Sustainable solutions to emerging environmental quality problems in Menemen agricultural plain

Müezzynoòlu A., Türkman A., Panahy M., Elbyr T.

in

Camarda D. (ed.), Grassini L. (ed.).
Interdependency between agriculture and urbanization: Conflicts on sustainable use of soil and water

Bari : CIHEAM
Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 44

2001
pages 137-147

SUSTAINABLE SOLUTIONS TO EMERGING ENVIRONMENTAL QUALITY PROBLEMS IN MENEMEN AGRICULTURAL PLAIN

Aysen Müezzýnoðlu, Ayþen Türkman, Mehdi Panahý, Tolga Elbýr
Dokuz Eylul University, Izmir, Turkey.

Abstract

Menemen plain that is located by the Aegean Sea at the western part of Turkey covers an area of 23.000 ha. This plain, that has a historical irrigation system connected to the Gediz River flowing through, is a very rich one producing traditional crops. Irrigation water problems have been emerging during the last decades, due to limitations of water resources connected with compatible uses of surface and groundwater reserves as well as due to pollution risks. Presently there are plans to use the treated effluents of the wastewater treatment facility of the city of Izmir (3 million population equivalent) for Menemen Plain irrigation. However, it is suspected that soil is already endangered by several polluting factors. Along with water pollution problems, Menemen plain is under the risk of atmospheric depositions from the large industrial premises located at the north and competing land-uses due to extending urbanisation plans from Izmir.

In this study, environmental quality deterioration with respect to soil, groundwater and surface water properties, air quality and the quality of precipitation in the area is discussed. Present data describing the existing environmental quality including the results of air pollutant emission dispersion and wet/dry deposition model runs were used in evaluations of the impacts of huge industrial sources at 20 km north of the Plain.

Future developments that would affect the environmental quality were estimated and the impacts on agriculture were predicted. Especially among them are the new thermal power plants at planning stage at the north in Aliaða and Izmir wastewater treatment plant effluents for use in irrigation. Impacts of existing and future environmental quality on vegetation, soil and Gediz River water quality were also evaluated. Sustainability and necessary plans concerning the preservation of valuable Menemen agricultural plain are evaluated as a conclusion.

Introduction

Menemen plain is located immediately north of the city of Izmir, a huge metropolitan city of about 3 million inhabitants. Nowadays the city is growing in a northerly axis shown in Figure 1. It is at such a speed that Menemen town can already be counted a suburban town connected to Izmir. Menemen district is situated near Izmir City and is connected to it by roads and railways.

Menemen plain is one of the most well-known agricultural areas of western Turkey famous for high agricultural production of some traditional crops like cotton, tobacco, seedless (sultana) grapes, many types of fruits, a rich variety of vegetables, corn, wheat and other grains, etc. Table 1 shows the plant pattern and its change between 1989 and 1996**.**

Tab. 1. Plant patterns of the Menemen Plain between years 1989-1995

Years	Cotton %	Vineyard %	Melons %	Fruits %	Maize %	Vegetables %	Cereals and others %
1989	72.3	7.8	0.7	2.5	1.6	2.6	12.5
1990	61.7	10.7	0.8	3.5	1.4	2.5	19.4
1991	71.3	10.6	1.5	3.1	2.4	2.8	8.3
1992	63.6	10.7	2.2	3.2	2.6	2.8	14.9
1993	50.6	9.2	2.5	2.8	5.1	2.6	27.2
1994	64.0	12.8	4.3	3.7	3.1	3.2	8.9
1995	71.87	9.43	3.39	3.22	2.08	2.14	7.87
Average	65.05	10.18	2.20	3.15	2.61	2.66	14.15

(source: Panahi, 1999)

Menemen is an important settlement area since antique periods. The antique name of "Melemen" has been officially changed to Menemen in 1867. It has many antique cities established as city-states. None was as big and rich as Pergamon located 40 km north of Aliaða, but definitely was very important for the economy of the area. Some were ports (like ancient Greek city Kyme at Aliaða or the pirates' nest Fokai) and some were established on strategic hills to control the area (like antique Larissa, Temnos, Neoteichus, etc.). Menemen town has also been an important settlement since antique times, too. It was established, developed or invaded and ruined successively by Lithians, Persians, Alexander's army, Romans, Byzantines and Ottomans. This place has always been an attractive pathway for the invaders as it is a rich agro-economic zone for exploitation of the rulers.

