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Assessment of physicochemical parameters and heavy metal pollution in Çeltek Pond water

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Present study consists the measurement results of physicochemical parameters and heavy metal concentrations for Çeltek Pond, Sivas-Turkey. Temperature, pH, salinity and electrical conductivity parameters were obtained from the field using a multiparameter. The analyses of nitrite, nitrate, ammoniac, ammonium nitrogen (NH_4^+), chloride, phosphate, sulphate, sulphite, potassium, calcium, sodium and magnesium were conducted by using HACH LANGE brand DR 6000 laboratory type spectrophotometer, and the analyses of the heavy metals were conducted by using a gas chromatography-Mass Spectrometry. The water quality in Çeltek Pond was found to be Class I according to the Surface Water Quality Management Regulation (SWQMR).

[Keywords:Water Quality, Heavy Metal, Surface Water, Çeltek Pond, Sivas]

Introduction

The availability of good quality water is a fundamental necessity for improving the quality of life[1]. Increasing population, its necessities and anthropogenic influences such as industrial, farming, forestry activities, the excessive water use significantly affect the quality of water, and also impair their use for drinking, agriculture, recreation and other purposes. The worldwide concern is that the good quality water may become a scarce resource in the near future[2]. Even now, unfortunately, many countries and regions face with the problems of water pollution[3]. Water quality is defined in terms of chemical, physical and biological contents of water[4]. The anthropogenic sources are associated mainly with industrial and domestic wastes, landfill leachate, and the increased use of metal based pesticides and fertilizer in agriculture[1,5]. Investigation of heavy metal contamination of water has become the primary focus of environmental scientists in recent years[6,7]. The concentrations of some heavy metals are beneficial and essentially required for normal body growth and functions of living organisms such as metal nutritional requirements (Cu, Fe, Mn, Zn etc.), whereas the high concentrations of other metals may be harmful and highly toxic (Pb, Cd, Cr etc.) even at trace levels. The existence of harmful and toxic heavy metals in aquatic environments leads to serious concerns about their influence on directly to the biota and indirectly to humans.

The heavy metals and other physical and chemical parameters are easily affected from environmental factors such as surface runoff, groundwater, dissolution from sediment, deposition from the atmosphere and anthropogenic pollutants. Hence, the proper determination and the regular monitoring of heavy metals and other physical and chemical parameters in an aquatic environment are ultimate important and essential for additional information to the existing data on water quality assessments, safety assessment of lakes and ponds status, and they may be sensitive indicators for monitoring changes in the aquatic environment[4,5,8]. Present study was to investigate monthly changes in the physicochemical water quality parameters and heavy metals contamination in the Çeltek Pond (Sivas/Turkey).

Materials and Methods

Çeltek Pond (39˚ 55’ 26.45’’N, 36˚ 47’ 16.36’’E) is located in north of Sivas province, on the southern slopes of the mountain Çeltek. This pond has 2.58 hm3 of storage volume and 8.4 m of mean depth. While determining the sampling stations on the pond, we consider the points that represent characteristics of dam homogenously. 1st station was located at the exit point of Çeltek Pond (the deepest point of the dam),

2nd station at midpoint of the pond, and 3rd station at entrance point of Çeltek Pond (Figure 1).

This study was started in October 2014, samples used in analyses of some chemical and physical parameters constituting the water quality were monthly collected for 12 months from 3 stations, and the sampling was ended in September 2015. The sampling tubes to be used in water sampling were flushed, and then immersed into 15 cm below water surface for taking water sample.

Maintenance and cleaning of all the equipment to be used in field, field-type measurement devices, and glass sample tubes were completed 1day before sampling process. The sampling tubes were sunk into acid solution, and then they are washed with pure water and dried in drying oven. The water samples were taken by shaking the sampling tubes and sinking them into 15 cm depth of watersurface[9].The obtained water samples have been taken to the laboratory within maximum 2 days for analysis. Temperature, pH, salinity and electrical conductivity parameters were measured via field type devices in region. These parameters were measured via HACH LANGE brand HQ40D model digital two channel multiparameter.

