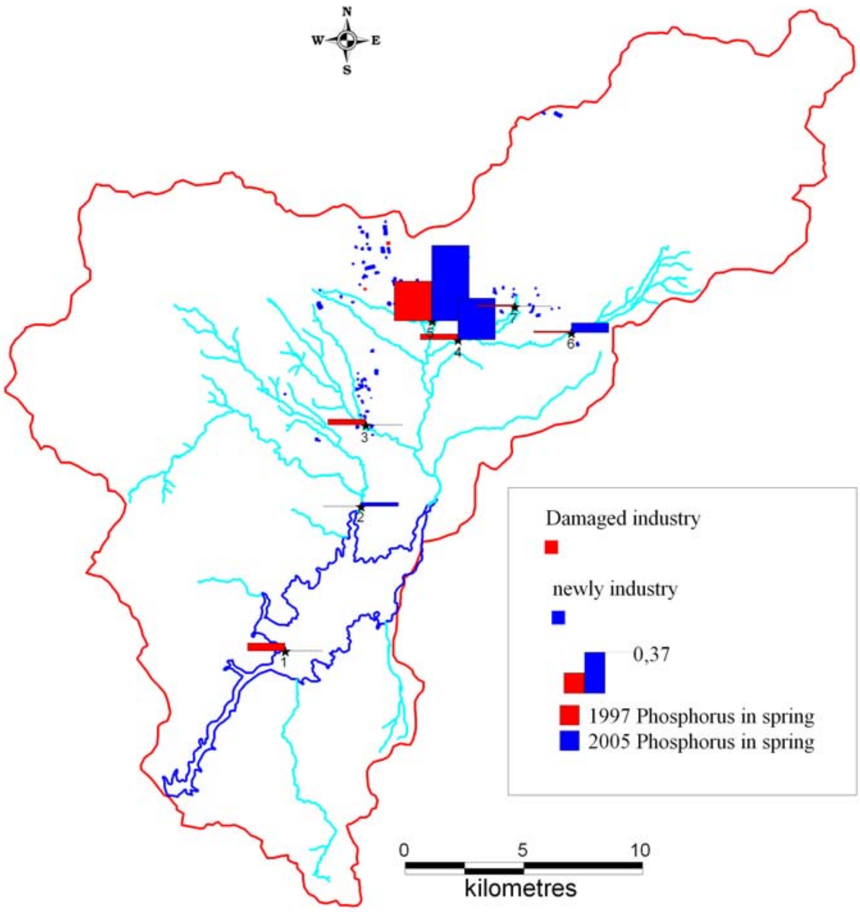


Figure.5.6. Changes of phosphorus between 1995-2005 for industry areas

Groundwater analysis must be combined with the surface water analysis to investigate the infiltration of from surface to groundwater. Nitrate pollution was investigated in groundwater at Cumaovası (station # 3) and at 35 stations in the Tahtalı basin. Around these stations, nitrate values increased to 150 mg/l. Decrease of nitrate in surface waters, points out that nitrate infiltrates to the groundwater quickly. Boron values increased in spring season in Tahtalı river and in winter season, increased especially in Aydın Motorway and Mersinli Kahve stations.

Table 5.2. Monitored water quality parameters within the basin.

1997 S	TP mg/l	BOD (mg/l	Boron mg/l	COD mg/l	Nitrate mg/l	*2005 W*	TP mg/l	BOD mg/l	Boron mg/l	COD mg/l	Nitrate mg/l
1	0,041	2,33	0,18	5,33	6,01		0,000	2,86	0,10	8,42	0.85
2	0,004	1,00	0,16	4,00	1,10		0,017	2,17	0,11	9,34	1.60
3	0,027	0,33	0,22	5,33	11,36		0,000	3,00	0,16	7,20	3.22
4	0,027	2,00	0,17	5,33	8,73		0,200	3,00	0,28	8,57	4.44
5	0,197	2,00	0,87	5,33	17,13		0,370	3,14	0,29	9,14	3.90
6	0,107	1,33	0,24	5,33	28,67		0,050	2,50	0,15	8,00	7.65
7	0,165	1,66	0,15	4,00	4,77		0,000	2,67	0,12	8,00	2.70
1997 S						*2005 W*					
1	0,077	1,00	0,22	8,00	9,70		0,000	4,14	0,13	9,50	0.23
2	0,000	1,00	0,17	4,00	6,15		0,050	3,75	0,22	9,00	0.78
3	0,020	1,00	0,29	4,00	13,75		0,100	3,00	0,31	10,00	2.40
4	0,030	1,50	0,56	8,00	18,85		0,100	2,66	0,37	6,67	2.80
5	0,020	1,00	0,86	11,50	16,40		0,130	4,00	0,35	8,00	2.56
6	0,000	1,00	0,24	4,00	36,50		0,100	2,00	0,43	4,00	2.70
7	0,016	1,00	0,27	4,00	9,25		0,100	4,00	0,54	8,00	3.90

Untreated sewage waters coming from settlement areas, run into streams. Increases are less and measurements are lower than the limit value of 3.5 mg/l. In aerobic conditions, amount of oxygen required to consumed of microorganism defined as biological oxygen demand (BOD) and total quantity of oxygen required to oxidize into CO_2 and water is defined as chemical oxygen demand (COD). Generally, BOD and COD values are used to determine pollution level of the domestic and industrial waste waters.

5.2.1. Water Quality Indexing

The water quality analysis was conducted on primary data based on the water quality measurements during 2001, 2002, 2003, 2004 and 2005. Parameters such as pH, dissolved oxygen (DO), biochemical oxygen demand (BOD), fecal coliform, total phosphate, nitrates, turbidity, and total solids have been considered for indexing of surface water. Fecal coliform and total phosphate data were not available for Lake Tahtali; the other data were obtained from measurements conducted by IZSU.