A historical irrigation system always existed, but as early as 1944 under Turkish authority one of the first irrigation systems of the Republic of Turkey was established. It starts from Emiralem regulator on Gediz River and extends to the west and south. More recently the system was expanded to cover the right bank (north) of the River. The main irrigation canal was built of concrete in a trapezoidal shape. The whole plain was irrigated by a single irrigation system.

Soil properties in the Menemen Plain are summarized in Table 2. Soil is known to be a mixture of metamorphic crystals of gneiss, shiest supported by a thick alluvial limestone at the bottom.

Tab. 2. Structure and texture of soils of Menemen Area.

Nature and Depth of soil	0-1.5 m	1.5-4 m	Texture
Heavy	25%	22%	SIC
Intermediate	74%	30%	SICL/SCL
Light	1%	48%	S/SL

(source: KHGM-Village Services,1991)

Telecommunication and transportation facilities are satisfactory in the area. The Turkish Bank of Agriculture and agricultural cooperatives are providing loans to farmers. The major products are sold to traders, or purchased by TARI Agriculture Cooperatives.

Topography and climate in the area

As can be noted from the topography of the area (Figure 1), Menemen plain (23,000 ha) is a lowland through which the Gediz River is flowing. This rivers drains a huge region inwards in western Anatolia.

The macro-climate of the Menemen Plain is typical of Mediterranean Sea Regions. During summer the weather is hot and dry whereas during winter it is lukewarm and rainy. The data regarding the plain 1954-1995 is given in the Table 3.

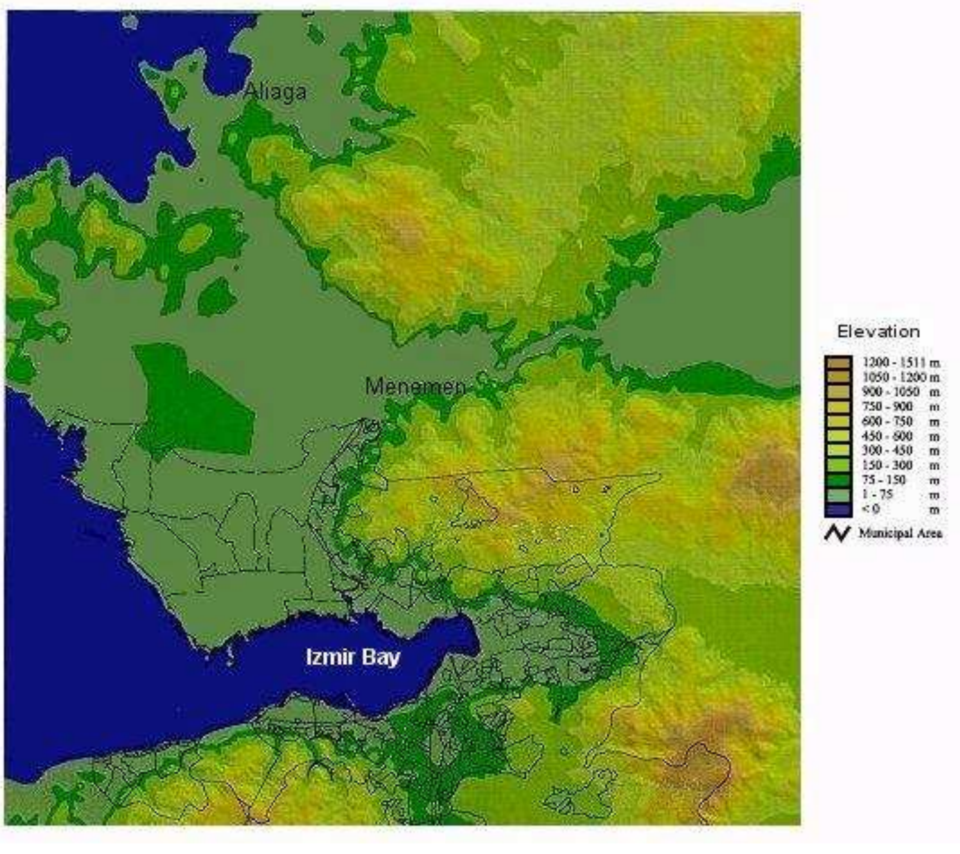

Fig. 1. Topography of the area

Tab. 3. Climatic conditions of Menemen Plain 1954-1995.

