Technical Note

Parameter Selection for Chemical Monitoring of Sediment in Lake Beysehir

Beyşehir Gölü Sedimanında Kimyasal İzleme Parametrelerinin Seçimi

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Abstract

Sediment plays a crucial role in water quality management. It acts as a potential sink for hydrophobic substances that cannot dissolve in water. With the emission of these substances to water body from the sediment, water quality can deteriorate. Since by monitoring only in the water column, it is impossible to detect these hydrophobic substances, chemical monitoring of sediment should also be conducted for water quality management Moreover, sediment monitoring provides information about historic contamination by vertical samplin of sediment. Thus, for the water bodies that have no historical water quality data, information about historical contamination can be gained. Also, the Water Framework Directive (WFD) states that environmental quality standards should be set for sediment and with the perspective of the WFD, basin based sediment management should be started. This study aimed to select the parameters that should be monitored in the sediment in Lake Beysehir. For this purpose, specific pollutants that can originate from industries around Beysehir were selected. Also, pesticides specific to the plants cultivated in Konya Basin were identified. Between these pollutants the ones that have the tendency to accumulate in the sediment were identified. The priority substances were also studied and the list of chemicals that should be monitored in the sediment was determined.

Keywords: *Sediment, chemical monitoring, Octanol-Water Partition Coefficient, Water Framework Directive*

Öz

Sediment su kalitesi yönetimi konusunda önemli bir role sahiptir. Sediment, suda çözünemeyen hidrofobik maddelerin çökelebileceği zemin görevi görmektedir. Sedimentte biriken maddelerin zaman içerisinde sedimentten su kütlesine geçişi ile birlikte su kalitesi bozulmaya uğrayabilir. Sadece su kolonunda yapılan izleme çalışmaları ile bu maddelerin tespit edilmesi mümkün olmadığından, su kalitesi yönetimi için sedimentte kimyasal maddelerin izleme çalışmaları yapılmalıdır. Ayrıca, sedimentte yapılan dikey örnekleme ile geçmişteki kirlenme hakkında bilgi sahibi olunabilmektedir. Böylelikle, geçmişe dönük su kalitesi verisi olmayan su kütlelerinde geçmişteki kirlenme hakkında bilgi edinilebilir. Ayrıca, Su Çerçeve Direktifi (SÇD), sediment için çevresel kalite standartlarının belirlenmesi gerektiğini ve havza bazlı sediment yönetiminin başlatılması gerektiğini belirtmektedir. Bu çalışma Beyşehir Gölünde sedimentte izlenmesi gereken kimyasal maddelerin seçilmesini hedeflemiştir. Bu amaç doğrultusunda, Beysehir Gölü etrafında yer alan endüstriyel tesislerden kaynaklanabilecek belirli kirleticiler ve Konya havzasında yetiştirilen bitkilere özgü pestisitler seçilmiştir. Bu kirleticiler arasından sedimentte birikme potansiyeli olanlar belirlenmiştir. Ayrıca öncelikli maddeler de çalışılarak, sedimentte izlenmesi gereken kimyasalların listesi oluşturulmuştur.

Anahtar kelimeler: *Sediman, kimyasal izleme, Oktanol-Su Ayrışım Katsayısı, Su Çerçeve Direktifi*

Introduction

In recent years, as a result of increase in population and in the number of industrial facilities, the amount of pollutants that are released to the environment is dramatically increased. Direct or indirect release of these substances into the environment causes the balance of nature to be disrupted. Additional to this disruption, reaching of these pollutants into the aquatic environment has raised the issue of water pollution. To have a solid grasp of the situation, monitoring, just only in water matrix is not sufficient for the integrated and comprehensive water quality management.

The pollutants released into the river bed have the potential of accumulation in the sediment. Especially, the hydrophobic pollutants that cannot dissolve in water precipitate in the sediment and, therefore, these hydrophobic pollutants cannot be detected by monitoring only in water matrix. In addition, no matter how much water quality is improved, the pollutants in the sediment have the potential to transport again into water matrix over time by causing water quality to deteriorate again. Moreover, for comprehensive and efficient water quality management, both present situation and historic contamination should be considered for establishing better programs of measures (Chapman, 1996). By performing vertical sampling in the sediment, it is possible to gain information about historical contamination. Thus, when dealing with water quality issues, it is crucial to evaluate the water column and the sediment in an integrated manner.