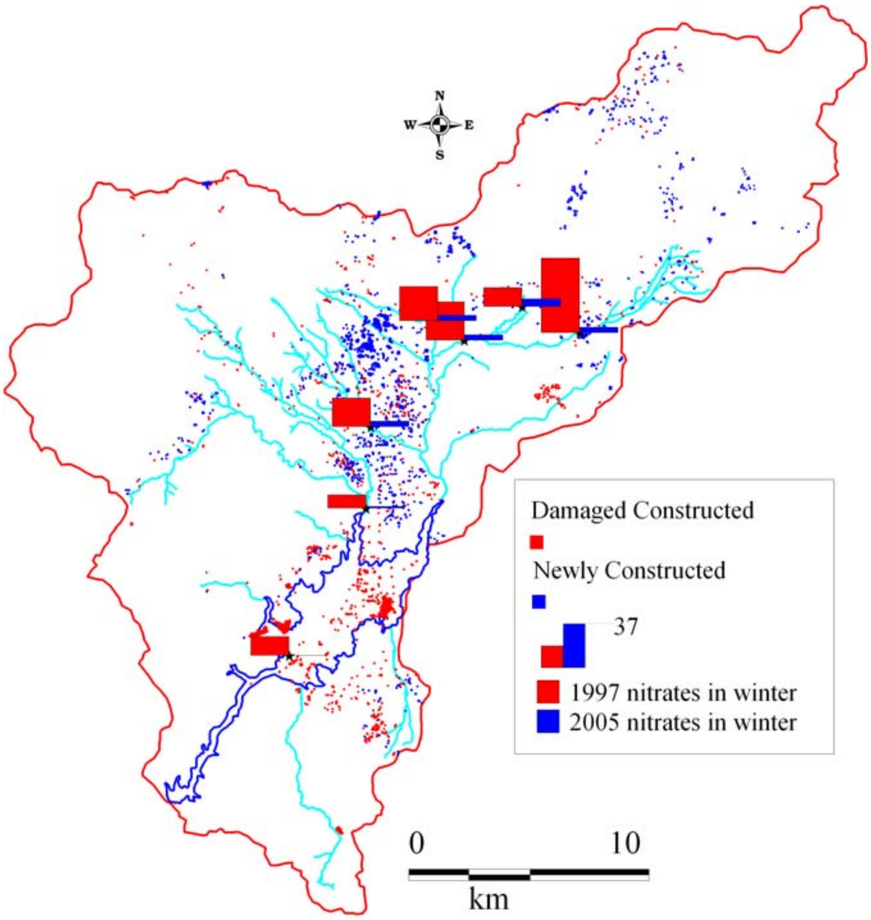


Figure.5.7. Changes of nitrates between 1995-2005 for residential.

The WQI was calculated using standard *Q*-value of each parameter and weighting factor by using NSF information software and compared with standard water quality rating for seven stations in Tahtalı Basin between 2001 and 2005 for summer season (Table 5.3.)

Table 5.3. Calculation of WQI at the monitoring station #1 (Tahtalı Lake) for 2001

Test Parameter	Test Results	Q- Value	Weighting Factor	Total
1. Dissolved Oxygen (% saturation)	5.10	46	0.17	7.82
2. Fecal Coliform (colonies/100 mL)	-	-	0.16	-
3. pH (units)	7.96	85	0.11	9.35
4. BOD (mg/L)	4.14	79	0.11	8.69
5. Temperature(°C)	21.10	20	0.10	2.00
6. Total Phosphate (mg/L)	-	-	0.10	-
7. Nitrates (mg/L)	1.21	91	0.10	9.10
8. Turbidity (NTU)	3.20	89	0.08	7.12
9. Total Solids (mg/L)	207.37	71	0.07	4.97
NSF WQI VALUE	67.01			

The water quality index of Tahtalı Basin's all stations ranged between 67,01 – 73,97 (medium category) in 2001, while, it ranged between 58,26-69,93 (medium category) in 2005. It was concluded that the overall water quality of the Tahtalı basin in general slightly decreased during 5 years. The high settlement development in the river banks might have decreased the capacity of water body. This condition affects water quality within the river basin. Results of land use analysis indicated that the development of industrial and greenhouse areas occured mostly in the downstream region in Tahtalı.

The change of land use from forests to settlement and industrial usage make the land surface impervious. This will affect the rise of waterflow, streamflow capacity and absorbtion into the ground. Furthermore, this condition will impact the accumulation of river water pollution. The change of land use, pervious areas and high activity will directly cause a change in water quality. The analysis results for the measured water quality during 2001 and 2005 are shown in Figure 5.8. Detailed results for water quality indexing is provided in the Appendix. Due to missing parameters (more than 3 missing parameters at monitoring stations for specific dates) the water quality indices are only presented for the main lake as shown in Table 5.4. According to the table except a slight decrease in summer, water quality in the lake has been incresed in other seasons.