Months	Monthly average temperature °C	Monthly average rainfall, **Birim	Monthly total evaporation from open water surface per **	Monthly average relative humidity, %	Monthly average duration of insolation, hrs	Monthly average wind speed, m/s
January	7.9	95.1	45.8	64.6	4.0	4.0
February	8.8	69.6	52.8	62.1	5.1	3.9
March	11	65.4	80.7	61.5	6.1	3.3
April	15	41.8	114	58.2	7.5	2.8
May	19.9	27.4	169.3	54.9	9.6	2.6
June	24.5	6.9	224.2	49	11	2.6
July	26.8	3.2	268.3	46.9	11.8	2.9
August	26.1	3.9	235.4	48.3	11.6	2.7
September	22.2	8.3	166.2	53.8	9.5	2.4
October	17.5	32.4	103.4	60	7.5	2.4
November	12.9	75.8	57.6	63.4	5.6	2.7
December	9.6	114.2	46.1	66.3	3.9	3.7

(source: Panahi, 1999)

General atmospheric circulation in the area is typical to the northern Aegeatic circulation pattern which is from the northerly directions especially during the summer period (Etesian winds). Figure 2 shows the day and night typical wind fields at 18 m level calculated from meteorological data at 700 hPa level by taking into consideration the topography and measured solar radiation over a grid system of 1x1 km^2 having Menemen at the center. Wind roses at 3000 meters (700 hPa geostrophic) and ground level (975 hPa) under summer (May-September 1996) and winter (January-April and October-November 1996) circulation patterns are notably different between these elevations and as well as between seasons (Figure 3). At still lower elevations local and regional topography as well as strong sea-breeze structure modify the wind speeds and directions. Sea-breezes are very important during the summer half of the year. However, occasional nocturnal temperature inversions are seen during sunrise and sunset as noted by fogs upon the Gediz basin during winter. Strong changes in winds with altitude are very important in air pollutant plume dispersion and they must be known to calculate high rising plumes from large industries in the North.