Among other parameters of the water quality, the analyses of total alkalinity, total hardness, ammonium nitrogen, nitrate, nitrite, phosphate, sulfite, sulfate, potassium, chloride, sodium, suspended solid matter (SSM), chemical oxygen demand (COD), biological oxygen demand (BOD), calcium, magnesium, copper, zinc, ferrous, lead, nickel, mercury and cadmium of the water samples were performed in Kastamonu University Fisheries Faculty Laboratory in three days.

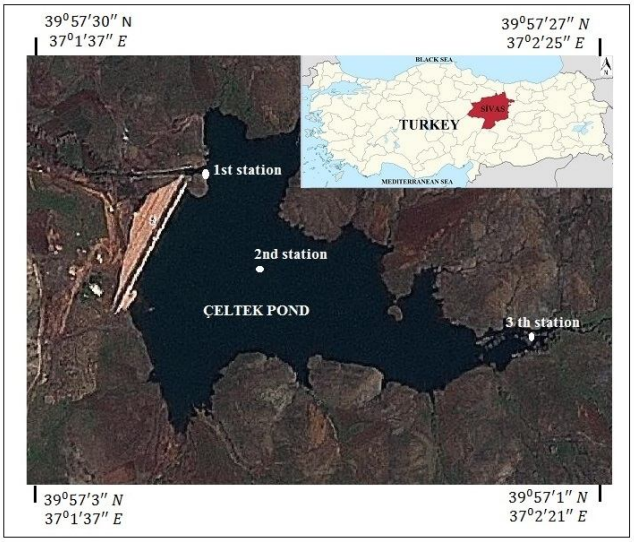

Fig. 1 — The location of sampling stations of Çeltek Pond

Titration with sulfuric acid (for total alkalinity) and titration with EDTA (for total hardness) were performed. The results are presented in mg/L CaCO3 unit. The level of biological oxygen was calculated via HACH LANGE brand BOD TRAK II type manometric measurement device. Chemical oxygen level was calculated through titration with ferrous ammonium sulfate based on determining the amount of oxygen being used while lysing the natural and organic pollutant load by using powerful chemical oxidants. The analyses of nitrite, nitrate, ammoniac, ammonium nitrogen (NH4+), chloride, phosphate, sulfate, sulfite, potassium, calcium, sodium and magnesium were conducted by using HACH LANGE brand DR 6000 laboratory type spectrophotometer. The analyses of the heavy metals such as lead, copper, ferrous and cadmium, mercury, nickel, and zinc of water samples were conducted using Shimadzu brand GCMS- QP2010 ULTRA type gas chromatography-Mass Spectrometry in laboratory. The analysis of Suspended Solid Matter (SSM) was conducted by filtering the water through Whatman brand 42 Nr 0.45 NM membrane filters, and then keeping filter papers at 103°C for 24 hours and calculating the weight difference[10].

Seasonal and annual mean values, standard deviations and graphics of each of the parameters were calculated by using Office Excel 2010 (Microsoft Office Professional Edition 2010). Pearson's correlation matrixes were created using a statistical package program (SPSS ver. 11.5) for the significance level of 0.01.

Results and Discussion

In this study, the water samples monthly collected from 3 stations for 12 months were analyzed from the aspects of physicochemical and heavy metal parameters. The physicochemical parameters and heavy metal concentrations by the seasons and stations are shown in the Table 1-4.

As shown in Table 1, the mean values of temperature exhibited non-significant variation between the stations. From the aspect of mean values, the lowest water temperature was found to be 7.74°C in winter season, while the highest water temperature was 23.56°C in autumn season (Table 2). Also, the annual mean temperature value was calculated to be 16.47°C. These results indicate that the temperature differences between the stations and the seasons were not at the level that can affect the aquatic life negatively.