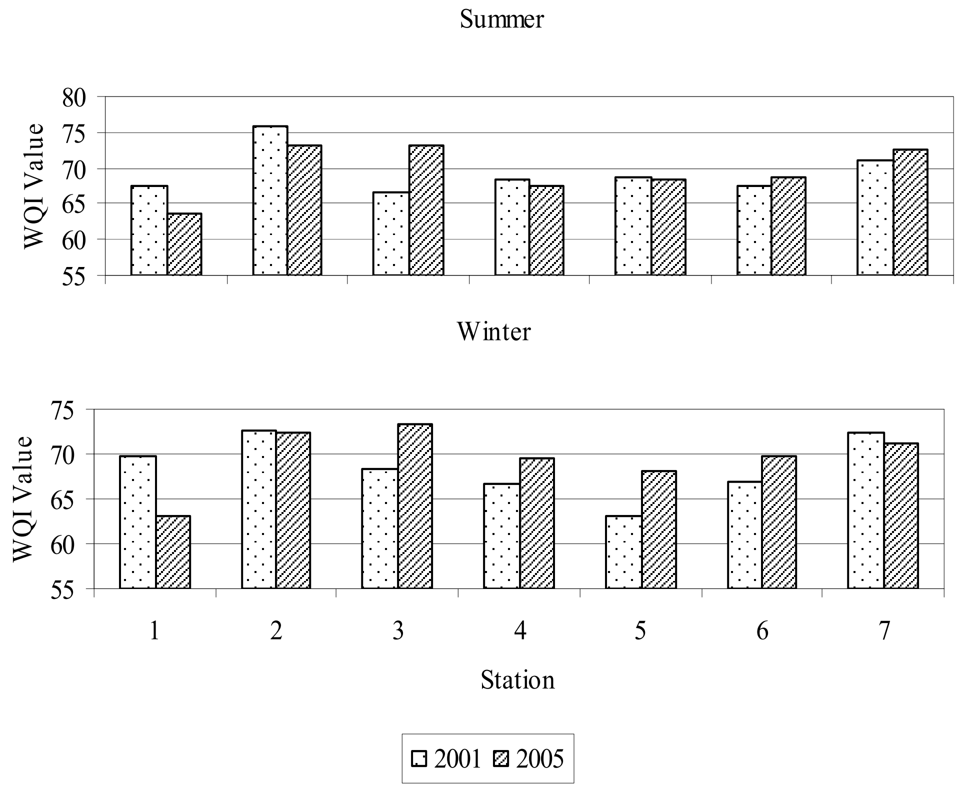


Figure 5.8. Water quality ındices calculated for two different years within the basin

Table 5.4 Water quality indices calculated for the main lake

Main Lake	**2003**	**2004**	**2005**	**2006**	**2007**
winter	73	77	72	-	80
spring	66	72	69	70	75
summer	59	56	58	57	-
fall	62	56	-	-	-

5.2.2. Trend Analysis

To assess the variation of the water quality parameters in time, trend analysis was applied. Seasonal Kendall test was applied with 90% confidence interval using monthly measured data as explained in USGS (2006). "Z" standard normal variable is calculated and compared for each station is given in Table 5.5.,(S here is the test statistic and (-) indicates decreasing trend, P shows the significance of trend and Padj shows the adjusted significance for covariance among seasons) If $Z<0$, there is a decreasing trend, if $Z>0$, there is an increasing trend and if $Z=0$ it means there is no trend. Numbers emphasize the importance of trend changes. According to the results, there is no trend in phosphorus, negative trend in boron and nitrate and positive trend in the parameters of biological oxygen demand (BOD) and chemical oxygen demand (COD). The main reason of the improvement in nitrate concentration can be explained with the controlled usage of fertilizers in greenhouses. Generally, biological oxygen need (BOD) points out the pollution degree of industrial wastes or sewer system, so, the values of biological oxygen demand (BOD) and chemical oxygen demand (COD) increased as expected due to the intensification of urbanization.

Table 5.5. Test statistics obtained from application of Seasonal Kendall test.

	1.Tahtalı Lake	**2.Saşal Bridge**	**3.Menderes Şehitoğlu**	**4.Tahtalı River**	**5.İstasyon District**	**6.Mersinli Kahve**	**7.Aydın Highway**
Nitrate							
S	38	2	-18	-43	-55	-17	-4
P	**0.164**	**0.957**	**0.276**	0.03	0.005	**0.295**	**0.851**
Padj	**0.438**	**0.928**	**0.474**	0.07	0.060	**0.537**	**0.856**
Boron							
S	-153	-40	-16	6	-88	-38	-11
P	0.000	0.024	**0.295**	**0.709**	0.000	0.010	**0.503**
Padj	0.008	0.062	**0.309**	**0.614**	0.009	0.076	**0.569**
COD							
S	23	82	31	13	19	34	36
P	**0.362**	0.000	0.050	**0.526**	**0.346**	0.02	0.02
Padj	**0.307**	0.011	0.163	**0.587**	**0.390**	0.05	0.05
BOD							
S	7	52	24	44	55	25	34
P	**0.794**	0.005	**0.103**	0.02	0.004	**0.102**	**2.403**
Padj	**0.815**	0.06	**0.154**	0.03	0.03	**0.129**	0.016
TP							
S	-97	-14	4	19	16	-32	-19
P	0.000	**0.418**	**0.830**	**0.323**	**0.411**	0.017	**0.139**
Padj	0.015	**0.562**	**0.809**	**0.587**	**0.594**	0.079	**0.226**

Table 5.6. shows Mann Kendall test results. (S here is the test statistic and (-) indicates decreasing trend, P shows the significance of trend)

Table 5.6. Test statistics obtained from application of Mann Kendall test.

	1.Tahtalı Lake	2.Şaşal Bridge	3.Menderes Şehitoğlu	4.Tahtalı River	5.İstasyon District	6.Mersinli Kahve	7.Aydın Highway
Nitrate							
S	41	49	-168	-178	-526	-148	-47
P	**0.890**	**0.770**	**0.102**	**0.304**	0.004	**0.136**	**0.652**
Boron							
S	-1810	-443	-158	-224	582	-295	-143
P	0	0.0057	**0.11**	**0.195**	0.001	0.002	**0.149**
COD							
S	270	666	349	179	121	221	275
P	**0.307**	0.0001	0.0008	**0.307**	**0.513**	0.023	0,006
BOD							
S	107	350	168	393	582	197	332
P	**0.673**	0.028	0.096	0.021	0.001	0.039	0.0004
TP							
S	-1232	-151	100	134	152	-153	-128
P	0.000	**0.301**	**0.278**	**0,432**	**0.396**	0.073	**0.141**

Both tests indicated similar trends at the monitoring stations. According to the results, there is an increasing trend in nitrate at the lake and at Şaşal bridge station and negative trend at Menderes Şehitoğlu, Mersinli Kahve and Aydın Highway stations. Boron decreased at Menderes Şehitoğlu, Tahtalı River and Aydın Highway stations and no significant trend was detected at the other stations. COD increased at all monitoring stations, but increases were significant at Tahtalı Lake, Tahtalı River and Istasyon District stations. Similarly COD increased at all monitoring stations, but increases were significant at only Tahtalı Lake and Menderes Şehitoğlu stations. The main reason of the improvement in nitrate concentration can be explained with the controlled usage of fertilizers in greenhouses. Generally, biological oxygen need (BOD) points out the pollution degree of industrial wastes or sewer system, so, the values of biological oxygen demand (BOD) and chemical oxygen demand (COD) increased as expected due to the intensification of urbanization in the basin. Total Phosphorus increased at

Menderes Şehitoğlu, Tahtalı River and Istasyon District stations whereas it decreased at Şaşal Bridge and Aydın Highway stations.