Despite being an integrated part of rivers and lakes and its importance in water quality, sediment does not significantly take place in the European Union Water Framework Directive. The WFD refers to the sediment mostly in the definitions and these definitions are mainly about water quality issues. The attributes to sediment in the WFD are as follows;

- In Article 2, Definitions, the definition of environmental quality standard (EQS) is; "the concentration of a particular pollutant or group of pollutants in water, sediment or biota which should not be exceeded in order to protect human health and the environment."

- In Article 16, Strategies against pollution of water; "The Commission shall submit proposals for quality standards applicable to the concentrations of the priority substances in surface water, sediments or biota."

- In Annex V, it is stated that "In deriving environmental quality standards for pollutants listed in points 1 to 9 of Annex VIII of WFD for the protection of aquatic biota, Member States shall act in accordance with the following provisions. Standards may be set for water, sediment or biota," (EC, 2000)

Apparently, the WFD mostly addresses to the sediment in EQS and it clearly states that EQS should be set for water, sediment or biota. Nevertheless, after the WFD has entered into force, a new perspective arose for the sediment. Instead of local sediment monitoring activities, basin based sediment management has started. Also, the European Sediment Network (SedNet) emphasizes that sediment should also take place in river basin management plans for sustainable sediment management. Therefore, it is crucial to integrate sediment monitoring activities in river basin monitoring programs (Brills, 2008).

Sediment monitoring frequency is not clearly specified in the WFD itself. However, according to 2013/39/EU Directive, it is said that for compliance with EQS, the monitoring should be conducted at least once a year (EU, 2013). This frequency for sediment can be changed due to the sedimentation rate and the hydrological regime in the water body. Also, for dynamic water bodies, the frequency of monitoring can be more than once a year (EC, 2010).

The time for the sediment monitoring should be set at the season when the sedimentation rate is maximum. Since the sedimentation rate is maximum when the flow rate of the water is slow, the sampling should be conducted in the summer season.

In Turkey, the studies on water quality monitoring are mainly carried out by some public institutions and organizations. However, except some research studies, chemical monitoring of sediment does not take place in water quality monitoring activities. Moreover, in most of these studies, the parameters monitored in the sediment are only heavy metals. However, monitoring of heavy metals in the sediment is not sufficient since hydrophobic substances can also precipitate and sink in sediment and those should be taken into account as well. These substances can be in lower concentrations in water matrix whereas they can be in higher concentration in sediment matrix, therefore; parameters that to be monitored in the sediment should be selected carefully considering their hydrophobicity.

The most fundamental criteria for the selection of chemical substances to be monitored in the sediment is the solubility of a substance in the water. As the substance become more hydrophobic, its tendency to accumulate in the sediment increases (Brils, 2008).

The hydrophobicity of a chemical substance can be determined by using Octanol-Water Partition Coefficient (K_{ow}). K_{ow} is defined as the parameter that states the solution ratio of a chemical substance in an organic or inorganic phase. For the selection of chemical substances that will be monitored in the sediment, the octanol-water partition coefficient is used. In principle, chemical substances that has log K_{ow} higher than 5, have a higher tendency to accumulate in the sediment. Therefore, these substances should be monitored in the sediment (AMPS, 2004). On the other hand, for chemical substances that has log K_{ow} higher than 3 and below 5, monitoring matrix is optional and it can be chosen as sediment or suspended material. The matrix selection for these chemical substances is due to the contamination of particular matrix (EC, 2010).

$$Kow = \frac{Coktanol}{Cwater} \quad \text{[EC, 2010]}$$

For the determination of chemical parameters to be monitored in Lake Beysehir, octanol-water partition coefficient is used and the substances that have the values of log K_{ow}>5 are chosen. Since chemical parameters that have log K_{ow} higher than 3 and below 5 is optional for sediment matrix and when the difficulties in analyses of these parameters for sediment is considered, for Beysehir Lake, chemical parameters that have log K_{ow} value higher than 5 is chosen.

For the metals, K_{ow} cannot be used as a criteria for the selection of those to be monitored in the sediment. When the behaviour of metals in the water is investigated, it is found that heavy metals are highly hydrophobic and they cannot be acquired in the water matrix in most of the water quality monitoring activities. Therefore, since heavy metals are very toxic and they have the high tendency to be adsorbed in the sediment, they should definitely be selected to be monitored in the sediment.