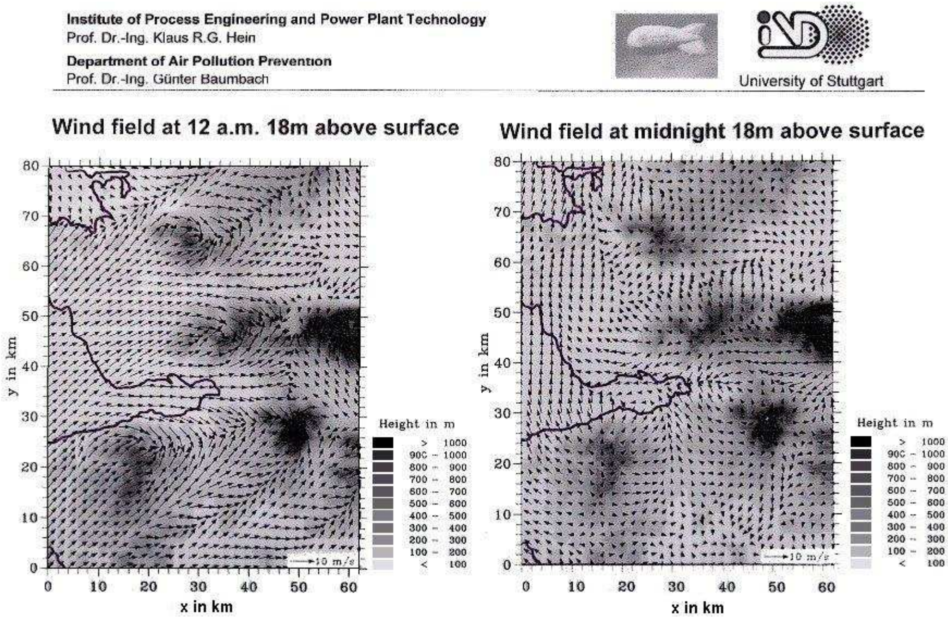

Fig. 2. Typical wind fields at 18 m level for night and day

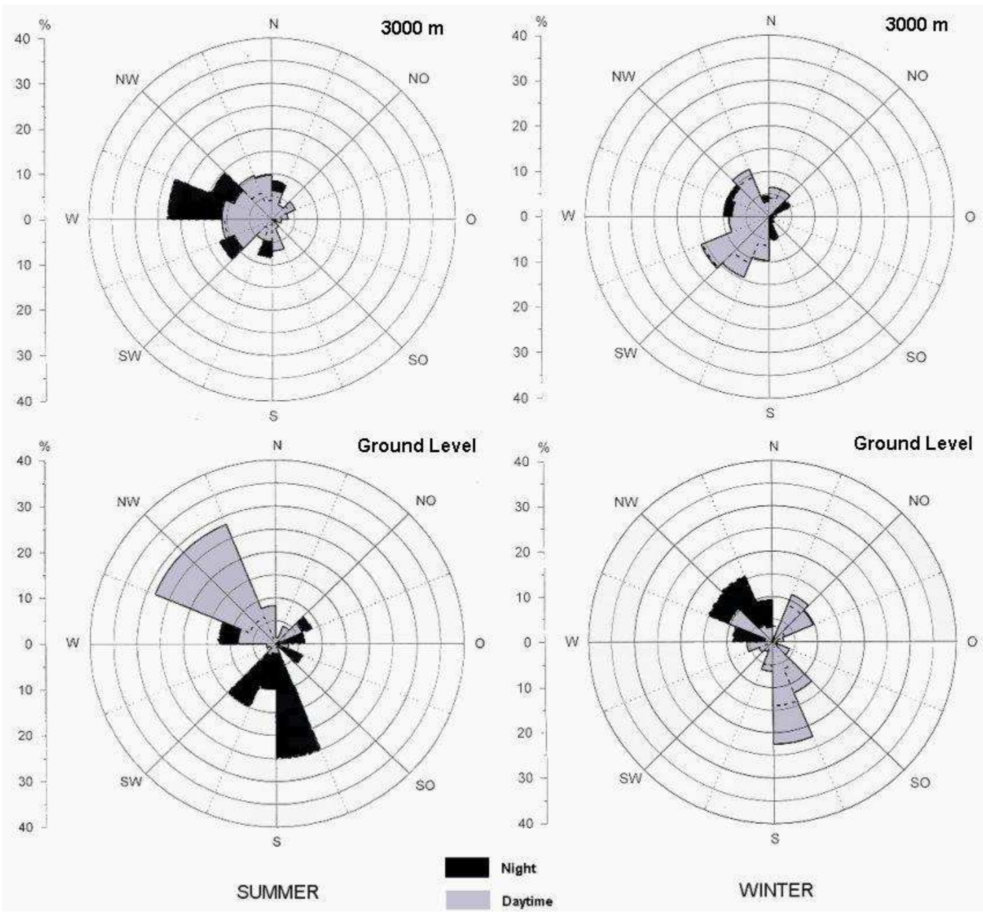

Fig. 3. Wind roses at 3000 meters and ground level under winter and summer

Agricultural productivity

The yield of the area is decreasing due to increasing salt/alkalinity problems caused by the lack of a sufficient drainage system. Some areas are already left uncultivated due to salt and alkali problems. In addition to salt and alkalinity problems, high water table problem has also been recorded. In the area, field, soil rehabilitation and salt problem of the high water table has been tackled with under the project named "Izmir II" by the development services. This project has been completed, with an achievement of 70%, during 1996. Although many problems in the area have been solved to a great extent, problems still exist in some spots of the area. The summary of the information regarding the quality of the groundwater of the area is given in Table 4, and 5.

Tab. 4. Salinity of groundwater

Electrical conductivity µmho/cm	Area (ha)	Area (%)
0-1000	1678	25
1000-2000	1690	26
2000-3000	2218	34
3000-5000	525	8
> 5000	442	7
Total	6553	100

(souce: KHGM-Village Services,1991)

Tab. 5. Sulfate content of the groundwater

Class	SO_4^- (mg/l)	Total area (ha)
Negligible	0-150	1232
Positive	150-2500	5428
Hard	2500-10000	1413
Very hard	>10000	0
Total		8073

(source: KHGM-Village Services,1991)

Industrialisation and urbanisation effects in the area

The number of industries, especially the leather manufacturers that are running away from the city of Izmir due to strong environmental mitigation programs of the municipality is increasing on the Gediz River-basin. The water in the canals of the Menemen area is polluted with discharge waters from these industries. Industrial wastewaters in canals are diluted with the irrigation water during irrigation season. However, except during the irrigation season, canals convey mostly industrial wastewaters, thus contaminating the soil. As far as the quality of the water is concerned the summary of analysis of the samples taken from Emiralem Regulator and Menemen-Gediz irrigation canal is given in Table 6.