Table 1 — The annual mean values of the physicochemical parameters by the stations

Physicochemical Parameters	Station 1	Station 2	Station 3	Annual Mean Value
Dissolved Oxygen (DO) (mg/L)	9.84±1.25	9.86±1.25	9.87±1.25	9.86±1.25
Salinity	0.11±0.040	0.10±0.036	0.09±0.036	0.10±0.037
pH	8.90±0.39	8.88±0.39	8.88±0.37	8.89±0.38
Temperature (˚C)	16.58±8.36	16.47±8.32	16.37±8.30	16.47±8.33
Electrical Conductivity (EC) (µs/cm)	277.85±47.37	275.35±47.39	273.72±47.06	275.64±47.26
Suspended Solids (SS) (mg/L)	6.24±2.12	6.24±1.89	6.19±1.86	6.22±1.95
Chemical Oxygen Demand (COD) (mg/L)	5.83±2.72	5.75±2.65	5.69±2.60	5.76±2.66
Biological Oxygen Demand (BOD) (mg/L)	1.42±0.51	1.37±0.50	1.34±0.49	1.38±0.50
Chloride (Cl^{-1}) (mg/L)	3.75±0.63	3.78±0.65	3.82±0.64	3.78±0.64
Phosphate (PO_4^{-3}) (mg/L)	0.056±0.012	0.053±0.012	0.051±0.011	0.053±0.012
Sulfate (SO_4^{-2}) (mg/L)	86.58±41.07	83.75±39.31	82.60±39.05	84.31±39.80
Sulfite (SO_3^{-2}) (mg/L)	4.64±1.20	4.57±1.20	4.54±1.20	4.58±1.20
Sodium (Na) (mg/L)	51.01±5.49	50.62±5.65	50.23±5.83	50.62±5.65
Potassium (K) (mg/L)	7.97±0.96	7.91±0.96	7.78±1.09	7.88±1.00
Total Hardness (TH) (mg/L)	377.83±34.45	375.54±33.51	373.95±33.46	375.77±33.80
Total Alkalinity (TA) (mg/L)	382.08±36.02	379.40±35.48	377.87±35.54	379.78±35.61
Magnesium (Mg^{++}) (mg/L)	69.60±13.55	68.81±13.41	66.22±16.06	68.21±14.15
Calcium (Ca^{++}) (mg/L)	73.13±14.23	72.42±14.09	71.38±14.34	72.31±14.21
Nitrite (NO_{2^-}) (mg/L)	0.003±0.002	0.003±0.002	0.003±0.002	0.003±0.002
Nitrate (NO_{3^-}) (mg/L)	4.68±1.95	4.57±1.96	4.52±1.93	4.59±1.94
Ammonium Nitrogen (AN) (mg/L)	0.0024±0.0020	0.0021±0.0018	0.0019±0.0017	0.0021±0.0018