Another important issue that should be considered for the selection of metals to be monitored in the sediment is the metal concentration in the natural structure of sediment, in other words, the background concentration of the metals in the sediment. If natural background concentration of a parameter is high, it is impossible to distinguish whether the concentration of the parameter is due to the nature of the sediment or due to the contamination of the sediment.

Similar to the selection of water quality monitoring points in the water bodies, selected monitoring points should be representative of a water body for sediment monitoring. Also, the point sources are very important for the determination of location in the sediment monitoring. Generally, monitoring points should be selected downstream of an industry to analyze the contamination (EC, 2010). Especially, if it is known that there was a point source in a certain area in the past, this area should be considered as a location for sediment monitoring to detect the historic contamination.

Method

Study Area

The Konya Basin is the third largest basin of Turkey, located in the central Anatolia of Turkey. The main pressures on the basin for water quality are agriculture and livestock, and the industries in the basin are mainly metal and automotive based. Other industries are food, chemistry, textile, paper and extractive industry. The basin has a water shortage problem due to low precipitation and overexploitation of water resources.

In this study, Lake Beysehir located in Konya Basin of Turkey was selected as a pilot area by considering the industries and the agricultural activities around the lake. For this study, the pressures on the lake were investigated and it was found that there is an organized industrial zone next to the lake. The main industries in the industrial zone are machine manufacturing, automotive, weapon manufacture and chrome plating that can be seen in Figure 1. Also, there is a sugar refinery close to the lake. This factory is also considered as a pressure to the lake since its discharges can reach to the lake via the tributaries (MoFWA,2013). When the pressures on the lake and the parameters that are discharged from the industries are considered, it is possible to have contaminated sediment at the bottom of the lake. Therefore, no matter how much precaution is taken for the lake in these circumstances, sufficient water quality is not likely to be provided unless the pollution in the bottom sediment is prevented. Therefore, it is important to plan monitoring activities for the sediment in Lake Beysehir.

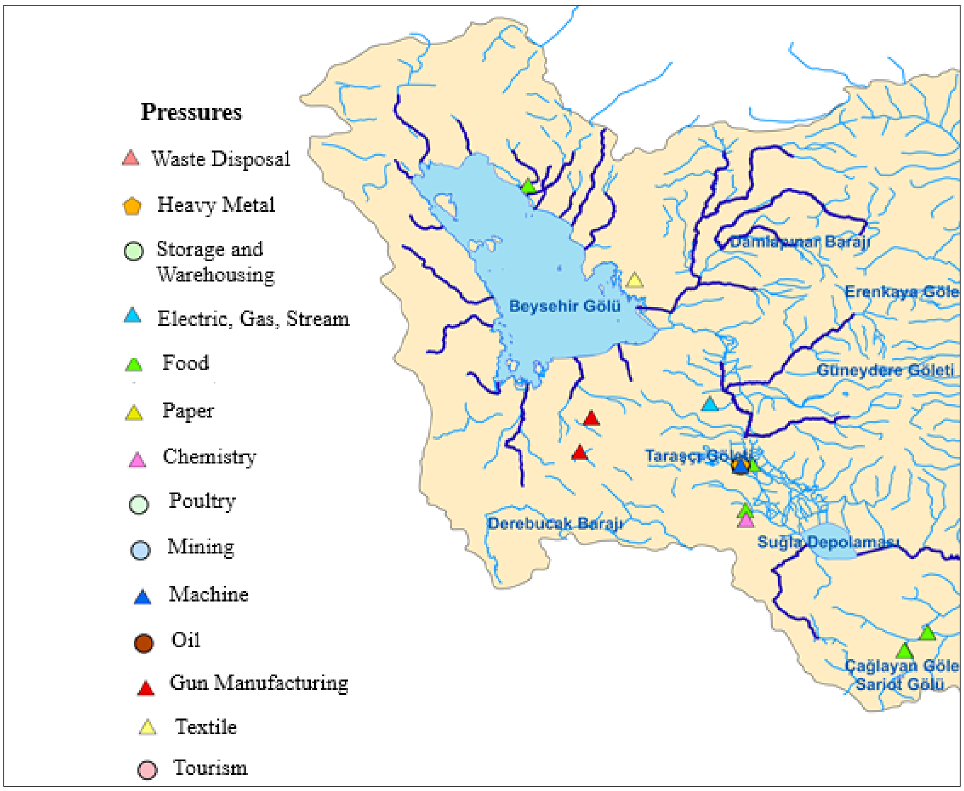

Figure 1. Beysehir Lake and the pressures around it.