Tab. 6. The quality of the groundwater of Menemen Plain

Sample	PH	EC*10^6	COD mg/l	CO_2 formation mg/100ml	Muddy-ness	Gas production	Coliform bacteria/ 100ml	Total bacteria *10^5/ml
1(Emiralem Regulator)	7.6	720	52	22.35	+	+	6500	140
2(Gediz River canal)	7.6	800	40	21.29	+	+	4200	18

(source: Çengel, 1996)

The farmers of the area use the low quality water shown in Table 6 for irrigation. Increasing industrialisation, competing land-uses and increasing population keep contaminating and diminishing the water and soil resources in the area. These end in lack of water of suitable quality for use in the agricultural and industrial production, as well as drinking and general hygienic requirements of the population.

The use of agricultural land for the construction of buildings and the development of cities and roadways are affecting the environment adversely by changing the plant cover pattern. The rapid increase in the population and unplanned development of cities are reducing the natural resources and the agricultural land. Such competitive land-use practices also contaminate the surface waters, prevent formation and free flow of soil water, inhibit agricultural activities due to the compaction of soil by forming hard and impermeable surfaces. As a result, deterioration of the living environment and climate change have been witnessed. Such an increase in constructed areas that end in a decrease in the vegetation cover create changes in the temperature, weather, moisture content of the soil and wind circulation of the area. With the loss of plant coverage, precipitation is decreased and soil erosion occurs resulting in changes in the texture of the soil. Productivity of the soil decreases at the end.

Atmospheric transport of pollution

Such a crooked and rapid growth in constructional and industrial uses of land contaminated the atmosphere in the area, too. Suspected acid rain due to this contamination is one of the most important threats to the environment. Accumulated toxic chemicals and nutrients coming from irrigational waters mixed with industrial wastewaters were added by the atmospheric depositions cause an enhanced imbalance in the soil chemistry. Such chemicals are changing the nutrient conditions, accumulated in the solid phase and pH changes create anomalies in the solubilities of chemicals in the soil. Therefore the dynamics of the soil are affected and the physical properties like permeability of the water are changed.