5.3. Prediction of Erosion with Respect to Land Use Change

Rain erosivity factor is calculated due to 8-32 years of data collected at 96 different weather stations in Turkey (Doğan 2002). The average annual R value calculated for Izmir (R=166) is used to predict the soil erosion in Tahtalı Basin. The distribution of calculated R values per month for Izmir is given in Table .5.7. As expected, R values are higher in winter months.(Çalışkan 2008). The average practice factor was taken as 0.44 as provided by Oguz, et. al. (2006) for Menemen/Izmir (ranged between 0.10-0.92).

Table 5.7. Distribution of rain erosivity factors (R) measured in Izmir- Menderes.

Months	Jan	Feb	March	April	May	June	July	August	Sep	Oct	Nov	Dec
R (ton-m/ha)	19.172	16.692	18.076	7.027	7.852	2.339	0.855	0.87	4.204	22.664	26.761	37.045

Table 5.8 .The results of land use change detection between 1995 and 2005

Land Usage (1995)	Area (km²) (1995)	Area (km²) (2005)
Fallow Land	83,716	63,784
Forest	193,22	163,555
Garden_Desmo	37,764	24,812
Grassland	10,341	9,282
Heath bell	169,99	201,360
Olive Tree	32,941	35,772
Tillage	2,457	27,908

The results from analysis of land use change detection by years in the study period have shown diverse land use, (Table 5.8). The most dominant land uses change was transformed from garden or fallow land to heath bell or tillage (Figure 5.10) Significant increases are observed in tillage areas

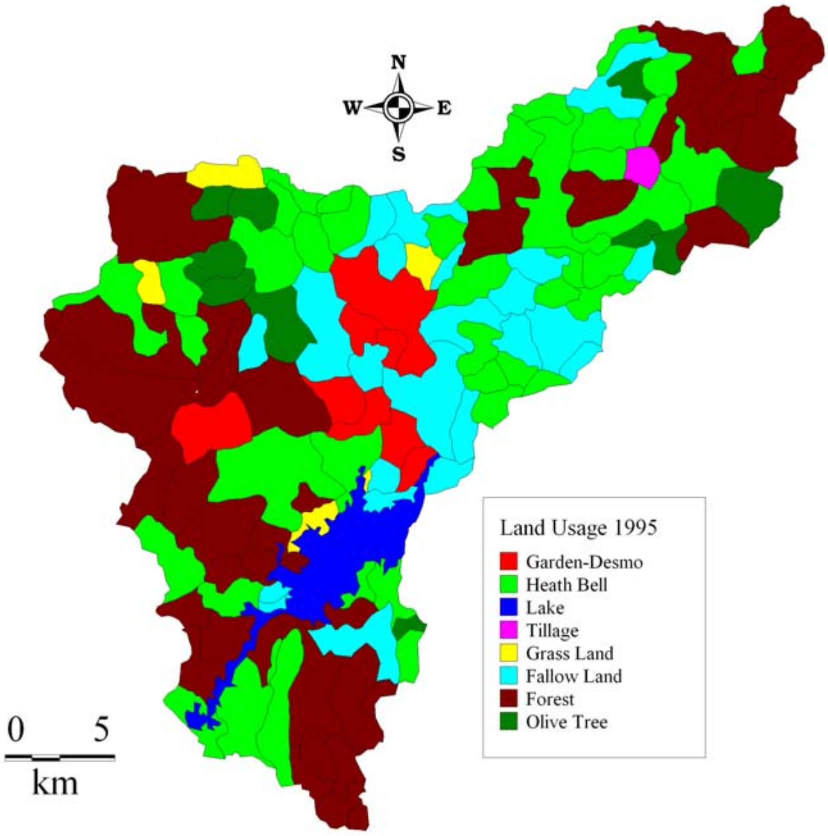


Figure 5.9. Chorophlet map of Tahtalı Basin showing land usages in 1995.

Figure 5.9 and 5.10 give different land usages in Tahtalı Basin. As can be seen from these figures, Tahtali Basin is mainly covered with forests and heath bell. Forest lands are low erosive whereas heath bell lands are considered high erosive. Erosion of soils is highest in fallow lands where crop management factor is equal to 1 in these lands.