Table 2 — The seasonal variations of the physicochemical parameters

Physicochemical parameters	Spring	Summer	Autumn	Winter
Dissolved Oxygen (DO) (mg/L)	11.00±0.070	9.89±1.47	8.27±0.51	10.27±0.42
Salinity	0.079±0.015	0.124±0.027	0.136±0.037	0.067±0.014
pH	8.58±0.14	8.97±0.16	9.38±0.33	8.62±0.17
Temperature (˚C)	11.20±3.34	23.38±5.07	23.56±5.68	7.74±3.06
Electrical Conductivity (EC) (µs/cm)	243.08±19.77	302.78±29.70	325.86±26.25	230.83±28.28
Suspended Solids (SS) (mg/L)	5.32±1.30	7.56±1.14	7.89±1.65	4.12±0.77
Chemical Oxygen Demand (COD) (mg/L)	4.34±0.24	6.70±2.60	8.50±2.75	3.48±1.05
Biological Oxygen Demand (BOD) (mg/L)	0.94±0.029	1.38±0.45	2.06±0.11	1.13±0.26
Chloride (Cl^{-1}) (mg/L)	4.32±0.47	4.02±0.96	3.23±0.20	3.55±0.06
Phosphate (PO_4^{-3}) (mg/L)	0.060±0.013	0.053±0.013	0.053±0.016	0.048±0.007
Sulfate (SO_4^{-2}) (mg/L)	58.66±17.83	102.26±20.22	130.28±25.74	46.03±21.98
Sulfite (SO_3^{-2}) (mg/L)	3.90±0.19	5.29±0.98	5.65±1.41	3.5±0.18
Sodium (Na) (mg/L)	55.65±2.63	54.11±5.09	43.69±3.10	49.04±1.20
Potassium (K) (mg/L)	7.95±0.87	9.02±1.08	7.32±0.18	7.24±0.72
Total Hardness (TH) (mg/L)	360.00±11.62	412.07±23.73	392.57±25.41	338.44±8.70
Total Alkalinity (TA) (mg/L)	363.88±13.21	418.50±26.92	396.20±25.52	340.55±9.14
Magnesium (Mg^{++}) (mg/L)	65.99±6.98	82.46±8.52	73.96±11.55	50.44±3.35
Calcium (Ca^{++}) (mg/L)	69.45±6.86	87.14±9.03	77.82±11.31	54.82±2.53
Nitrite (NO_{2^-}) (mg/L)	0.0020±0.0013	0.0050±0.0011	0.0043±0.0016	0.001±0.0004
Nitrate (NO_{3^-}) (mg/L)	3.23±0.32	5.31±1.62	6.89±1.48	2.93±0.47
Ammonium Nitrogen (AN) (mg/L)	0.0009±0.0002	0.0038±0.0023	0.0030±0.0017	0.0008±0.0003

Table 3 — The annual mean values of the heavy metal concentrations by the stations

Heavy Metal Concentrations (μg/L)	Station 1	Station 2	Station 3	Annual Mean Value (μg/L)
Fe	9±2	8±2	7±2	8±2
Pb	2.56±0.77	2.88±1.69	2.69±1.63	2.71±1.18
Cu	13.42±5.71	11.83±5.36	10.92±4.80	12.06±5.28
Cd	0.82±0.38	0.73±0.37	0.60±0.35	0.72±0.37
Hg	0.015±0.010	0.013±0.009	0.011±0.008	0.013±0.009
Ni	8.83±3.54	7.75±3.60	7.00±3.16	7.86±3.42
Zn	57.92±23.47	54.25±24.65	52.33±24.60	54.83±24.20

Table 4 — The seasonal variations of the heavy metal concentrations

Heavy Metal concentrations (μg/L)	Spring	Summer	Autumn	Winter
Fe	8±1	9±2	8±3	7±1
Pb	2.08±0.57	3.19±0.15	2.64±0.74	2.93±0.39
Cu	13.6±6.62	12.7±4.48	13.8±7.18	8.2±2.71
Cd	0.44±0.20	0.98±0.22	1.04±0.29	0.40±0.20
Hg	0.007±0.002	0.018±0.006	0.021±0.009	0.005±0.003
Ni	7.56±2.04	10.78±4.44	8.56±2.91	4.55±1.35
Zn	62.67±30.81	73.11±12.67	58.56±9.66	25.00±8.38

Alkalinity of water is a measure of its capacity to neutralize acids to a designated pH[4]. During this study, the lowest mean pH value was measured to be 8.88 in 2nd and 3rd station and the highest pH value was determined to be 8.90 in 1st station, while the annual mean pH mean of the pond was found to be 8.89 .These results indicate that no statistically significant change was observed in the mean pH values between the stations (Table 1). Also the seasonal mean values were calculated to be 8.58, 8.97, 9.38 and 8.62 for spring, summer, autumn and winter, respectively (Table 2). Alkalinity between 30 and 500 mg/ L is acceptable to fish production[11,12]. High alkalinity results in physiological stress on aquatic organisms, and it also may lead to the loss of biodiversity[13]. In the study area, total alkalinity (TA) results were changed from 377.87 to382.02 mg/L among the stations, and annual mean value was found to be379.78 mg/L. The maximum TA level was determined to be 418.50 mg/L in summer season. According to these results, it can be said that the Çeltek Pond is suitable for aquatic life.