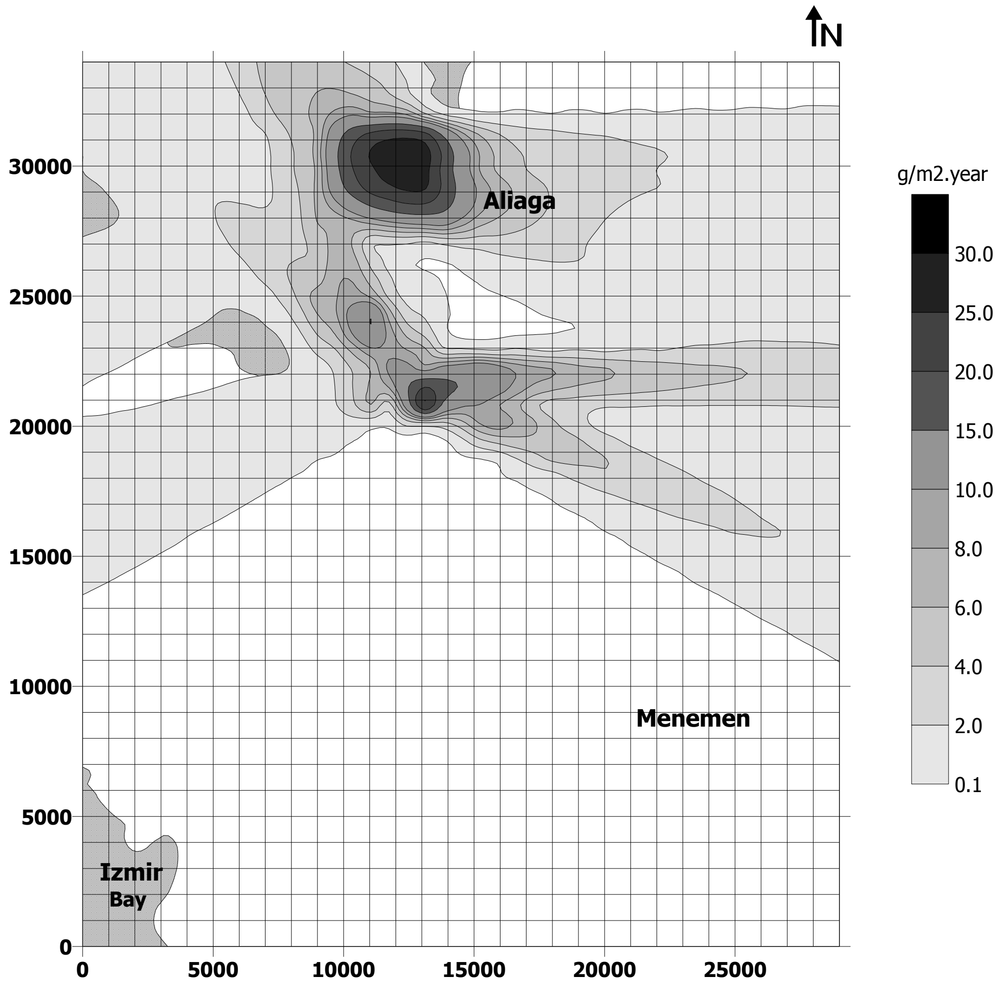

Fig. 4. Annual total (dry+wet) sulfate deposition in the study area, g/m^2.year

Previous research in the Menemen area indicated that 23.6 kg/ha.year of total sulfate deposition was received in the sampling station (Al-Momani I.F. et.al., 1995). For this presentation however, a dispersion test taking into account the large SO_2 industrial source emissions at north were distributed by using ISCST (Industrial Source Complex Short Term) computer model for wet and dry sulfate precipitation. Results of the dispersion test are plotted for annual averages in terms of total sulfate (wet plus dry) deposition. Details of the model run are not given here for simplicity. Results however, indicate that from one square kilometer grid to anouther in Menemen, the ratio of wet to dry sulfate input varied between 1-3.5, majority around 2-2.5. This is a similar finding as the measured values by Al-Momani, et. al. However, the area wide investigation shown in Figure 4 there are some grids under the direct effects of the huge industries at north with 100-150 times more sulfate precipitation. Highest figures are 310 kg/ha.year of total sulfate.

In the direction of the highest precipitation impacts in Figure 4, part of the northern (right bank) irrigation as well as new forest areas take place. Such high precipitation figures are definitely causing some direct impacts on the vegetation, spruce stands and perhaps even on the soil and groundwater chemistry.

Other research studies showed that with heavy metal (iron, copper, cadmium, tin, etc.) fall-out from the atmosphere at north of Menemen plain is also very important. Data show that in the Aliaða industrial area within a circle of 2.5 km rather unacceptable levels of heavy metal pollution in the soil (Henden, E. and Türkan, Ý, 1997) and in the aquifer underneath are endangering the ecological balances (Karaoðlu, N. and Sponza, D., 1998) are found.

These atmospheric fall-out of toxic chemicals add to the already severe picture in Menemen plain caused by waterborne substances of phenols, detergents, pesticides, etc. which are accumulated in the soil and partly absorbed by the growing plants. Many of them are toxic compounds that are known to interfere with the growth and development of plants and known to be harmful to the animals and humans consuming these plants if they exceed critical levels. Many industrial compounds are not only harmful to the ecological cycles but also inhibit the biological activities at increased energy levels.

The enhanced circulation of compounds used for the plant protection affect the environment, too. When compounds used to control the diseases and aim at minimising the losses are spread to the environment, they leach out from soil to the groundwater by the rainwater and enter the hydrological cycle. In many cases animals and humans take in the pesticides accumulated on the surface of the plant. These accumulated pesticides may cause acute toxicity or genetic disorders as well as cancers. Besides these, pesticides may have indirect effects, too. These indirect effects include decreased availability of food for some animals and increased resistance to pesticides thus enhancing populations of competitors like rival kinds of plants. All of these dangers maybe true for the agricultural area of Menemen at least on local dimensions.

Future projects to affect environmental quality of Menemen Plain

The lack of high quality irrigation water and atmospheric deposition of acidifying and toxic chemicals originating from the industries and heavy traffic arterials are the future threats.

