

A RESEARCH FOR WATER POLLUTION OF MELENDIZ STREAM IN TERMS OF SUSTAINABILITY OF ECOLOGICAL BALANCE

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Abstract: In order to provide the continuity of ecological balance, the presence of water as well as its quality is of capital importance. In this study; a research was carried out about the water pollution in Melendiz stream which feeds the Mamasun dam and meets the drinking and usage water need of Aksaray Plain and its environment. The samples were taken from totally 14 stations between 2006 and 2009 (February, June, September, December) throughout the whole study. These samples were analyzed in terms of 22 parameters, its water quality was determined by evaluating according to “*Continental Water Sources Quality Classification Criteria*” (Republic of Turkey Ministry of Environment and Forest / Regulation for Water Pollution Control) and thus the factors that cause pollution in Melendiz stream were determined. Moreover, the seasonal variations in quality criteria of Melendiz stream were determined and the precautions necessary to minimize the pollution were discussed. As a result of the research; the effects of domestic wastewater, thermal spring wastewater and wastewater of touristic plants as point pollution sources and agricultural drainage water as a common source were determined. In point sources, organic substances and nitrite were determined whereas, nitrate pollution related with excess fertilizer usage was determined in common sources. The concentrations of these parameters increased especially in dry spells and caused a certain decrease in water quality. According to continental water quality classification criteria, the surface water had IIIrd and IVth class water property in terms of especially nitrate, nitrite and total nitrogen and IInd class water property in terms of other parameters. When the analysis results of samples taken between 2006 and 2009 were compared, it was determined that the amount of pollution increased in time. It was also observed that the surface water of Melendiz stream was exposed to pollution by point and common sources and the quality of water decreased gradually.

Key Words: Melendiz stream, Mamasun dam, water quality, seasonal variation, environmental pollution

1. INTRODUCTION

Secure water is necessary to provide the sustainability of life, to drink, to cook and to clean as well as for the needs in agriculture and gardening (Durga Rao, 2005). To follow raw water quality for performing the management of drinking water quality is as important as following the water quality in treatment processes and distribution system (Sadiq & Rodriguez, 2005). Cobourn (1999) indicated that it was necessary to consider the

amount of water together with its quality in defining the properties of integrated watershed management and it was not enough to be interested just in problems such as water supply and flood control. The self-perpetuation period of a watershed or a river, the natural structure of which was decomposed, is so long as to affect the human life and environmental conditions. For this reason, it's necessary to follow continuously watersheds and rivers against effects that decompose and pollute their natural structure and to determine the level of

their pollution. Thus, the aims for the efficient usage of surface and ground water sources can be easily determined (Dikmen, 2001). As a result of river pollution due to some factors, the present ecological balance decomposes and both plants and animals are affected negatively. When environmental integration was considered, an idea was latched on that the management of water sources was an ecosystem management (Black, 1997).

There are six factors in order to evaluate the quality of surface waters. These are; organic, nutrient, physicochemical parameters, variations caused by weather effect, solubility's in water and soil as well as toxic anthropogenic factors (Simeonov et al., 2003). The quality of surface water is a very critical subject. Anthropogenic effects (urbanization which increased the consumption of water sources, industrial and agricultural effects) as well as natural events (rains, erosion, metals) decompose the quality of surface waters and weaken their usage in drinking, industry, agriculture, recreation and other areas (Interlandi & Crockett, 2003). Atmospheric and anthropogenic inputs together with climatic conditions have important effects on surface waters. Since rivers can be used as drinking water and for the aims of agriculture, industry and recreation, their importance and economical contributions are excessive.

The human activities affect river systems in different respects; these are, damaging forests, urban settlement, agricultural development, pollutant discharge, flow arrangements such as drainage and dam (Bellos & Sawidis, 2005). The quality of surface water is weakened with the pollutants discharged from point and common sources. These pollutant sources are urban activities, agricultural and industrial activities, handcrafts and traffic. The concurrent presence of a few pollutants causes important variations in the concentrations and distributions of certain pollutants. This significantly affects water quality and most of the time, is not suitable for human consumption (Dassenakis et al., 1998). As a fundamental human right "sufficient, safe, acceptable, physically accessible and affordable water for personal and domestic uses" is vital for all (Gurzau et al., 2010). Therefore, researchs on water quality monitor is increasing every day (Akköz et al., 2009; Ferenczi & Balog, 2010; Dragicevic et al., 2010; Parvulescu and Hamchevici, 2010). As a result of degradation in soil usage applications in the river and its environment, the amount and quality of usable fresh water rapidly decrease. The water quality in the rivers is generally related with the area usage in its environment. The amount and duration of rainfall affect the amount and quality of water (Ngoye & Machiwa, 2004).

Our study area, Melendiz stream, feeds Mamasun dam which meets drinking and usage water needs of the most drought place of Central Anatolian Region and Turkey, i.e. Aksaray plain and its environment. Mamasun dam meets 60% of drinking water need of Aksaray city. Mamasun dam also has a certain potential in terms of other activities such as agricultural irrigation, recreation and fishing. Melendiz stream is the main source of irrigation in Aksaray plain (Can, 1996; Hmis, 2007). Since the amount of rainfall is little and most of the region is private environmental protection area, the water potential here is one-fold valuable. The region has continental and arid climate. Aksaray city has 327.6 mm total rain amount according to the average of 40-year observations. While the total average annual rain amount is 22.6 mm in 2007, it decreased to 19.6 mm in 2008 (Anonymous, 2008a).

Melendiz stream rises from northeast foot of Melendiz Mountain at a height of 2963 m in the southeast of Aksaray and enters to Ihlara valley by mixing with small and large forty ground water around Ihlara town. This stream which passes Belisırma and Selime after going 14 km in the valley with its 110 m depth makes 26 winds from Ihlara to Selime and reaches to Mamasun dam which meets the drinking and irrigation water need of Aksaray and its environment today (Sivaci, 1995).

In order to provide the sustainability of ecological balance, the presence and quality of water are very important. It's necessary to make water quality control regularly within certain periods to protect and take under control the ecosystems which are fed by water sources (rivers, lakes, wetland areas). It's also necessary to take required precautions to determine pollution factors and to minimize them after determination of water quality. In this study, the samples taken from Melendiz stream, which is one of the most important surface water sources of Melendiz watershed, were evaluated according to 'Continental Water Sources Quality Classification Criteria' (Republic of Turkey Ministry of Environment and Forest/Regulation for Water Pollution Control, Table 1), its water quality was determined and the factors causing pollution in Melendiz stream were also determined. Furthermore, the seasonal variations in the quality criteria of Melendiz stream were specified and the precautions that should be taken to minimize the pollution were also discussed.