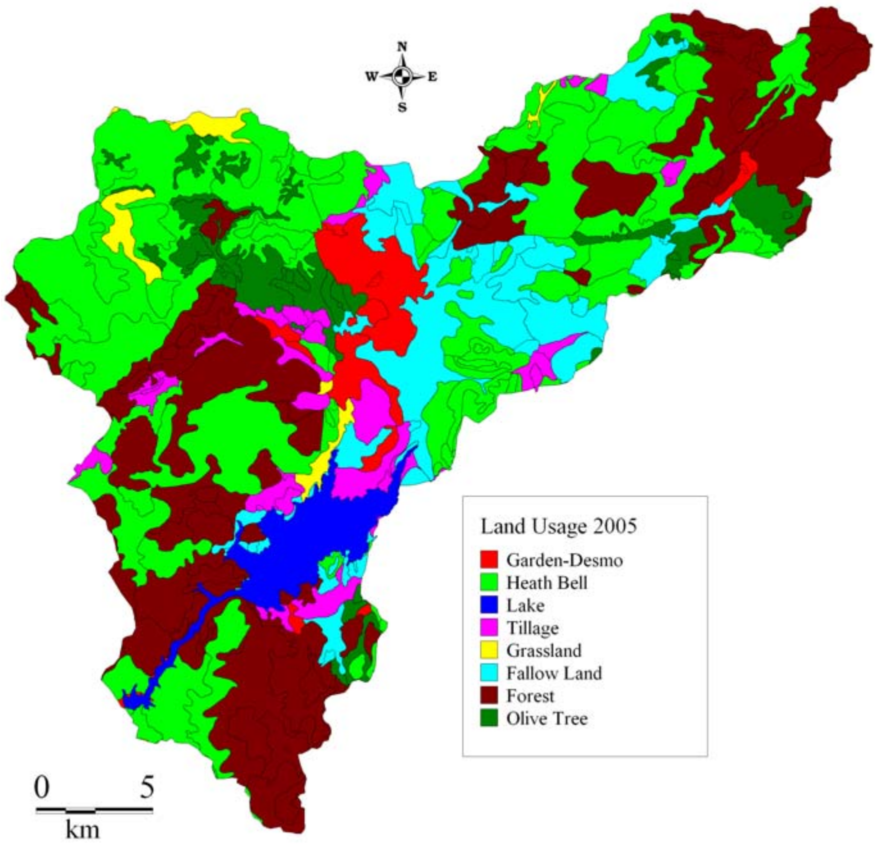


Figure 5.10. Chorophlet map of Tahtalı Basin showing land usages in 2005.

As seen from the Figure 5.11, high erosive soils are located close to the lake in 1995. In general, erosion is very low or non in alluvial soil types; low or medium in colluvial soil types and finally high in soils including silt and iron in its structure.

Soil erosion can be controlled and reduced by protective measures such as furrowing, soil replacement, and seeding of the land. The average practice factor for Menemen/ Izmir was found as 0.44 in average (ranging between 0.10-0.92). The annual soil erosion in each polygon was calculated as shown in Figures 5.11. and 5.12. For instance, for the polygon number 3 circled in the chorophlet map, the crop type is heath bell (C=0.200); erosion rate is very low due to the vegetal cover (K=0.15); slope and the slope length of the polygon were calculated using the measured values available in attributes table of digitized maps of the basin (L=15.55 ft; S=4%); the average annual R value calculated for Izmir (R=166) was used and the supporting practice factor for the reservoir area was taken as 0.44. As a result, the erosion rate of the soils in polygon number 3 (Table 5.9.) was found to be 0.046 ton/ha/year. Similarly, for the polygon number 6, this rate was calculated as 3,180 ton/ha/year.

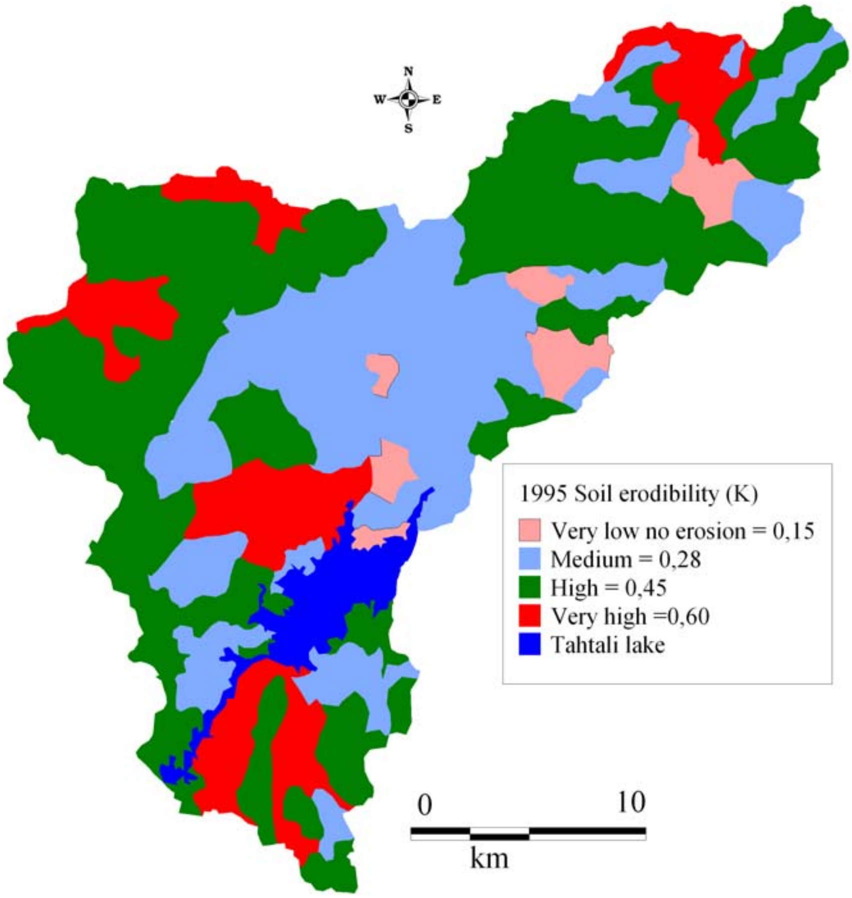


Figure 5.11. Chorophlet map of Tahtalı Basin erosion types in 1995.

Comparison of two polygons indicated that although the other characteristics of the polygons were the same, the crop type in polygon number 6 was tillage in which cropping management factor was very high (C=0.48) indicating more erosion would occur in the area (Table 5.9.) Acording the year of 2005; about 70% of the areas with slope class of 0-5% were located in the low erosion potential category; however, more than 30% of the areas with slope classes of more than 30% show a rate of high to very high erosion potential .