Another action which requires a very big attention for the future is project for the diversion/irrigation of treated domestic wastewaters of Izmir. After domestic wastewaters will be treated in the wastewater treatment system built Çiðli (just south of Menemen plain) they may be utilized in the Menemen area for irrigation purpose. This project will fulfil the irrigational water requirement of the Menemen Plain if implemented. The quality of the effluent from the Izmir wastewater treatment plant is estimated as presented in the Table 7.

Tab. 7. Expected effluent water quality from Izmir wastewater treatment plant

Parameters	Concentration of used water	Expected level in domestic wastewater	Average levels in creek waters	Levels in treated water
Elect. Conductivity µmho/cm	550	1110	9600	2400
Total solids, mg/l	400	600		
Chlorides, mg/l	25	110	2485	470
Sodium, mg/l	13	95	2000	380
Calcium, mg/l	80	110	220	130
Magnesium, mg/l	25	55	215	230
SAR index	0.3	2.0	22.6	4.6

(source: Türkman et.al., 1995)

According to Turkish Technical Methods Notification the quality of discharge water from Izmir wastewater treatment plant is of 4th class for irrigation. If this water is prevented from contamination by the industrial wastewater, the electrical conductivity will decrease more and quality of this water will be Class 3 for irrigation. According to the above Notification, the quality of treated water is between C_3S_2 –C_4 S_2. The quality of water will then be C_3 S_1, if the electrical conductivity value of the water is brought to about 2000 mg/l by utilizing the high dilution capacity of the wastewater treatment system (Turkman et al., 1995).

The flow rate of treated wastewaters was estimated as 7 m^3/s for the final stage year of 2010. Menemen distribution system for irrigation water is 55.641.600 m^3 for three months during the whole irrigation season. After the establishment of storage system, the availability of 220.752.000 m^3 treated wastewater will be possible for the Menemen Plain under full capacity.

Another aspect of the future industrialisation projects are a multiplicity of new energy projects being planned in Aliaða region which are definitely going to add to the already high deposition levels. Total capacity of these power generators were about 4000 MW_e according to a plan revealed two years ago. Whatever the capacity these projects and the existing plants should be equipped with flue gas desulfurisation facilities. Also nitrogen oxides are dangerous compounds to add to the sulfate depositions as they contribute to the acid precipitation in the area. Therefore if new projects will be implemented for energy generation, NOx control should be considered for waste gas control.

Conclusion

It is not realistic to stop the urbanisation and industrialisation although they are causing big environmental problems in the Menemen Plain. For the prevention of environmental pollution, governmental and non-governmental institutions and organizations are conducting research on different aspects of the problems and try to be effective on the land-use plans.

When the industrial organizations are strict enough to obey environmental rules and regulations, the extend of pollution will be kept within certain limits. This will partly solve the problems created by industries on agricultural areas.

References

Atýþ Ý., Alpaslan A.H., Tomar A. (1996), "Gediz Nehri Yataðýnda ve Havzasýnda Çevre Sorunlarýna Genel Bir Bakýþ" (A General Review of the Environmental Problems in Gediz River Bed and the Catchment Area), Paper presented at the Second Agriculture, Erosion and Environmetnal Problems Symposium, 2-4 Dec. 1996, Ýzmir.

Al-Momani I.F., Ataman O.Y., Anwari M.A., Tuncel S., Köse C., Tuncel G. (1995), "Chemical Composition of Precipitation Near an Industrial Area at Izmir, Turkey", Atmospheric Environment, 29, pp. 1131-1144.

IZSU (Izmir Municipality Water and Wastewater Administration) (1997), Summary Report for Wastewater Treatment Plant of Izmir Sewerage Project, Izmir.

Köy Hizmetleri Genel Müdürlüðü (KHGM) (1991), Village Services, Izmir II Proje Raporu.

Panahi M. (1999), A Study of Improving the Distribution of Water in Izmir-Menemen, Ph.D. Thesis, Aegean University.

Teknik Usuller Tebliði (Technical Methods Notification) (1991), Under Su Kirliliði Kontrol Yönetmeliði (Water Pollution Control Regulation), Ministry of Environment, Ankara, 1991.

Türkman A., Þengül F., Özer A., Kayalar A.Þ. et al. (1995), Ýzmir Kenti Atýksu Toplama, Arýtma ve Bertaraf Alternatiflerinin Deðerlendirilmesi Projesi (Ýzmir Wastewater Collection, Treatment, and Disposal Alternatives Project), DEÜ Dept. of Env. Eng., Ýzmir.