2. MATERIALS AND METHODS

Melendiz watershed is between 34°10' - 34°36' east longitudes and 38°04' - 38°22' north latitudes in

Central Anatolian Region. In the north of the watershed, Mamasun dam which is fed by Melendiz water is present (Doğdu, 1995). Within the scope of this research, the samples were taken from specified 14 surface water sampling stations starting from Ciftlik town in Nigde city to the entrance point of Mamasun dam in Aksaray city (approximately 44 km).

Table 1. Continental water sources quality classification criterions (Anonymous, 2008b)

PARAMETERS (mg/L)	WATER QUALITY CLASS			
	I	II	III	IV
Temperature	25	25	30	>30
pH	6.5-8.5	6.5-8.5	6-9	<6-9<
Dissolved Oxygen (%)	90	70	40	<40
Cl ⁻	25	200	400	>400
SO ₄ ⁻²	200	200	200	>400
NH ₄ ⁺ -N	0.2	1	2	>2
NO ₂ -N	0.002	0.01	0.05	>0.05
NO ₃ -N	5	10	20	>20
PO ₄ ⁻³ -P	0.02	0.16	0.65	>0.65
TDM	500	1500	5000	>5000
COD	25	50	70	>70
BOD	4	8	20	>20
TOC	5	8	12	>12
TA	0.5	1.5	5	>5
Cd	0.003	0.005	0.01	>0.01
Pb	0.01	0.02	0.05	>0.05
Cu	0.02	0.05	0.2	>0.2
Zn	0.2	0.5	2	>2
F ⁻	1	1.5	2	>2
Fe	0.3	1	5	>5
Mn	0.1	0.15	3	>3
B	1	1	1	>1

The coordinates of sampling stations were determined by *Garmin* trade GPS 12CX equipment.

11 of sampling stations were on Melendiz stream, 1 station was at the point where Melendiz stream flows into Mamasun dam, 1 station was at the point where Karasu stream flows into Mamasun dam and the other one is at the mixing point of Melendiz and Karasu streams in the dam (Figure 1). The sampling stations and their properties are given in Table 2. The samples of surface water were taken compositely from 15-20 cm under the surface and collected in polyethylene bottles.

2.1. Analysis of data

The analysis was carried out both in the area and in the laboratory. The values of temperature and pH were measured by WTW pH 330i / SET equipment; dissolved oxygen by WTW OXI 340i / SET equipment; total suspended solids, salinity by WTW LF 330i / SET equipment; turbidity by WTW TURB 355 IR (Portable Turbidimeter / 0 -1100 NTU) equipment in the area and the following analysis were carried out in the laboratory.

Major anion – cation analysis was carried out by Perkin & Elmer model 2280 atomic absorption spectrophotometer (± 0.001 mg/l) and Thermo Elemental X7 ICP-MS (≥ 0.1378 ppb) equipments while major ion analysis were carried out by HP trademark IC equipment in the laboratory. Titration method (Alkalinity (2320) / Titration Method S. 2-35 Standart Methods) was used in the measurements of HCO₃ and CO₃.

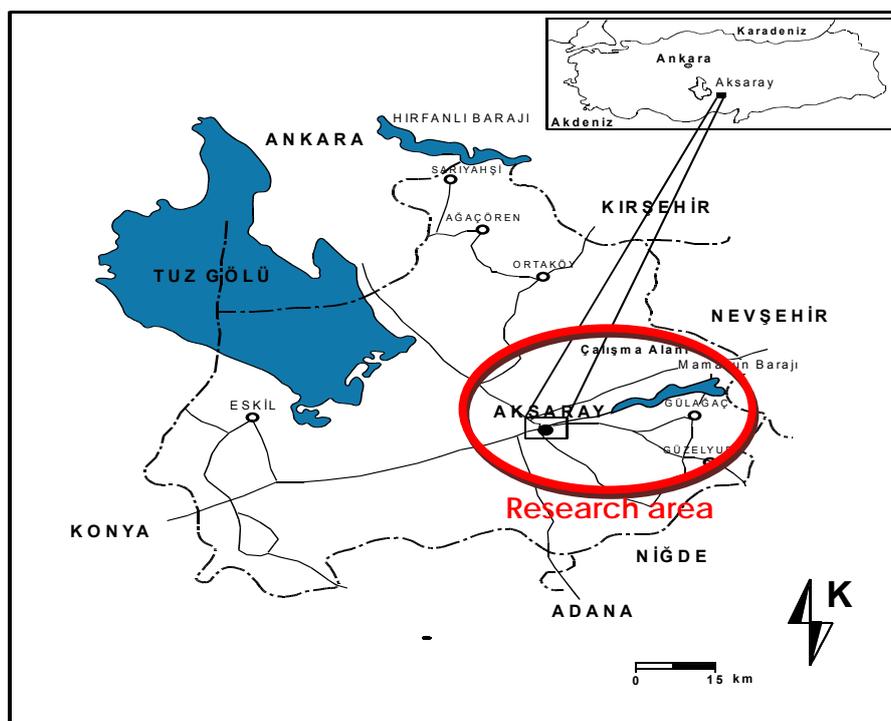


Figure 1. The place of Melendiz stream in the region (Karadavut, 2009).

Table 2. Sampling stations along Melendiz stream and their properties

SAMPLING STATIONS AND THEIR PROPERTIES				
No	Name	Coordinates	Distance ^a	Property
M1	Çitflik Entry	38°10'48" / 34°27'36"	0	Beginning point. Location, plant, no agricultural area
M2	Ilisu Entry	38° 13'48" / 34° 21'36"	15200	Before location, agricultural area is present.
M3	Ilisu Exit	38° 13'48" / 34° 19'48"	2200	Location is present, extensive agricultural area, laundry and Ilisu hot water mixing.
M4	Ihlara Entry	38° 14'24" / 34° 19'12"	2200	Before location, agricultural area is present
M5	Ihlara Exit	38° 15'36" / 34° 17'60"	5300	Location is present, no agricultural area, in private environmental protection area.
M6	Belısırma Entry	38° 16'12" / 34° 17'24"	2900	Before location, in Ihlara valley and in protection area, no agricultural area.
M7	Belısırma Exit	38° 16'12" / 34° 17'24"	500	Location is present, in valley and in protection area, touristic plant is present.
M8	Ziga Exit- Yaprakhisar Entry	38° 17'24" / 34° 16'48"	2200	Before location, in protection area, Ziga hot water and bathhouse wastewater mixing is present.
M9	Yaprakhisar Exit- Selime Entry	38° 17'60" / 34° 15'36"	1400	Location is present, valley exit, agricultural area and touristic plant are present.
M10	Selime Exit- Kızılkaya Entry	38° 19'12" / 34° 15'00"	2500	Extensive agricultural area, location and sand pit are present.
M11	Kızılkaya Exit	38° 21'36" / 34° 13'12"	2100	Extensive agricultural area and location are present.
M12	Melendiz Dam Entry	38° 22'48" / 34° 12'36"	2200	Agricultural area is present.
M13	Karasu Dam Entry	38° 22'48" / 34° 12'36"	1000	Agricultural area is present.
M14	Melendiz –Karasu Dam Mixing	38° 22'48" / 34° 12'36"	44820	Mixing point