Selection of Monitoring Parameters

Parameters to be monitored in the sediment for this lake were selected by using octanol-water partition coefficient for determination of hydrophobic properties of pollutants and by considering the previous monitoring activities conducted in water matrix of the lake.

In 2014, the chemical monitoring of the sediment was carried out in the Konya Basin as a part of the project called "Basin Monitoring and Determination of Reference Points" and the sampling was conducted for four times within a year in Lake Beysehir. However, in this study, the parameters monitored were only heavy metals and the monitoring results are given in Table 1.

Table 1

Results of Heavy Metals Concentration in The Sediment Of Lake Beysehir (Mofwa, 2014)

Sampling Date		28.01.2014	26.05.2014	05.07.2014	22.09.2014	Average
Parameter	Unit					
Aluminium (Al)	mg/kg	2755	4025	11598	2975	5338.2
Copper (Cu)	mg/kg	10.75	8.5	22.3	27.5	17.26
Zinc (Zn)	mg/kg	17.5	18.25	54	47.5	34.31
Chromium (Cr)	mg/kg	37.75	8.5	42	13	25.31
Cadmium (Cd)	mg/kg	<0.25	<0.25	<0.25	<0.25	<0.25
Mercury (Hg)	mg/kg	<0.25	<0.25	<0.25	<0.25	<0.25
Lead (Pb)	mg/kg	7.25	5.75	13.3	9	8.82
Arsenic (As)	mg/kg	3.25	1.3	4.25	3.5	3.07

As can be seen in Table 1, the aluminium concentration is very high compared to the other metals. However, this high concentration can be due to background concentration of sediment. Therefore, in this case, aluminium should not be selected as a monitoring par

In this project, together with sediment sampling, the monitoring in the water matrix in Lake Beysehir has been conducted and the monitoring results for heavy metals and priority substances are presented in Table 2 and Table 3.

When the monitoring results of heavy metals in the sediment and in the water column are compared, heavy metal concentration is lower in the water column while the heavy metal concentration in the sediment is considerably higher. For instance, average concentration of zinc in water column is 5.46 µg/L in water column, whereas its concentration in the sediment is 34.31 mg/kg. When the water quality is investigated, this amount of zinc corresponds to Class I, which is defined as very good quality in terms of physicochemical parameters, however, when the concentration in sediment is considered, this concentration is quite high. Therefore, it can be concluded that it is not possible to determine the heavy metal contamination just by monitoring water matrix. On the other hand, when the results of priority substances presented in Table 3 are investigated, it is obvious that most of the results are found below the environmental quality standards, in other words "passed". However, since there is hydrophobic chemicals among priority substances, their concentrations are expected to be higher in the sediment.

Table 2

Monitoring Results of Heavy Metals in Water Matrix of Beysehir Lake (Mofwa, 2014)