Dissolved oxygen (DO) concentration is another parameter influencing the formation of a balanced fauna. DO is both important for the aquatic life and require for the biochemical oxidations. The lowest mean DO was measured at the station 1 as 9.84 mg/L, however, the highest dissolved oxygen was found to be 9.87 mg/L at station 3 (Table 1). In addition, for spring, summer, autumn and winter seasons, the mean values of DO were found to be 11.0, 9.89, 8.27 and 10.27, respectively (Table2). From the aspect of dissolved oxygen amount in Çeltek pond, the differences observed were statistically non-significant. In fresh waters, the dissolved oxygen shall be at least 5 mg/L for the healthy aquatic life[14]. The results obtained from this study indicate that the water of Çeltek Pond is suitable for aquaculture from the aspect of DO concentration, and it is in Class I in accordance with SWQMR[15].

Chemical Oxygen Demand (COD) is used for investigating the pollution level of waters[16]. COD levels of the waters higher than 25 mg/L indicate the pollution. Also, COD levels higher than 50 mg/L indicate the intense pollution and possible toxicity for aquatic organisms[17]. The COD values of the study area showed non-significant variation within the stations. While the minimum COD level was measured to be 5.69 mg/L in 3rd station, the maximum value was measured to be 5.83 mg/L in 1ststation. The annual mean value was calculated to be 5.76mg/L (Table 1). The seasonal changes of the mean COD values can be seen in Table 2. The maximum and minimum COD values were measured in autumn and winter seasons to be 8.50 mg/L and 3.48 mg/L, respectively. The mean COD values showed slight changes between seasons. These results showed that the Çeltek Pond is in Class I in terms of COD according to SWQMR[15].

The mean biological oxygen demand (BOD) values of the study area varied between 1.34 and 1.42 mg/L.

Values showed non-statistically significant variation within the stations (Table 1). In addition, among the seasonal variation of the mean BOD levels, the minimum and maximum values were found to be 0.94 and 2.06 mg/L for spring and autumn seasons, respectively (Table 2). Annual mean BOD value in Çeltek Pond was ascertained as 1.38 mg/L, and it is Class I according to SWQMR in terms of BOD[15].

Suspended solids (SS) affect aquaculture directly. High concentrations of suspended solids can impair water quality as a result of absorbing the light. Then, waters become warmer and the water's ability to hold oxygen, which is essential for aquatic life, decreases[4]. Mean suspended solid values varied from 6.19 to 6.24 mg/L between the stations, and the annual mean value was calculated to be 6.22 mg/L, which is about 1.6 times lower than the maximum acceptable level of 10 mg/L for SS in aquaculture[18]. Within the seasonal variation, the max mean value was found to be 7.89 mg/L in autumn season. Even this maximum value is about 1.3 times lower than the maximum acceptable level, which means that the conditions in the Çeltek Pond are suitable for aquaculture.

The sources of the nitrogen penetrating into the surface waters originate from natural, domestic and agricultural resources[19]. Nitrite (NO_2^-) sources in waters are the organic matters, nitrogenous fertilizers, and some of the minerals. Nitrite concentration higher than 1 mg/L in waters indicates the presence of pollution[20]. In Çeltek Pond, the annual mean value of NO_2^- was calculated to be 0.001 mg/L. Nitrogen derivatives of nitrite (NO_2^-), nitrate (NO_3^-) and ammonium nitrogen play important role in the water pollution process. Nitrate (NO_3^-) is the final product of nitrogenous organic matters. High concentration of nitrate in surface waters indicates that the water has been polluted before by the industrial and domestic waste waters containing ammonium and organic nitrogen and the fertilizers used in agricultural lands and containing nitrate[21]. It has been reported that fish mortality starts at 4 mg/L and higher doses[22]. The presence in surface waters is also an indicator of the pollution of those waters caused by domestic and industrial waste waters and the nitrogenous fertilizers[21]. Nitrate mean values of the study area varied from 4.52 to 4.68 mg/L, and the annual mean value was found to be 4.59 mg/L. The values show that the variation between the stations is statistically non-significant (Table 1). Also, among the seasonal variation of the mean NO_3^- levels, the minimum and maximum values were found to be 2.93 and 6.89 mg/L for winter and autumn seasons, respectively (Table 2). The mean ammonium nitrogen (AN) values of the Çeltek Pond varied from 0.0019 to 0.0024 mg/L, and the annual mean value was calculated to be 0.0021 mg/L. Among the seasonal variation of the mean AN levels, the minimum and maximum values were found to be 0.0008 and 0.0038 mg/L for winter and autumn seasons, respectively (Table 2). According to the SWQMR, the Pond has Class I water characteristic from the aspect of nitrate (NO_3^-) and ammonium nitrogen and Class II in terms of nitrite (NO_2^-)[15].