a: Distance to the previous station in meters

In the analysis for the measurements of Total Organic Carbon (TOC) and Total Nitrogen (TN), Apollo 9000 TOC – TN Analyzer (measurement range 100 ppb – 25000 ppb measurement sensitivity \pm 3%) was used. Biological Oxygen Demand (BOD) analysis were performed with WTW Oxi Top IS 12 system and Chemical Oxygen Demand (COD) measurements were carried out by using Chemical Oxygen Demand (5220) /Closed Reflux, Colorimetric Method, Standard Methods. The analysis for Suspended Solid Materials (SSM) and Total Solid Materials (TSM) were carried out gravimetrically by Solids (2540); Total

Suspended Solids 2540 D and Total Solids 2540 B, Standard Methods, respectively. Determination of alkalinity was performed titrimetric with Alkalinity (2320) / Titration Method, Standard Methods.

3. FINDINGS

The results for the analysis of samples collected from 14 sampling stations in Melendiz stream in February, June, September and December months of 2006 and 2009 are given in Table 3 - Table 10 together with Figure 2 - Figure 5.

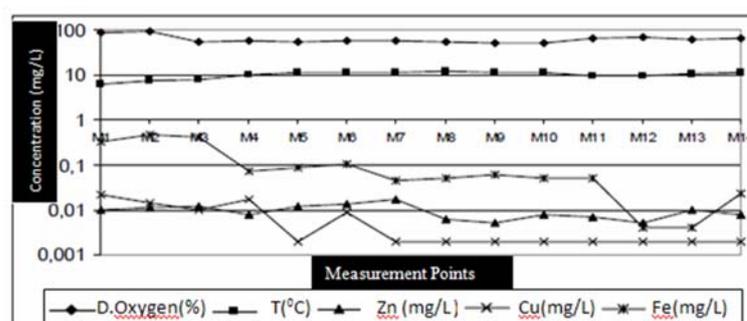


Figure 2. Temperature, DO variation and heavy metal concentration along the flow of Melendiz stream (February, 2006)

Table 3. Classification of quality parameters of Melendiz stream according to quality criterions of continental water sources (February, 2006)

PARAMETERS (mg/L)	MEASUREMENT POINTS													
	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14
Temperature	6.1	7.4	7.8	10.2	11.2	11.2	11.6	12.1	11.7	11.5	9.6	9.7	10.7	11.5
Ph	7.5	8.2	8.0	7.4	7.8	7.7	7.6	7.5	7.4	7.5	8.4	6.9	8.3	6.9
Dissolved Oxygen (%)	87	96	56	58	56	57	57	56	53	50	64	71	61	67
Cl ⁻	3.21	6.11	6.69	5.45	6.25	6.95	6.76	28.74	29.27	25.84	24.85	34.28	27.81	35.96
SO ₄ ⁻²	27.55	51.65	49.20	36.09	35.02	34.71	33.25	30.13	30.36	28.60	33.19	27.54	17.24	24.03
NH ₄ ⁺ -N	0.20	0.05	0.36	0.35	0.35	0.12	0.01	0.14	0.04	0	0	0.40	0	0.79
NO ₂ -N	0	0.13	0	0	0	0	0	0	0	0	0	0	0	0
NO ₃ -N	11.13	17.29	16.54	12.91	12.25	12.45	11.78	10.78	10.59	9.99	10.97	6.30	6.36	4.33
PO ₄ ⁻³ -P	0	0	0	0	0	0.08	0.06	0.03	0	0.05	0	0	0	0.03
TDM ^a	125	214	219	189	196	201	204	253	284	295	294	353	483	329
COD	X	X	9.7	X	2.5	X	4.4	X	9.0	7.6	4.6	X	X	X
BOD	X	X	3.9	X	1.7	X	2.6	X	3.6	2.1	2.3	X	X	X
TOC ^b	1.42	2.02	2.84	3.25	0.87	1.14	1.76	7.19	1.82	1.25	1.36	1.24	1.08	1.00
TN ^c	3.72	6.40	6.50	5.15	4.08	5.33	4.19	8.09	4.13	5.19	5.00	2.48	3.63	4.13
Cd	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pb	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Cu	0.022	0.014	0.01	0.017	<0.002	0.009	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Zn	0.01	0.011	0.012	0.08	0.012	0.013	0.017	0.006	0.005	0.008	0.007	0.005	<0.01	0.008
F ⁻	0	0.065	0.048	0.02	0.087	0.121	0.037	0.098	0.049	0.057	0.069	0.128	0.178	0.042
Fe	0.317	0.469	0.424	0.073	0.087	0.101	0.045	0.049	0.059	0.051	0.049	<0.004	<0.004	0.023
Mn	0.038	0.023	<0.002	0.013	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
B	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

a: Total Dissolved Matter, b: Total Organic Carbon, c: Total Nitrogen x: It didn't do analysis for sampling

Table 4. Classification of quality parameters of Melendiz stream according to quality criteria of continental water sources (February, 2009)