Table 5.9. Calculation of erosion rate by USLE method for two polygon layers for 1995

object	Land Usage	A (t/ha/year)	R	K	L	S	C	P
3	Heath Bell	0,046	166	0,15	15,554	0,030	0,200	0,44
6	Tillage	3,180	166	0,15	15,118	0,040	0,480	0,44

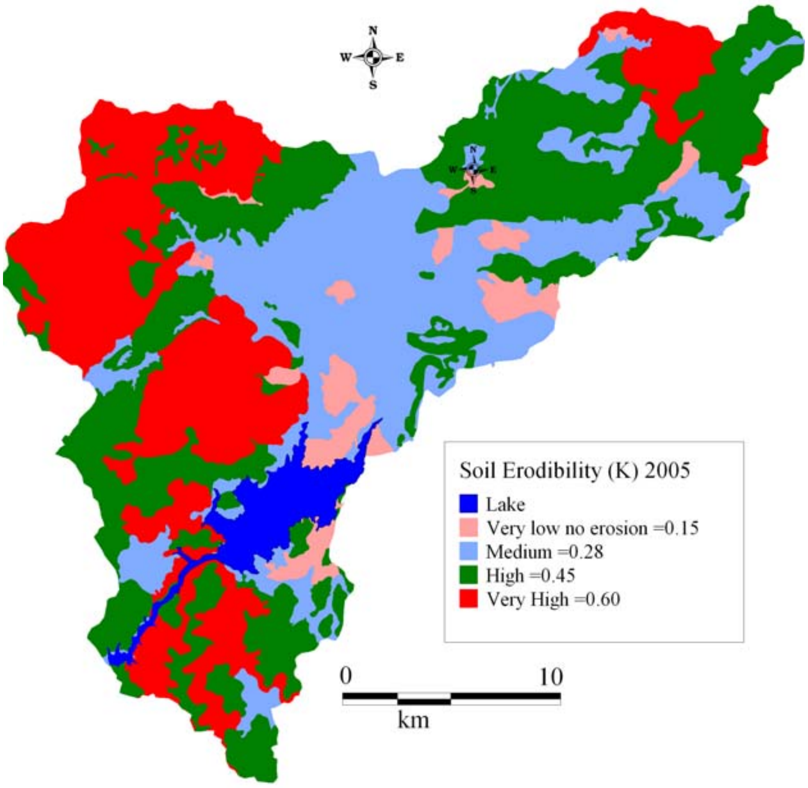


Figure 5.12. Chorophlet map of Tahtalı Basin erosion types in 2005

Table 5.10. Comparison of erosion rate for two years (1995 and 2005) in Tahtalı Basin

Land Usage (1995)	The Erosion Rate of the Soils A (t/ha/year) 1995	The Erosion Rate of the Soils A (t/ha/year) 2005
Fallow Land	57,542	31,261
Forest	1,023	1,731
garden	0,437	0,367
grassland	3,947	5,982
heath bell	7,406	13,637
Olive Tree	0,952	2,641
Tillage	3,180	127,472
∑ A	**74,487**	**183,091**

For year 1995 ,total sum of 136 polygon layers and for year 2005, 316 polygon layers were considered in the whole basin of Tahtalı. The steps summarized for two polygons (3 and 6) were repeated for each polygon and the total erosion rate occurred for year 1995 and 2005 were calculated. They are shown in Table 5.10.

The total soil loss rate was estimated as 74 ton/ha/year when the landuse map for year 1995 was utilized and this rate increased to 183 ton/ha/year when the landuse map for 2005 was used in the prediction of soil loss.

CHAPTER 6

CONCLUSIONS

For the understanding and management of land resources, the availability of information on them is a vital factor. The development of science and technology in our century demand great volumes of geographic data that can be used for quickly and more accurately analyses, to be presented in graphical forms. The computer-based GIS were developed to provide the power of analyzing large volume of geographic data Combination of digital satellite maps and aerial photos is useful procedure to prepare land use map, especially for last decades. In this study, interpretations of available maps have done as under Micro Station computer software and Map Info Softwares. The land use/and land cover change, land degradation and population pressure analysis were carried out for Tahtalı Basin at a scale of 1:5000 based on aerial photographs of 1995 and Ikonos satellite images at a scale of 1:5000 belonging the year 2005. The effects of landuse changes in Tahtalı Basin between 1995 and 2005, were summarized and the effects of these changes on water quality, at 7 different monitoring stations were discussed. Three categories of landuse in the basin were given special attention: landuse for residential settlements, landuse for industrial facilities and landuse for greenhouses. Comparison of landuse changes indicated an increase of 61% in industrial land, a 350 % in greenhouse areas and a 5 % decrease in of residential areas from 1995 to 2005.

This thesis was intended to show relationship between land use change and water quality. Both agricultural land uses and residential/urban land use were significant predictors of nutrient loading. The analysis revealed that rapid urbanization corresponds to the rapid degradation of water quality. There is also a strong correlation between proportion of urban land use (e.g., residential and industrial) and worsening water quality classifications. However, there is a strong negative correlation between the proportion of agricultural land and water quality classifications. It appears that land use is an important contributor and explaining factor regarding the quality of water in Tahtalı Basin. Controlling the rate, form, and type of urbanization can play an important role in protecting valuable urban water resources. This points to the fact that no single approach can be effectively used for water quality control in a megacity such as Izmir. Rather, an integrated management strategy, which includes a number of disciplines, such as environmental engineering and urban-regional planning, is required.

In fact, as indicated in the literature review, rapid population growth by itself need not be a problem if it were supported and guided with appropriate land use policy. Otherwise it is a huge threat to the environment as observed in many parts of the Tahtalı Basin.

Application of water quality index suggested by NSF revealed that water quality in the Tahtalı Basin is fairly good. Increasing pollutant concentrations in the middle basin lead to eutrophication in the main lake, which is due to the significant pollutant loading of incoming canals. Their pollution characteristics are: high nitrate, nitrite, total nitrogen loads originating from agriculture such as greenhouse .High phosphate and total phosphorus loads originating out of industries (high density of factories), domestic wastewater and animal farms. WQI indexing showed an increase in water quality in four years at most of the stations except the lake which was related to the new regulation for protection zones forbidding use of fertilizers and pesticides in agricultural practices.