The phosphate in water resources is an element that is necessary for aquatic life[23]. The reason for fluctuation in phosphate level is the use of agricultural fertilizers containing phosphate. The phosphate level in the study area was determined to be very low. The phosphate level in lake was determined to be very low. The highest mean value was observed in spring season to be 0.060 mg/L, while the lowest mean value was determined in winter season to be 0.048 mg/L and annual mean was found to be 0.053 mg/L. The phosphate, one of the nutrient minerals affecting the productivity of aquatic life, showed increase in spring months. This phosphate concentration indicates that the water of Çeltek Pond is in Class II in accordance with SWQMR[15].

Among natural anions in the water, the presence of the sulfate (SO4) is important for the improved biological productivity[20]. Maximum limit for sulfate in water for aquatic products has been determined as 90 mg/L[24]. The sulfate value of Çeltek Pond showed insignificantly differences between stations. The maximum value was found as 86.58 mg/L in 1st station, while the minimum was observed as 82.60 mg/L in 3rd station and the annual mean value was determined as 84.31mg/L. The seasonal mean values of sulfate were 58.66 mg/L, 102.26 mg/L, 130.28 mg/L and 46.03 mg/L for spring, summer, autumn and winter, respectively (Table 2).

Besides the sulfate, the chloride level is an important indicator for the water quality. The highest mean chloride value was observed in spring season to be 4.32 mg/L, while the lowest level was recorded in autumn to be 3.23 mg/L. Annual mean value was determined to be 3.78 mg/L. In addition, the sulfite mean values varied from 4.54 to 4.64 mg/L between the stations and the annual mean value was calculated to be4.58 mg/L. Also, within the seasonal variation,

the max and min mean values were found to be5.65 mg/L and 3.5 mg/L in autumn and winter seasons, respectively (Table 2). As a result of these data, it can be said that the Çeltek Pond is suitable for aquaculture.

Ca^{++} and Mg^{++} are the most important dissolved solid matters and alkali soil minerals in fresh water[25]. The max recommended level of Ca^{++} is reported to be75 mg/L[26]. In this research, the annual mean calcium (Ca^{+}) level was found to be 72.31 mg/L. This calcium concentration indicates that the annual mean value of Ca^{++} in Çeltek Pond is near the acceptable limits. On the other hand, within the seasonal variation, the max mean value was found to be87.14 mg/L in summer season, and the min mean value was found to be 54.82 mg/L in winter season. This max value is about 1.2 times higher than the max acceptable level of Ca^{++}, while the min value is about 1.4 times lower than the acceptable level. The Ca^{++} mean values in study area showed significant variance between the seasons. The level of magnesium in normal waters should vary from 5 mg/L to 60 mg/L. In mildly hard waters, the values between 60 and 100 mg/L can be accepted as typical, and the recommended concentration of Mg^{++} is 50 mg/L[26]. In this research, the annual mean value was ascertained as 68.21 mg/L. The Mg^{++} mean values in Çeltek Pond showed non-significant variance between the stations (Table 1).