PARAMETERS (mg/L)	MEASUREMENT POINTS													
	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14
Temperature	6.8	7.6	7.9	10.5	11.5	11.6	11.9	12.6	11.9	11.6	9.8	9.9	10.9	11.7
Ph	7.6.	8.3	8.1.	7.6	7.9	7.8	7.7	7.7	7.6	7.5	8.6	7.0	8.5	7.1
Dissolved Oxygen (%)	85	94	53	56	55	54	55	54	51	49	62	69	60	65
Cl ⁻	3.45	6.80	6.87	5.79	6.41	6.98	6.84	29.52	30.12	26.21	25.48	35.57	28.20	37.40
SO ₄ ⁻²	28.42	53.70	50.65	38.23	36.80	35.07	34.11	32.45	33.06	29.45	34.89	29.65	19.42	25.08
NH ₄ ⁺ -N	0.28	0.08	0.40	0.37	0.38	0.17	0.08	0.19	0.09	0.03	0.07	0.67	0.04	0.083
NO ₂ -N	0.01	0.08	0.02	0	0.02	0	0	0	0.03	0	0	0	0	0
NO ₃ -N	12.11	18.40	17.10	13.41	12.89	13.05	12.22	10.87	11.20	9.89	11.21	6.54	6.62	4.84
PO ₄ ⁻³ -P	0	0	0	0	0	0.09	0.07	0.05	0	0.06	0	0	0	0.06
TDM ^a	138	231	238	195	199	208	207	265	289	304	306	375	496	374
COD	X	X	10.4	X	3.6	X	4.9	X	9.8	8.3	5.1	X	X	X
BOD	X	X	4.4	X	2.5	X	3.2	X	3.8	2.7	2.8	X	X	X
TOC ^b	1.52	2.85	2.94	3.80	1.12	1.76	1.92	7.80	1.98	1.66	1.87	1.48	1.38	1.34
TN ^c	3.87	6.80	6.95	5.34	4.17	5.74	4.45	8.16	4.28	5.87	5.07	2.84	3.75	4.56
Cd	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pb	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Cu	0.023	0.016	0.01	0.019	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Zn	0.02	0.013	0.014	0.09	0.013	0.015	0.018	0.007	0.008	0.009	0.008	0.006	<0.01	0.009
F ⁻	0	0.0068	0.051	0.05	0.089	0.125	0.040	0.099	0.051	0.060	0.071	0.131	0.182	0.063
Fe	0.321	0.473	0.436	0.078	0.090	0.103	0.047	0.052	0.060	0.055	0.050	<0.005	<0.005	0.025
B	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

a: Total Dissolved Matter, b: Total Organic Carbon, c: Total Nitrogen x: It didn't do analysis for sampling

Table 5. Classification of quality parameters of Melendiz stream according to quality criteria of continental water sources (June, 2006)

PARAMETERS (mg/L)	MEASUREMENT POINTS													
	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14
Temperature	14.8	15.7	19.1	16.0	19.7	20.8	21.9	26.1	24.2	24.4	25.3	25.5	22.8	23.9
Ph	7.9	8.6	8.5	7.9	8.5	8.1	8.1	7.6	7.4	7.2	8.2	7.8	7.8	7.7
Dissolved Oxygen (%)	113	103	138	114	128	82	60	86	67	47	70	70	85	78
Cl ⁻	4.77	7.85	21.19	4.96	8.28	10.63	11.44	103.1	122.1	108.6	105.9	93.80	52.18	68.57
SO ₄ ⁻²	17.91	42.63	20.00	13.78	13.86	13.88	13.53	16.18	18.50	24.05	24.26	32.88	42.18	34.17
NH ₄ ⁺ -N	0.16	0.16	0.41	0.39	0.17	0.43	0.77	0.50	1.06	1.10	0.96	1.08	0.57	0.56
NO ₂ -N	0	0	0.47	0.11	0.08	0.04	0.73	0	0.34	0.34	0.21	0.61	0.25	0.30
NO ₃ -N	2.07	2.65	9.49	6.91	6.25	5.78	5.80	6.02	6.30	5.43	1.95	3.95	9.77	3.94
PO ₄ ⁻³ -P	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TDM ^a	144	236	288	140	166	182	194	420	495	507	485	516	555	453
COD	X	X	15.0	X	16.6	X	24.3	X	11.8	19.4	13.5	X	X	X
BOD	X	X	6.0	X	7.0	X	10.0	X	7.0	8.0	6.7	X	X	X
TOC ^b	1.51	6.48	4.17	4.65	5.32	6.01	6.13	8.56	5.99	4.71	7.50	6.14	10.77	7.55
TN ^c	1.98	2.16	3.62	3.57	3.49	3.34	3.09	2.66	4.01	3.44	2.17	2.73	3.87	2.93
Cd	0	<0.001	0	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Pb	<0.03	0.06	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Cu	0.001	0.001	0.001	0.001	0.001	0.001	0.003	0.002	0.004	0.013	0.009	0.008	0.009	0.006
Zn	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
F ⁻	0	0.252	0	0.125	0.146	0.073	0.214	0.304	0.231	0.289	0.169	0.192	0.205	0.758
Fe	0.019	0.012	0.045	0.037	<0.01	0.012	0.053	0.034	0.02	0.11	<0.1	0.064	0.038	0.03
Mn	0.003	0.009	0.004	<0.002	<0.002	<0.002	0.004	0.002	0.002	0.004	0.006	0.034	0.006	0.005
B	0.103	0.122	0.338	0.162	0.151	0.190	0.204	1.62	1.95	1.68	1.56	1.41	1.30	0.197

a: Total Dissolved Matter, b: Total Organic Carbon, c: Total Nitrogen x: It didn't do analysis for sampling

Table 6. Classification of quality parameters of Melendiz stream according to quality criteria of continental water sources (June, 2009)

PARAMETERS (mg/L)	MEASUREMENT POINTS													
	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14
Temperature	15.2	16.3	20.3	16.4	20.3	21.0	22.4	27.4	25.5	25.8	26.7	26.9	24.1	25.4
pH	8.0	8.8	8.7	8.1	8.7	8.4	8.5	7.8	7.6	7.5	8.3	7.9	7.9	7.8
Dissolved Oxygen (%)	110	100	136	112	126	80	57	84	65	44	68	67	82	75
Cl ⁻	4.82	7.92	18.70	4.60	9.34	11.41	12.14	15.21	13.17	11.88	11.65	75.26	46.90	55.80
SO ₄ ⁻²	19.35	38.79	22.24	15.86	16.89	15.42	16.10	19.37	19.45	21.17	22.67	28.95	38.49	36.21
NH ₄ ⁺ -N	0.23	0.14	0.43	0.47	0.25	0.39	0.68	0.60	0.98	0.96	1.02	0.94	0.66	0.68
NO ₂ -N	0.02	0.01	0.20	0.08	0.06	0.02	0.35	0.38	0.27	0.29	0.17	0.29	0.24	0.32
NO ₃ -N	2.57	3.21	8.45	7.24	6.59	6.01	8.06	7.04	6.22	7.45	3.48	5.68	8.76	4.98
PO ₄ ⁻³ -P	0.02	0	0	0	0.01	0	0	0.01	0.01	0	0	0	0	0
TDM ^a	168	248	298	167	182	193	204	443	498	514	496	525	570	486
COD	X	X	15.8	X	17.0	X	26.7	X	13.2	20.1	14.8	X	X	X
BOD	X	X	6.5	X	7.4	X	11.0	X	7.6	8.5	6.9	X	X	X
TOC ^b	1.72	6.89	4.78	5.00	5.67	6.25	6.28	8.59	6.14	4.87	7.78	6.58	11.12	8.27
TN ^c	2.23	2.67	3.89	4.01	3.67	3.58	3.25	3.03	4.26	3.76	2.56	2.82	3.91	3.15
Cd	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Pb	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Cu	0.002	0.002	0.002	0.002	0.001	0.003	0.002	0.001	0.006	0.008	0.009	0.005	0.006	0.004
Zn	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
F ⁻	0	0.260	0	0.138	0.153	0.0098	0.276	0.326	0.258	0.291	0.187	0.212	0.224	0.875
Fe	0.034	0.024	0.054	0.048	0.010	0.015	0.067	0.048	0.09	0.14	0.014	0.074	0.041	0.05
B	0.112	0.134	0.356	0.189	0.172	0.208	1.10	1.58	1.76	1.89	1.39	1.27	1.44	0.245

a: Total Dissolved Matter, b: Total Organic Carbon, c: Total Nitrogen x: It didn't do analysis for sampling