Parameter	CAS No	LOQ (µg/L)	Unit		1st Period 28.01.2014 (µg/L)	2nd Period 26.05.2014 (µg/L)	3rd Period 05.07.2014 (µg/L)	4th Period 22.09.2014 (µg/L)	Average concentration (µg/L)	Class I Boundry	Class II Boundry	Class III Boundry	Class IV Boundry	Quality Class of the sample
Mercury (Hg)	743 9-97-6	0.002	µg/L	Surface	0.155	<0.002	<0.002	0.161	0.043	<0.1	0.1-0.5	0.5-2.0	>2	Class I
				Middle	0.081	<0.002	0.00327	0.05						
				Bottom	0.007	<0.002	0.00334	<0.002						
Cadmium (Cd)	744 0-43-9	0.002-0.04	µg/L	Surface	<0.04	<0.04	<0.04	<0.04	0.02	≤ 2	2.5	5-7	>7	Class I
				Middle	<0.04	<0.04	<0.04	<0.04						
				Bottom	<0.04	<0.04	<0.04	<0.04						
Lead (Pb)	743 9-92-1	0.01-0.1	µg/L	Surface	0.719	<0.1	0.171	11.1	1.217	≤ 10	10-20	20-50	>50	Class I
				Middle	0.359	<0.1	0.192	1.27						
				Bottom	<0.1	<0.1	0.456	0.147						
Cupper (Cu)	744 0-50-8	0.01-0.1	µg/L	Surface	1.38	0.489	0.611	7.27	1.624	≤ 20	20-50	50-200	>200	Class I
				Middle	0.92	0.4115	2.47	1.5						
				Bottom	0.457	0.334	3.14	0.501						
Nickel (Ni)	744 0-02-0	0.05-0.3	µg/L	Surface	3.13	1.52	1.42	7.89	2.94	≤ 20	20-50	50-200	>200	Class I
				Middle	2.07	1.1295	1.1	12.2						
				Bottom	1.01	0.739	1.78	1.29						
Zinc (Zn)	744 0-66-6	0.2-2	µg/L	Surface	13.9	<2	<2	22.1	5.46	≤ 200	200-500	500-2000	>2000	Class I
				Middle	6.95	<2	<2	13.2						
				Bottom	<2.0	<2	2.41	<2						

Table 3

Monitoring Results of Priority Substances in Beysehir Lake in Water Matrix (MoFWA, 2014)

Parameter	CAS No	1st Period 28.01.2014	2nd Period 26.05.2014	3rd Period 05.07.2014	4th Period 22.09.2014	Average concentration (µg/L)	AA-EQS (µg/L)	Evaluation of the sample (Passed or Failed)
Fluoranthene	206-44-0	<0.01	<0.01	<0.01	<0.01	0.005	0.0063	Passed
Alachlor	15972-60-8	<0.02	<0.02	<0.02	<0.02	<0.02	0.3	Passed
Anthracene	120-12-7	<0.01	<0.01	<0.01	<0.01	<0.01	0.1	Passed
Atrazine	1912-24-9	<0.02	<0.02	<0.02	<0.02	<0.02	0.6	Passed
Benzene	71-43-2	<0.1	0.11	<0.1	<0.1	0.065	10	Passed
Brominated diphenylethers	not applicable	<0.031	<0.031	<0.031	<0.031	<0.031	-	-
Cadmium and its compounds	7440-43-9	<0.04	<0.04	<0.04	<0.04	<0.04	-	-
Carbon-tetrachloride	56-23-5	<0.1	<0.1	<0.1	<0.1	<0.1	12	Passed
Chloroalkanes, C10-13	85535-84-8	<0.2	<0.2	<0.2	<0.2	<0.2	0.4	Passed
Chlorfenvinphos	470-90-6	<0.02	<0.02	<0.02	<0.02	<0.02	0.1	Passed
Chlorpyrifos (Chlorpyrifos-ethyl)	2921-88-2	<0.012	<0.012	<0.012	<0.012	<0.012	0.03	Passed
Aldrin	309-00-2	<0.02	<0.02	<0.02	<0.02	<0.02	Σ=0.01	-
Dieldrin	60-57-1	<0.02	<0.02	<0.02	<0.02	<0.02		-
Endrin	72-20-8	<0.02	<0.02	<0.02	<0.02	<0.02		-
Isodrin	465-73-6	<0.02	<0.02	<0.02	<0.02	<0.02		-
Total DDT	not applicable	<0.02	<0.02	<0.02	<0.02	<0.02	0.025	Passed
4,4' - DDT (p,p'-DDT)	50-29-3	<0.02	<0.02	<0.02	<0.02	0.01	0.01	Passed
1,2-dichloroethane	107-06-2	<0.1	<0.1	<0.1	<0.1	<0.1	10	Passed
Dichloromethane	75-09-2	<0.1	1.925	0.31	<0.1	0.58	20	Passed
Di(2-ethylhexyl)phthalate (DEHP)	117-81-7	0.17	<0.1	<0.1	0.08	0.087	1.3	Passed
Diuron	330-54-1	<0.04	<0.04	<0.04	<0.04	<0.04	0.2	Passed
Endosulfan	115-29-7	<0.02	<0.02	<0.02	<0.02	<0.02	0.005	-
Hexachlorobenzene	118-74-1	<0.02	<0.02	<0.02	<0.02	<0.02	-	-
Hexachlorobutadiene	87-68-3	<0.1	<0.1	<0.1	<0.1	<0.1	-	-
Hexachlorocyclohexane	608-73-1	<0.02	<0.02	<0.02	<0.02	<0.02	0.02	Passed