The concentration of sodium (Na) and potassium (K) vary within the ranges of 2-100 mg/L and1-10 mg/L in natural waters, respectively[27]. Annual mean potassium level in this study was 7.88 mg/L that can be considered to be within the normal ranges. But the annual mean level of sodium concentration was found to be 50.62 mg/L, which is about 5 times higher than the recommended max level of 10 mg/L in natural waters.

Figure 2 shows the distribution of some of the physicochemical parameters of the water samples in Çeltek Pond. Besides the physicochemical parameters, the heavy metal concentrations were examined in water samples taken from Çeltek Pond. The results are presented in Tables 3 and 4 by the stations and the seasons. In Table 3, it is seen that the presence of three essential micronutrients (Fe, Cu and Zn) was detected in samples. Mean concentrations were ranged 7-9, 10.92-13.42, and 52.33-57.92 µg/L for first, second and third stations, respectively. Annual mean values for these metals were found to be

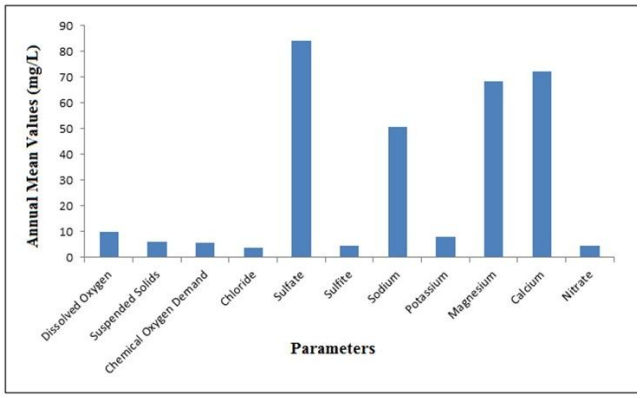

Fig. 2 — Distribution of the physicochemical parameters of the water samples in Çeltek Pond

8, 12.06 and 54.83 µg/L, respectively. Since the use of ferrous-containing agricultural pesticides for increasing the grain productivity of wheat plants increases especially between May and June, the ferrous-containing waters and particles can penetrate into the pond through the rain waters and the leakages. Mean concentration of ferrous in summer season was calculated to be 9 µg/L, and this value is higher than the calculated mean value of the other seasons. Annual mean concentration of the copper (Cu) was found to be 12.06 µg/L. Mean concentrations of copper in spring and autumn seasons are 13.6 and 13.8 µg/L, and these values are higher than the calculated mean value of the summer and winter seasons. The reason for this level is believed to be the penetration of copper, which accumulate in the soil due to common use of copper vitriol during maintenance and pruning in fruit gardens, into the pond via the rain waters. Maximum annual mean concentration of Zinc (Zn) was found to be 357.92 µg/L in 1st station. Also, for overall stations, the annual mean value was found to be54.83 µg/L. In summer season, the mean concentration of Zn is higher than the other seasons to be 73.11 µg/L. It can be concluded that the Çeltek Pond has Class I water characteristic in terms of copper (Cu) and zinc (Zn), according to SWQMR[15].

Besides the three essential micronutrients, the presence of four toxic heavy metals (Pb, Cd, Hg and Ni) was detected in the range of 2.56-2.88, 0.60-0.82, 0.011-0,015 and 7.0-8.83 µg/L between the stations. Annual mean values were found to be of 2.71, 0.72, 0.013 and 7.86 µg/L, respectively (Table 3). Seasonal mean concentrations of these heavy metals in the water samples collected from Çeltek Pond were observed to be 2.08, 0.44, 0.007 and 7.56 µg/L for the

Table 5 — Pearson correlation coefficient among the physicochemical parameters and metal concentrations in Çeltek Pond