Seasonal Kendall Test was used to assess the increasing/decreasing trends in the monitored parameters during the study period. Results of the trend analysis indicated a significant increasing trend in biological oxygen demand (BOD) and chemical oxygen demand (COD) attributed to urbanization. Nitrate, Boron and Total Phosphorus values showed increasing and decreasing trends according to the locations of the stations. The improvement in nitrate concentrations can again be attributed to the new regulations for use of fertilizers in greenhouses. However, as expected, with the increase of the settlement areas and industrial zones, the values of biological oxygen demand (BOD) and chemical oxygen demand (COD) increased as a result of insufficient waste water treatment within the basin.

Utilization of the full USLE method yields erosion rates quantified in tons/acre/year, which are more physical than high, medium, low ratings. This format may also draw more attention to the problem than ratings. Sediment yield estimated by USLE before the construction of reservoir (1998) was 74,487 (t/ha/year) in total. The results indicated that the estimated total soil loss rate increases about 2.5 times that of 1995 when the changed landuse composition in 2005 is considered in the calculations. This analysis pointed out how susceptible the area is to erosion, and the necessity of investigation of the effects before applying any development activities in the area. This part of study area needs an urgent management of erosion hazard to reduce the rate of erodibility. Damage from erosion and sedimentation is expensive economically and environmentally. On-site erosion may cause costly site damage and degradation and can damage adjacent sites or facilities.

In summary, this study revealed the importance of temporal and spatial remote sensing data to detect the changes in water quality as a result of human activities in the basin. The application of GIS tools was essential for analyzing different attribute data and understanding and quantifying changes

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APPENDICES

APPENDIX A Image Registration (using Mapinfo software)

Click to “Quick Start→ Open A Table → Open”. "Raster Image - jpeg, tif" type files are opened. Click to “Standard Places”, directory which files are stored in is opened.
To form TAB file; “File type→ ‘’Raster Image” is chosen, “Register” option is chosen then map sheet is registered, if “Display” is chosen, map sheet will be just displayed Register” option is chosen. “Image Registration” window is opened. Before entering coordinates, “Projection” is chosen and “UTM (ED 50)” (Universal Transverse Mercator) is chosen from “category" site.

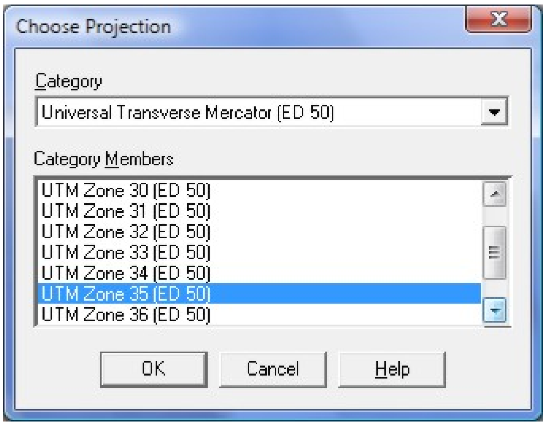

Figure A. 1 Projection Type determination in mapınfo professional 8.0 software

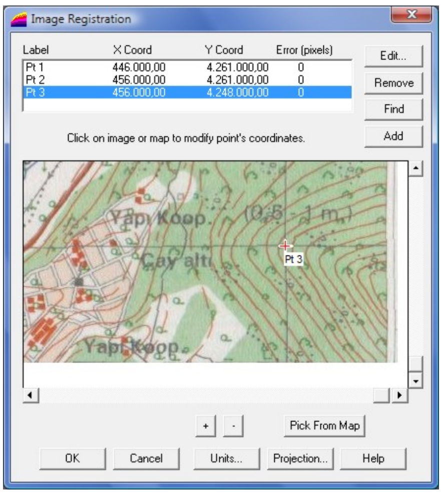

Figure A. 2. Corrected registration of a map in Mapinfo professional 8.0 software

Zoom in to the map when coordinates are entered. First point is found and marked by using “Cursor (+)” and using “Add Control Points” window, coordinates are entered in “Map X, Map Y” fields.

When all points’ coordinates are entered, errors are checked. Ideal number is 0. “1” error is tolerable. If the error is 2 or bigger that point is zoomed. Clicking right or left and up and down site of the point by trying, errors are lowered. This process is repeated for other points.

Raster formatted soil map are registered using MapInfo Professional 8.0 software. After registration process, all fields are digitized as regions.

Click to Table→Maintenance→ Table Structure command. Click to the Add Field command to add new column. Then rename the new table, choose type of data and its width

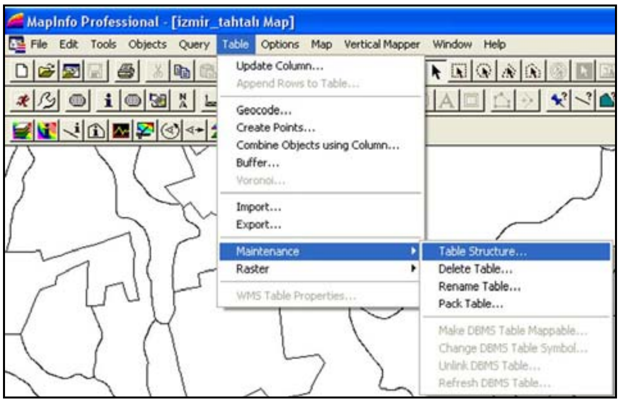

Figure A 3. Table→Maintenance→Table Structure Command.

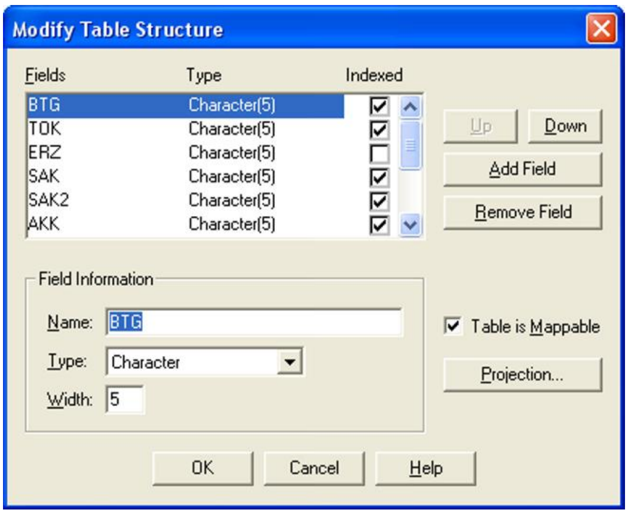

Figure A. 4. Table Structure Window.