Parameter	CAS No	1st Period 28.01.2014	2nd Period 26.05.2014	3rd Period 05.07.2014	4th Period 22.09.2014	Average concentration (µg/L)	AA-EQS (µg/L)	Evaluation of the sample (Passed or Failed)
Isoproturon	34123-59-6	<0.04	<0.04	<0.04	<0.04	<0.04	0.3	Passed
Lead and its compounds	7439-92-1	0.376	<0.1	0.273	4.17	1.22	1.2	Failed
Mercury and its compounds	7439-97-6	0.081	<0.002	0.0025	0.0388	0.031	-	-
Naphthalene	91-20-3	<0.1	<0.1	0.071	<0.1	0.055	2	Passed
Nickel and its compounds	7440-02-0	2.07	1.13	1.43	7.12	2.94	4	Passed
Nonylphenols	not applicable	0.576	<0.05	0.487	0.485	0.393	0.3	Failed
Octylphenols	not applicable	<0.05	<0.05	<0.05	<0.05	<0.05	0.1	Passed
Pentachlorobenzene	608-93-5	<0.02	<0.02	<0.02	<0.02	<0.02	0.007	-
Pentachlorophenol	87-86-5	<0.1	<0.1	<0.1	<0.1	<0.1	0.4	Passed
Benzo(a)pyrene	50-32-8	<0.01	<0.01	<0.01	<0.01	<0.01	0.00017	-
Benzo(b)fluoranthene	205-99-2	<0.01	<0.01	<0.01	<0.01	<0.01	-	-
Benzo(k)fluoranthene	207-08-9	<0.01	<0.01	<0.01	<0.01	<0.01	-	-
Benzo(g,h,i)perylene	191-24-2	<0.01	<0.01	<0.01	<0.01	<0.01	-	-
Indeno(1,2,3-cd)pyrene	193-39-5	<0.01	<0.01	<0.01	<0.01	<0.01	-	-
Simazine	122-34-9	<0.02	<0.02	<0.02	<0.02	<0.02	1	Passed
Tetrachloroethylene	127-18-4	<0.1	<0.1	<0.1	<0.1	<0.1	10	Passed
Trichloroethylene	79-01-6	<0.1	<0.1	<0.1	<0.1	<0.1	10	Passed
Trichlorobenzenes	12002-48-1	<0.1	<0.1	<0.1	<0.1	<0.1	0.4	Passed
Trichloromethane	67-66-3	<0.1	7.86	1.35	<0.1	2.33	2.5	Passed
Trifluralin	1582-09-8	<0.02	<0.02	<0.02	<0.02	<0.02	0.03	Passed
Dicofol	115-32-2	<0.0033	<0.0033	<0.0033	<0.0033	<0.0033	0.0013	-
Perfluorooctane sulfonic acid and its derivatives (PFOS)	1763-23-1	<0.05	<0.05	<0.05	<0.05	<0.05	0.00065	-
Quinoxyfen	124495-18-7	<0.04	<0.04	<0.04	<0.04	<0.04	0.15	Passed
Dioxins and dioxin-like compounds (PCDD,PCDF)	not applicable	n.d.	n.d.	n.d.	n.d.	n.d.	-	-
Aclonifen	74070-46-5	<0.04	<0.04	<0.04	<0.04	<0.04	0.12	Passed
Bifenox	42576-02-3	<0.04	<0.04	<0.04	<0.04	<0.04	0.012	Passed

Parameter	CAS No	1st Period 28.01.2014	2nd Period 26.05.2014	3rd Period 05.07.2014	4th Period 22.09.2014	Average concentration (µg/L)	AA-EQS (µg/L)	Evaluation of the sample (Passed or Failed)
Cybutryne	28159-98-0	<0.04	<0.04	<0.04	<0.04	<0.04	0.0025	Passed
Cypermethrin	52315-07-8	<0.02	<0.02	<0.02	<0.02	<0.02	0.00008	Passed
Dichlorvos	62-73-7	<0.02	<0.02	<0.02	<0.02	<0.02	0.0006	Passed
Hexabromocyclododecane (HBCDD)		<0.05	<0.05	<0.05	<0.05	<0.05	0.0016	Passed
Heptachlor	76-44-8	<0.02	<0.02	<0.02	<0.02	<0.02	0.0000002	-
Terbutryn	886-50-0	<0.04	<0.04	<0.04	<0.04	<0.04	0.065	-

Note.AA=Anual Average, *n.d*=not detected.