Table 7. Classification of quality parameters of Melendiz stream according to quality criterions of continental water sources (September, 2006)

PARAMETERS (mg/L)	MEASUREMENT POINTS													
	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14
Temperature	15.1	16.2	19.4	16.0	17.2	18.8	20.4	23.7	23.0	24.8	24.2	22.2	20.9	21.2
pH	7.1	7.6	7.9	7.1	8.0	7.9	7.9	7.8	7.9	8.2	8.6	8.5	8.3	8.2
Dissolved Oxygen (%)	73	69	64	62	65	67	62	72	62	92	81	68	84	76
Cl ⁻	6.60	10.80	9.96	5.07	8.24	9.54	9.99	97.80	99.93	94.65	100.5	101.3	59.48	74.05
SO ₄ ⁻²	10.70	29.44	24.77	14.99	5.17	15.67	14.67	14.99	18.45	20.09	22.91	24.65	29.02	23.58
NH ₄ ⁺ -N	0	0	0	0.37	0	0	0.10	0	0	0	0	0.09	0.05	0.07
NO ₂ -N	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NO ₃ -N	1.20	1.05	4.36	2.94	3.04	2.77	2.88	2.52	2.54	1.18	0.84	1.19	3.30	2.15
PO ₄ ⁻³ -P	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TDM ^a	161	280	319	150	180	192	197	441	447	478	501	508	549	442
COD	X	X	17.6	X	17.2	X	14.3	X	16.4	12.7	11.8	X	X	X
BOD	X	X	13.5	X	10.5	X	9.4	X	9.9	7.2	8.2	X	X	X
TOC ^b	1.70	2.96	12.80	6.02	8.08	8.98	7.41	11.68	12.53	7.95	5.35	13.15	12.43	9.13
TN ^c	1.17	1.36	2.94	2.30	3.50	3.11	2.52	3.62	2.85	1.38	0.55	1.71	2.15	2.71
Cd	0	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Pb	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cu	0.003	0.006	0.005	0.005	0.005	0.003	0.015	0.003	0.003	0.003	0.004	0.004	0.004	0.004
Zn	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
F ⁻	0	0.781	0.189	0.195	0.383	0.514	0.430	0	0	0.364	0.246	0.192	0.194	0.176
Fe	0.019	0.071	0.039	0.073	0.047	0.047	0.04	0.045	0.049	0.056	0.065	0.063	0.031	0.037
Mn	0.003	0.023	<0.002	<0.002	<0.002	<0.002	<0.001	0.003	0.005	0.006	0.01	0.004	<0.002	<0.001
B	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

a: Total Dissolved Matter, b: Total Organic Carbon, c: Total Nitrogen x: It didn't do analysis for sampling

Table 8. Classification of quality parameters of Melendiz stream according to quality criteria of continental water sources (September, 2009)

PARAMETERS (mg/L)	MEASUREMENT POINTS													
	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14
Temperature	15.9	16.4	19.9	17.0	17.9	19.2	21.0	24.1	23.8	25.0	24.9	23.6	21.4	21.9
pH	7.4	7.8	7.9	7.5	7.9	8.0	8.1	7.9	8.0	8.1	8.5	8.5	8.6	8.3
Dissolved Oxygen (%)	70	67	62	60	63	65	60	68	59	89	79	65	81	73
Cl ⁻	6.87	11.23	15.22	6.03	8.15	9.67	10.12	101.0	98.76	98.27	101.6	102.4	72.80	67.41
SO ₄ ⁻²	11.87	22.65	21.87	16.56	8.26	14.87	15.10	13.48	17.46	21.30	21.87	28.14	27.39	25.35
NH ₄ ⁺ -N	0.05	0.03	0.02	0.28	0.11	0.21	0	0	0	0.07	0.03	0.06	0.03	0.06
NO ₂ -N	0.08	0.01	0.02	0	0	0	0	0	0	0	0	0.01	0.01	0.02
NO ₃ -N	2.21	2.12	3.67	2.76	1.87	2.90	2.76	2.67	2.70	1.80	1.08	1.69	2.89	2.98
PO ₄ ⁻³ -P	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TDM ^a	185	298	357	187	198	210	225	480	432	450	504	509	534	490
COD	X	X	18.2	X	18.3	X	15.2	X	17.2	13.8	13.7	X	X	X
BOD	X	X	14.1	X	11.1	X	9.9	X	10.2	8.4	8.7	X	X	X
TOC ^b	2.10	1.58	3.11	2.78	3.69	3.22	3.15	3.76	2.97	1.85	1.10	13.21	13.23	10.12
TN ^c	1.28	1.42	2.96	2.43	3.51	3.23	3.76	2.89	1.45	0.99	1.82	2.23	2.84	2.80
Cd	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Pb	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cu	0.004	0.005	0.005	0.004	0.005	0.006	0.012	0.004	0.004	0.004	0.004	0.004	0.004	0.004
Zn	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
F ⁻	0	0	0.243	0.223	0.370	0.476	0.448	0.227	0.193	0.286	0.315	0.229	0.218	0.196
Fe	0.021	0.068	0.040	0.065	0.050	0.051	0.041	0.042	0.054	0.058	0.069	0.048	0.033	0.041
B	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

a: Total Dissolved Matter, b: Total Organic Carbon, c: Total Nitrogen x: It didn't do analysis for sampling

Table 9. Classification of quality parameters of Melendiz stream according to quality criterions of continental water sources (December, 2006)