APPENDIX B Water Quality Indexing Results

Table B 1 Some WQI results

Aydın Motorway

2002 _W

Test Parameter	Test Results	Q-Value	W. Factor	Total
1. Diss. Oxygn.	7,58	80	0,17	13,6
2. F.Coliform			0,16	0
3. pH	8,08	84	0,11	9,24
4. BOD	2,5	78	0,11	8,58
5. Temp.	9,63	45	0,10	4,5
6. T.P.			0,10	0
7. Nitrates	4,26	82	0,10	8,2
8. Turbidity			0,08	0
9. Total Solids	324,63	56	0,07	3,92
				73,98

2002_S

Test Parameter	Test Results	Q-Value	W. Factor	Total
1. Diss. Oxygn.	6,972	71	0,17	12,07
2. F.Coliform			0,16	0
3. pH	7,96	86	0,11	9,46
4. BOD	1,6	85	0,11	9,35
5. Temp.	14,40	29	0,10	2,9
6. T.P.			0,10	0
7. Nitrates	2,88	82	0,10	8,2
8. Turbidity			0,08	0
9. Total Solids	306,80	59	0,07	4,13
				71,01

2003_W

Test Parameter	Test Results	Q-Value	W. Factor	Total
1.Diss. Oxygn.	6,55	65	0,17	11,05
2. F.Coliform			0,16	0
3. pH	8,02	85	0,11	9,35
4. BOD	2,40	79	0,11	8,69
5. Temp.	8,50	48,5	0,10	4,85
6. T.P.			0,10	0
7. Nitrates	3,06	83	0,10	8,3
8. Turbidity			0,08	0
9.Total Solids	345,00	52,5	0,07	3,675
				70,71

2003_S

Test Parameter	Test Results	Q-Value	W. Factor	Total
1. Diss .Oxygn.	6,68	67	0,17	11,39
2. F.Coliform			0,16	0
3. pH	7,97	86	0,11	9,46
4. BOD	2,57	78	0,11	8,58
5. Temp.	20,00	21	0,10	2,1
6. T.P.			0,10	0
7. Nitrates	4,26	81	0,10	8,1
8. Turbidity			0,08	0
9.Total Solids	396,71	48,5	0,07	3,395
				66,26

2004_W

Test Parameter	Test Results	Q-Value	W. Factor	Total
1.Diss. Oxygn.	7,51	81	0,17	13,77

2004_S

Test Parameter	Test Results	Q-Value	W. Factor	Total
1. Diss. Oxygn.	6,98	72	0,17	12,24

2. F.Coliform			0,16	0
3. pH	8,14	83	0,11	9,13
4. BOD	2,17	80	0,11	8,8
5. Temp.	8,00	49	0,10	4,9
6. T.P.			0,10	0
7. Nitrates	3,97	82	0,10	8,2
8. Turbidity			0,08	0
9.Total Solids	336,67	52	0,07	3,64
				74,60

2. F.Coliform			0,16	0
3. pH	7,93	87	0,11	9,57
4. BOD	2,50	78	0,11	8,58
5. Temp.	12,50	35	0,10	3,5
6. T.P.			0,10	0
7. Nitrates	3,45	82,5	0,10	8,25
8. Turbidity			0,08	0
9.Total Solids	352,00	53	0,07	3,71
				70,61

2005_W

Test Parameter	Test Results	Q-Value	W. Factor	Total
1.Diss .Oxygn.	6,95	71	0,17	12,07
2. F.Coliform			0,16	0
3. pH	8,05	84	0,11	9,24
4. BOD	3,00	75	0,11	8,25
5. Temp.	10,25	41	0,10	4,1
6. T.P.			0,10	0
7. Nitrates	3,00	83	0,10	8,3
8. Turbidity			0,08	0
9.Total Solids	281,50	61	0,07	4,27
				71,19

2006_W

Test Parameter	Test Results	Q-Value	W. Factor	Total
1. Diss. Oxygn.	6,20	63	0,17	10,71
2. F.Coliform			0,16	0
3. pH	7,80	95	0,11	10,45
4. BOD	1,00	86	0,11	9,46
5. Temp.	14,00	33	0,10	3,3
6. T.P.			0,10	0
7. Nitrates	1,70	90	0,10	9
8. Turbidity			0,08	0
9.Total Solids	399,00	48,5	0,07	3,395
				71,33

Menderes Şehitoğlu

2002_W	68,33	2002_S	68,52
2003_W	75,03	2003_S	64,76
2004_W	73,66	2004_S	74,96
2005_W	76,55	2005_S	69,93
2005_W	63,66	2005_S	68,02

Tahtalı Stream

2002_W	70,19	2002_S	62,90
2003_W	68,08	2003_S	61,46
2004_W	72,89	2004_S	64,15
2005_W	73,22	2005_S	67,02
2006_W	64,82	2006_S	61,06

Mersinli Kahve

2002_W	69,73	2002_S	63,94
2003_W	72,32	2003_S	68,58
2004_W	68,50	2004_S	60,52
2005_W	69,70	2005_S	67,87
2006_W	66,42		

İstasyon District

2002_W	69,54	2002_S	57,99
2003_W	69,47	2003_S	61,80
2004_W	73,44	2004_S	64,14
2005_W	70,99	2005_S	65,19
2006_W	69,42	2006_S	
2007_W	68,70	2007_S	71,44

Şaşal Bridge

2002_W	,	2002_S	71,56
2003_W	73,78	2003_S	66,85
2004_W	74,32	2004_S	67,32
2005_W	75,45	2005_S	69,55
2006_W	73,04	2006_S	69,70
2007_W	75,78	2007_S	78,32