Results

In Turkey, the specific pollutants were identified by conducting projects on hazardous chemical substances named Project on Control of Hazardous Substances Pollution, Project on the Determination of Hazardous Substances in Coastal and Transitional Waters of Turkey and Ecological Coastal Dynamics and Project on the Determination of the Water Pollution Caused by Use of Plant Protection Products and Identification of Environmental Quality Standards for Substance or Substance Groups. As a result of these projects, 117 specific pollutants and 133 pesticides are determined as specific pollutants in the surface waters in Turkey.

In this study, priority substances and specific pollutants including pesticides determined with these projects were studied and the parameters that should be monitored in the sediment matrix of Lake Beysehir were investigated. In Tables 4 and 5, the parameters that have log K_{ow} higher than 5 are shown. Since these parameters have the tendency to accumulate in the sediment, they should be monitored in sediment matrix together with water matrix.

Table 4

Priority Substances Which Have Log K_{ow} > 5

	Priority Substance	CAS No	Log K_{ow} (USEPA, 2018)
1	Cadmium and its compounds	7440-43-9	Heavy Metal*
2	Di(2-ethylhexyl)phthalate (DEHP)	117-81-7	7.60
3	Fluoranthene	206-44-0	5.16
4	Hexachlorobenzene	118-74-1	5.73
5	Lead and its compounds	7439-92-1	Heavy Metal*
6	Mercury and its compounds	7439-97-6	Heavy Metal*
7	Pentachlorobenzene	608-93-5	5.17
8	Polyaromatic hydrocarbons (PAH)	not applicable	6.44
9	Dicofol	115-32-2	5.02
10	Perfluorooctane sulfonic acid and its derivatives (PFOS)	1763-23-1	6.28
11	Dioxins and dioxin-like compounds	not applicable	6.80
12	Heptachlor and heptachlor epoxide	76-44-8/1024-57-3	6.10/ 4.98
13	Nickel	7440-02-0	Heavy Metal*
14	Trifluralin	1582-09-08	5.3
15	Brominated diphenyl ethers	not applicable	6.6
16	Chloroalkanes, C10-13	85535-84-8	4.4-8.7
17	Nonylphenols	not applicable	5.5
18	Octylphenols	not applicable	5.3

Note.*log Kow is used for organic compounds to determine hidrophobic character of compound. For heavy metals, log Kow is not used; however, heavy metals are hydrophobic and they have high tendecy to accumulate in sediment; therefore, they are selected without using log Kow value.

Table 4 and Table 5 shows that monitoring of only heavy metals in sediment is not sufficient to ensure adequate prevention of sediment contamination since there are other parameters that have the high potential to sink in sediment. According to hyrophobic charateristic properties of parameters, 18 priority substances and 16 specific pollutants should be monitored in sediment matrix.

Furthermore, when the area around Lake Beysehir is studied, agriculture activities are found to be the main pressures around the lake. Therefore, pesticides which indicate hydrophobic features, are specific to the basin, listed in Table 6, and should also be monitored.

Table 5

Specific Pollutants That are Possible to Discharge from The İndustries Near Lake Beysehir