PARAMETERS (mg/L)	MEASUREMENT POINTS													
	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14
Temperature	0.5	1.8	3.1	7.2	6.8	6.6	7.0	8.2	8.2	7.2	7.3	7.2	5.5	6.7
pH	8.9	8.6	8.6	8.4	8.4	8.0	8.3	8.3	7.9	8.2	8.9	8.6	8.4	8.5
Dissolved Oxygen (%)	92	91	85	89	84	83	79	77	79	73	76	84	76	73
Cl ⁻	2.51	5.38	6.49	4.49	5.51	6.41	6.90	41.76	41.57	43.78	42.52	42.09	0	37.46
SO ₄ ⁻²	25.43	36.54	34.48	21.58	20.06	19.75	19.25	19.32	19.00	19.23	19.35	18.62	15.62	14.21
NH ₄ ⁺ -N	0.31	0.27	0.37	0.29	0.27	0.26	0.30	0.64	0.50	0.60	0.53	0	0.41	0.51
NO ₂ -N	0.05	0.14	0.09	0.17	0.02	0.03	0	0	0	0	0	0	0	0
NO ₃ -N	11.08	11.61	11.75	8.56	8.37	8.44	8.21	7.33	7.36	6.85	6.88	7.43	9.07	5.27
PO ₄ ⁻³ -P	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TDM ^a	133	202	210	167	178	186	188	315	314	330	322	326	461	351
COD	X	X	2.6	X	2.4	X	2.6	X	2.5	1.9	2.1	X	X	X
BOD	X	X	2.0	X	1.7	X	1.9	X	2.0	1.5	1.7	X	X	X
TOC ^b	0.44	0.61	1.03	0.82	0.96	0.60	1.04	0.75	1.07	0.87	0.90	0.87	1.56	0.93
TN ^c	1.03	1.74	3.96	2.34	2.68	1.90	3.40	2.98	2.59	2.75	2.62	2.87	3.68	2.95
F ⁻	0.053	0.232	0.125	0.0092	0.076	0.144	0.300	0.126	0.220	0.220	0.308	0.155	0.432	0.268

a: Total Dissolved Matter, b: Total Organic Carbon, c: Total Nitrogen x: It didn't do analysis for sampling

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Table 10. Classification of quality parameters of Melendiz stream according to quality criterions of continental water sources (December, 2009)

PARAMETERS (mg/L)	MEASUREMENT POINTS													
	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14
Temperature	0.9	2.1	3.9	7.8	6.9	6.8	7.2	8.6	8.7	7.3	7.5	7.4	6.8	6.9
pH	8.8	8.7	8.7	8.5	8.6	8.1	8.2	8.4	8.2	8.5	8.6	8.4	8.6	8.5
Dissolved Oxygen (%)	88	87	82	87	80	81	77	75	75	72	74	79	73	71
Cl ⁻	2.78	5.82	6.53	4.67	5.67	6.48	6.98	47.96	46.52	44.69	43.88	44.76	45.72	40.13
SO ₄ ⁻²	28.63	38.75	36.23	35.49	28.34	23.51	22.14	21.38	20.67	20.51	20.25	19.59	17.69	17.15
NH ₄ ⁺ -N	0.37	0.29	0.39	0.31	0.29	0.27	0.33	0.68	0.59	0.67	0.57	0.40	0	0.65
NO ₂ -N	0.06	0.16	0.10	0.16	0.07	0.02	0.01	0.01	0	0	0	0.02	0.03	0
NO ₃ -N	12.05	12.36	12.53	9.21	9.23	9.45	9.12	8.24	7.87	7.47	8.45	6.95	8.27	6.12
PO ₄ ⁻³ -P	0.02	0.01	0	0	0	0.01	0	0	0	0	0	0	0	0
TDM ^a	165	231	227	183	186	188	190	336	332	345	331	329	425	384
COD	X	X	2.9	X	2.7	X	2.9	X	2.8	2.3	2.6	X	X	X
BOD	X	X	2.3	X	1.9	X	2.2	X	2.3	1.8	2.1	X	X	X
TOC ^b	0.52	0.75	1.12	0.97	1.07	0.75	1.18	0.86	1.12	0.92	0.98	0.94	1.75	1.05
TN ^c	1.45	1.89	4.01	2.76	2.84	1.99	3.45	3.17	2.92	2.87	2.71	2.89	3.72	3.07
F ⁻	0.041	0.216	0.120	0.089	0.087	0.136	0.277	0.118	0.212	0.247	0.298	0.187	0.342	0.274

a: Total Dissolved Matter, b: Total Organic Carbon, c: Total Nitrogen x: It didn't do analysis for sampling

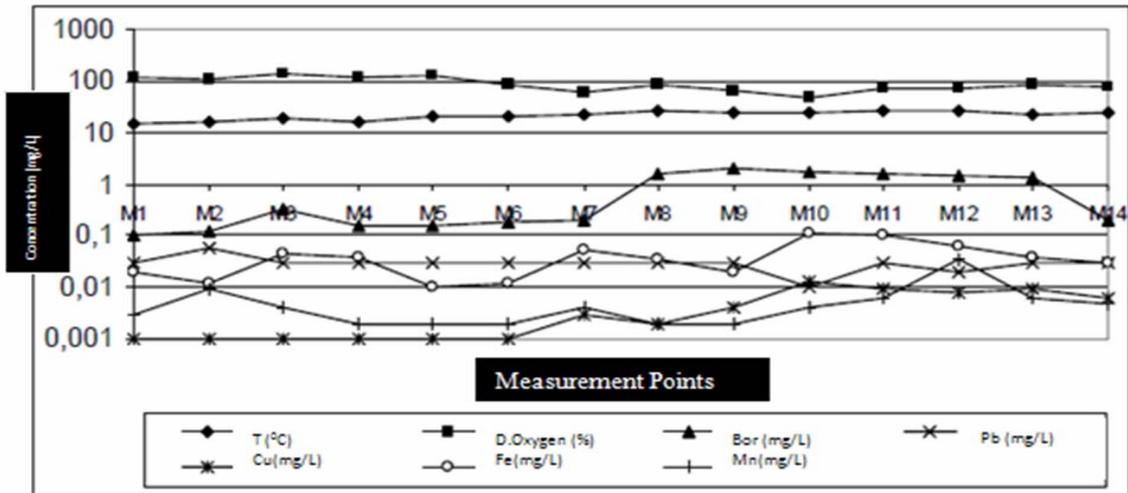


Figure 3. Temperature, DO variation and heavy metal concentration along the flow of Melendiz stream (June, 2006)