	DO	Sal.	pH	Temp.	EC	SS	COD	BOD	PO_4^{-3}	SO_4^{-2}	SO_3^{-2}	TH	NO_2^-	NO_3^-	AN
Fe	0,250	-0,074	0,120	0,094	0,086	0,083	-0,280	-0,028	0,862	0,147	-0,162	0,077	0,110	-0,073	-0,208
Pb	-0,127	0,276	0,092	0,209	0,162	0,216	0,046	0,049	-0,144	0,112	0,235	0,188	0,266	0,156	0,280
Cu	0,119	0,009	0,186	0,119	0,161	0,140	-0,190	0,077	0,873	0,233	-0,117	0,049	0,128	0,018	-0,218
Cd	-0,751	0,977	0,815	0,979	0,972	0,958	0,851	0,771	-0,160	0,923	0,926	0,910	0,948	0,906	0,891
Hg	-0,789	0,990	0,801	0,964	0,957	0,946	0,934	0,762	-0,333	0,900	0,966	0,915	0,926	0,932	0,921
Ni	0,111	0,215	0,279	0,355	0,323	0,344	-0,015	0,069	0,710	0,353	0,113	0,353	0,383	0,157	0,033
Zn	0,004	0,487	0,396	0,576	0,509	0,644	0,279	0,124	0,615	0,528	0,419	0,610	0,656	0,361	0,317

Correlation is significant at the 0.01level (2-tailed).

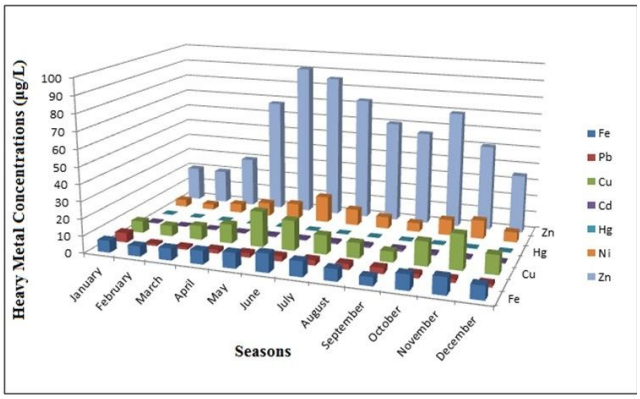

Fig. 3 — Seasonal variations of the heavy metals in Çeltek Pond

spring season, 3.19, 0.98, 0.018 and 10.78 µg/L for the summer season, 2.64, 1.04, 0.021 and 8.56 µg/L for the autumn season and 2.93, 0.40, 0.005 and 4.55 µg/L for the winter season, respectively (Table 4). The seasonal variations of the heavy metals in Çeltek Pond are presented Figure 3. The lead (Pb) concentration of 0.01 mg/L and higher are considered to be an indicator of polluted water. Although the presence of cadmium (Cd) in waters at the concentration of 5 µg/L and higher has been reported to be toxic, and it directly leads to mortality in aquatic organisms[28]. Annual mean levels of lead (Pb) and cadmium (Cd) in Çeltek Pond were found to be 2.71 µg/L and 0.72 µg/L, respectively. These levels of Cd and Pb can be attributed to the use of artificial phosphate fertilizers for the agricultural purposes around the pond. Also the mercury (Hg) concentration may be caused from the flows from cultivation areas into the pond, since the use of fertilizers is very common around the studied area. Also, the correlation coefficients among the physicochemical parameters and metal concentrations in Çeltek Pond are given in Table 5. The Pearson correlation test yielded a significant correlation between Cd, Hg and the physicochemical parameters except DO and PO_4^{-3} for the studied Pond water. According to these findings, it is said that the studied surface water has Class I water characteristics from the aspect of lead (Pb), cadmium (Cd), mercury (Hg) and nickel (Ni) elements according to SWQMR[15].

Conclusion

In this research, the physicochemical parameters and the heavy metal concentrations in water samples collected from the Çeltek Pond were determined. It is known that the heavy metals constitute an important pollutant group. These pollutants accumulate within the bodies of living organisms, and also they have significant toxic and carcinogenic effects. As it can be seen in results of the analyses, the water quality in Çeltek Pond is considered to be Class I according to SWQMR. In order to protect the water quality and to ensure the health of aquatic life in this pond, it is required to make regular observations and to monitor the parameters affecting the water quality and aquatic life.

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