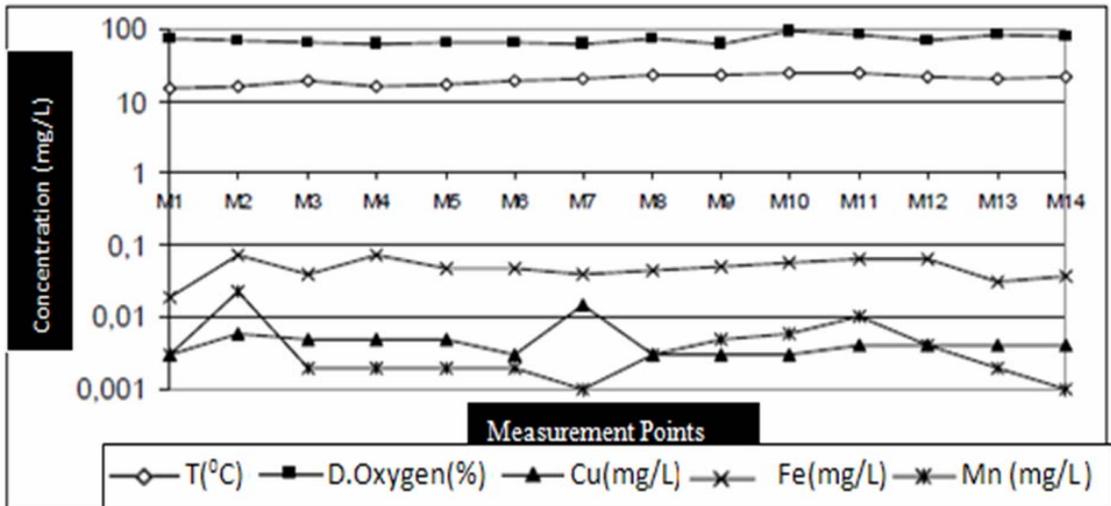


Figure 4. Temperature, DO variation and heavy metal concentration along the flow of Melendiz stream (September, 2006)

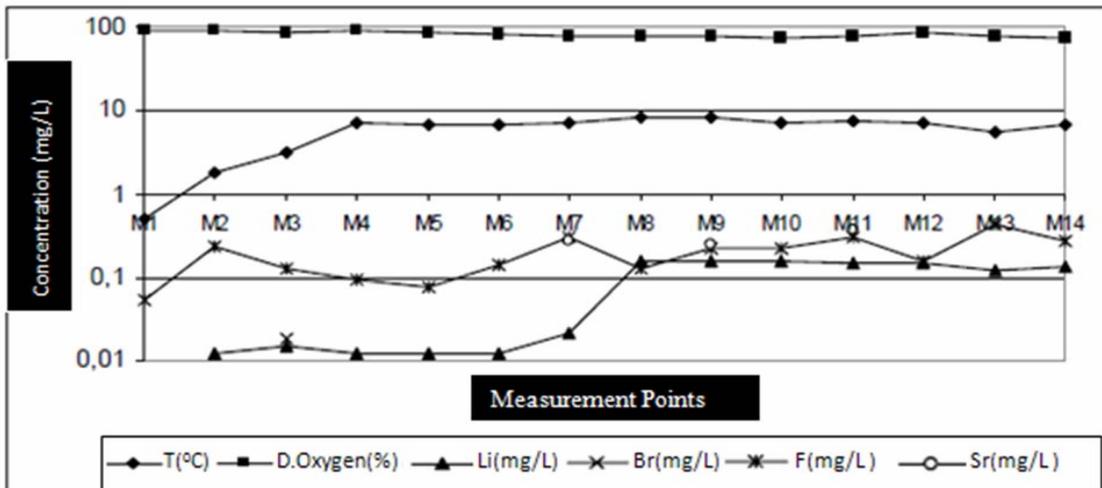


Figure 5. Temperature, DO variation and trace element concentration along the flow of Melendiz stream (December, 2006)

3.1. Seasonal variation in quality criterions of Melendiz stream

When seasonal water quality variations of Melendiz stream were taken into consideration, it was observed that its water had IVth class water property in terms of nitrite and total nitrogen according to continental water sources quality criterions in February, June and December months. February and June months are weaker periods in terms of water quality along the river when compared with December (Table 9, Table 10).

When it was considered that there was approximately 63 thousand decar agricultural area along Melendiz stream and about 65 thousand tonnes of fertilizers were used, it's possible to understand why the water of the river had IVth class water quality in terms of nitrite and total nitrogen. Moreover, since the wastewaters belonging to settlements present along the stream with their approximately 50 thousand population were discharged directly and this discharge increased depending on domestic and foreign tourisms in June, it was inevitable to have quite weaker quality river in terms of nitrite. The passage of nitrogen from the fertilizers to the soil occurred by rain and irrigation water. It was determined that June was the worst period in terms of the water quality in spring when the

snow started to melt and the flow rate of stream was maximum (Table 5 and Table 6). The fertilizing in this period and the increase in the wastewater discharge related with the increase in population provide a basis for this situation.

A decrease in water quality was observed in February due to passage of nitrogen-including fertilizers to stream depending on excess rainfall. The increase in total organic substances caused IVth class water quality in September. The flow rate of stream was the minimum in this period. The stream reached IVth class water quality depending on domestic wastewater mixture and low flow rate (Table 3 and Table 4). However, when all sampling points were taken into consideration, IInd class water property was observed in DO, BOD and TN. When these evaluations were considered, the water quality of Melendiz stream was mostly affected by agricultural activities and not as much as them but by domestic wastewaters, too.

When stations and seasonal variations were evaluated from statistical points of view (Table 12), there was a significant difference between stations and seasons in terms of TN (ANOVA, $p < 0.05$). In addition to this, when Table 11, Table 13 and Table 14 were observed, there was a significant difference for DO, NO₂ and NO₃ parameters, respectively from statistical point of view (ANOVA, $p < 0.05$).

Table 11. Statistical evaluation of DO values of Melendiz stream in terms of stations and seasonal variations

Variance source	SS	df	MS	F	P-value	F criterion
Station	3993,929	13	307,2253	1,301428	0,2535	1,980528
Season	5166,857	3	1722,286	7,295726	0,000536	2,84507
Error	9206,643	39	236,0678			
Total	18367,43	55				

Table 12. Statistical evaluation of TN values of Melendiz stream in terms of stations and seasonal variations

Variance source	SS	df	MS	F	P-value	F criterion
Station	20,46754	13	1,574426	2,009674	0,046495	1,980528
Season	54,45947	3	18,15316	23,17157	8,88E-09	2,84507
Error	30,55353	39	0,783424			
Total	105,4805	55				

Table 13. Statistical evaluation of NO₂ values of Melendiz stream in terms of stations and seasonal variations

Variance source	SS	df	MS	F	P-value	F criterion
Station	0,15213	13	0,011702	0,742248	0,711729	1,980528
Season	0,582448	3	0,194149	12,31438	8,25E-06	2,84507
Error	0,614877	39	0,015766			
Total	1,349455	55				

Table 14. Statistical evaluation of NO₃ values of Melendiz stream in terms of stations and seasonal variations

Variance source	SS	df	MS	F	P-value	F criterion
Station	136,7497	13	10,51921	2,456603	0,015183	1,980528
Season	592,7986	3	197,5995	46,1464	6,67E-13	2,84507
Error	166,9985	39	4,282014			
Total	896,5469	55				

4. RESULTS

It was observed that there was a significant increase in temperature values in all months (February-June-September-December) in M3 (Ilisu output) and M8 (after Ziga plants) stations. This situation results from hot and mineral water mixture from Ilisu and Ziga, respectively with Melendiz stream in M3 and M8 stations. However, temperature values in all measurement points were within the range of Ist class water quality according to continental water sources quality classification.

The concentrations of Total Dissolved Solid Material (TDSM) increased in four months due to mixing of domestic, agricultural wastewaters, hot and mineral water along Melendiz stream. There was a definite increase at mixing points of Ilisu and Ziga hot and mineral waters with Melendiz. This increase was especially higher in June and September than other two months. The flow rate was the highest in June when thermal springs were active and the population increased depending on domestic together with foreign tourists. September, on the other hand, was the month when the lowest value of the flow rate of the river was observed. TDSM values were higher depending on lower flow rate. According to continental water sources quality classification, the river had Ist class water quality property in all four periods.

Melendiz stream almost had IInd class water property in September in terms of Dissolved Oxygen (DO) (Figure 4). The values of Total Organic Carbon (TOC) and Biological Oxygen Demand (BOD) were also higher than the other periods. IInd and IVth class water properties were determined in terms of TOC and IInd class water property was determined in terms of BOD (Table 7 and Table 8). When the lowest flow rate of the river in this period was taken into consideration, it comes forward that the water prospered in terms of organic materials and DO was used biologically. In February, it was considered that DO was consumed with nitrification process (Figure 2). In June, higher value of DO indicated excess algae formation in the river (Figure 3).

The increase in turbidity values was observed in M8, M10 and M12 stations. The increase in M8 was caused by the mixing of hot and mineral water; in M10, the increase was due to sand pit operating by Selime Municipal and high turbulence due to drawdown for agricultural activities in that region caused the increase in M12. The value of Suspended Solids (SS) was higher in June than the other months. This month was the one when the population of the region increased therefore more wastewater was mixed with stream, the snow melted and carried particulate materials to the stream and hot thermal springs came into activity in the region. Point factors increasing the rate of SS were mixing of hot and mineral water (Ilisu and Ziga), sand pit in the exit of Selime Town and turbulence occurring due to drawdown with machines from the river in the entry of Melendiz dam. The values of SS were not as serious as to make a problem in terms of surface water.

When total nitrogen (TN) and nitrate values were taken into consideration, higher values were obtained in February, June and December than September. In Melendiz watershed, approximately 55966 dekar area along the stream was used for agriculture and 65 thousand tonnes of nitrogenous fertilizers were used. In these three months, the values of nitrate and total nitrogen increased along the river due to the passage of present nitrogen in terrestrial area to the water depending on rainfall and snowmelt. It was observed that the river had IVth class water property in terms of water quality classification criterions.

When the results of analysis performed with 22 parameters were evaluated according to continental water sources classification criterions, it was determined that Melendiz stream had IIIrd and IVth class water quality in terms of nitrate, nitrite and total nitrogen. The values of IInd class water quality were obtained in terms of other parameters. The river had almost IInd class water quality value except the values of nitrate, nitrite and total nitrogen. IInd class water property was determined in terms of total organic carbon just in September when the flow rate was the lowest.

In the research of Alas and Cil (2002) which was carried out in the sources feeding Mamasun Dam Lake (Melendiz and Karasu streams), it was determined that the sources had generally 1st class water quality. In our study, on the other hand, Melendiz stream had IIIrd and IVth class water property in terms of nitrate, nitrite and total nitrogen while it had IInd class water property in terms of other parameters. This situation aroused the feeling of surface waters of Melendiz stream was exposed to pollution by point and common sources and its water quality decreased gradually.

5. SUGGESTIONS

Most of our study area was announced as private environmental protection region. Approximately 32735 dekar area in this region was used for agriculture. Agricultural pollution was determined in surface waters depending on the usage of extensive fertilizers. Ziga hot and mineral water sources and the wastewater of touristic plants and settlements present in this protection area were discharged to Melendiz stream. Most of the local community did not know about the existence of this protection area. First of all, local government and then the public should be informed and raised awareness. Turkey should not lose Ihlara private environment protection region which is the one among 14 private environment protection regions. In addition to this, the protection region should be extended, the settlement should be rearranged according to this, agricultural and touristic activities should be taken under control and this esteem and surface and ground water existences that perish to this esteem should be put under protection.

The precautions should be taken to protect hot water sources that give service to domestic and time to time to foreign tourists and the thermal water which is benefit for both health and economy should be removed from the medium without giving any damage to surface and ground waters. Reinjection (return the water to aquifer) of thermal water used in this area should be considered. While considering it from economical point of view, the problems that it will cause in terms of environmental pollution should not be ignored.

The wastewater belonging to the settlements present along Melendiz stream should be given to the receiving medium after treatment by the common studies and behaviours of local governments. The drawdown from the stream in the aim of using it in agricultural areas close the entry of Mamasun dam along Melendiz stream decomposes both the regime of the flow and the river bed. In

order to prevent such activities, the necessary studies should be carried out by local governments or necessary arrangements should be performed for controlled usage. The sand pit operating by Selime Municipal which is between Selime and Kizilkaya towns negatively affects Melendiz stream. It especially decomposes the base of the stream and its regime of the flow. The operating of this sand pit should be terminated and such applications along Melendiz stream should not be permitted. Decomposed river bed should be rearranged. The required studies should be performed about carrying the settlements along Melendiz stream especially the closer ones and animal houses belonging to them to the backside of the valley by forming a protection region around the stream. This will both provide less risk for the pollution of the river and a protection for these settlements against floods.

Approximately 62971 dekar area from Ilisu to the entry of Mamasun dam covering the whole study area is used for the agriculture and annually approximately 65246 tonnes nitrogenous, 50444 tonnes phosphorated and 1374 tonnes potash fertilizers were used. The main reason for the nitrate pollution of surface and especially the ground water is the agricultural applications and fertilizing the soil. In order to minimize this situation, the authorized organizations should take fertilizer usage under control with scientific approaches.

An education programme should be organized to the local community by the efforts and attempts of local governments and educational studies by experts should be performed. The importance of surface and ground waters, their usage and protection should be taught, education should be given about protection and careful usage of water, irrigation, agricultural activities and fertilizing and the required precautions should be taken by local governments with legal sanctions, if necessary.

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