	Parameter	CAS No	Log K_{ow} (USEPA, 2018)	Monitoring parameters chosen for Sediment Matrix
1	1,1-Dikloroetan	7534-3	1,79	
2	1,2,4-trimetilbenzen	95-63-6	3,63	
3	Aluminium	7429-90-5	Heavy metal*	x
4	Antimon	7440-36-0	Heavy metal*	x
5	Acenaphthene	83-32-9	3,92	
6	Cupper	7440-50-8	Heavy metal*	x
7	Barium	7440-39-3	Heavy metal*	x
8	Benzyl butyl phthalate (BBP)	85-68-7	4,73	
9	Benzo[a]fluorene	238-84-6	5,4	x
10	Berilyum	7440-41-7	Heavy metal*	x
11	Boron	7440-42-8	Heavy metal*	x
12	Zinc	7440-66-6	Heavy metal*	x
13	Iron	7439-89-6	Heavy metal*	x
14	dibutyltin oxide	818-08-6	5,33	x
15	Diphenyl ethere	101-84-8	4,21	
16	Free Cyanide	57-12-5	-0.182	
17	Phenanthrene	85-01-8	4,46	
18	Fluorene	86-73-7	4,18	
19	Silver	7440-22-4	Heavy metal*	x
20	Tin	7440-31-5	Heavy metal*	x

21	Cobalt	7440-48-4	Heavy metal*	x
22	Chrysene	218-01-9	5.46	x
23	Chromium	7440-47-3	Heavy metal*	x
24	n-Butyltin trichloride	1118-46-3	0,18	
25	Pyrene	129-00-0	4,88	
26	Polycyclic aromatic hydrocarbons	-		
27	Titanyum	7440-32-6	Heavy metal*	x
28	Trichloroethylene (TRI)	79-01-6	2,42	

Note. *log Kow is used for organic compounds to determine hidrophobic character of compound. For heavy metals, log Kow is not used; however, heavy metals are hydrophobic and they have high tendecy to accumulate in sediment; therefore, they are selected without using log Kow value.

Table 6

Hydrophobic Pesticides Specific to Konya Basin

	Pesticides	CAS No	Log Kow (at 20°C and pH=7), (IUPAC, 2018)
1	Bromopropylate	18181-80-1	5.4
2	Cyfluthrin	68359-37-5	6
3	Diafenthiuron	80060-09-9	5.76
4	Etoxazole	153233-91-1	5.52
5	Fenbutatin oxide	13356-08-6	5.15
6	Fenpropathrin	39515-41-8	6.04
7	Lufenuron	103055-07-8	5.12
8	Pendimethalin	40487-42-1	5.4
9	Pyridaben	96489-71-3	6.37
10	Tefluthrin	79538-32-2	6.4

Table 6 shows that there are 10 pesticides having potential to sink in sediment. In water quality monitoring programmes these pesticides are included for water matrix. However, they are not monitored in sediment matrix. Since agriculture is an important pressure for Beysehir lake, monitoring of these pesticides in sediment should also take place.

Discussion and Conclusion

In this study, the industries around Lake Beysehir were investigated and the chemicals that may originate from these industries were identified. Then, among these chemicals the ones that have the potential to accumulate in the sediment were detected by using octanol-water partition coefficient. Moreover, the pesticides specific to the basin were studied and the ones that should be monitored in the sediment were distinguished. According to these studies, it was found out that 18 priority substances, 16 specific pollutants and 10 pesticides should be monitored in the sediment.

This work revealed that monitoring of heavy metals are not sufficient to ensure the prevention of sediment contamination. There are other parameters that have high potential to sink in sediment. These parameters may act as a source of pollution to a water body. No matter how much the quality of water body is improved, with the emission of these parameters to the water body from the contaminated sediment, the quality of water body can deteriorate. Therefore, for the achievement of good water quality status, quality of sediment plays a crucial role and for the management of quality of water body, water and sediment should be considered in an integrated manner.

Moreover, by sediment monitoring, information about historical contamination can be obtained. In Turkey, there are water bodies that have no historical water quality monitoring data. With sampling in deeper sediment in these water bodies, information about historical contamination of the water body can be gained and precautions can be taken accordingly.

In Europe, by the reduction of point and diffuse pollution, sediment quality is tried to be improved. However, studies have shown that the reduction of pollution resulted in a slow and delayed response in sediment quality. Therefore, sediment quality management is a long term process and it should be conducted in basin scale. (SedNet, 2004)

In conclusion, except for some research studies, chemical monitoring of the sediment in Turkey is not included in the surveillance monitoring in line with the WFD requirements. This paper recommends that the places where the contamination of the sediment is likely to occur should be identified and the chemical parameters that have the tendency to accumulate in the sediment should be selected for monitoring in the each river basin of Turkey. Sediment monitoring programmes should be prepared for each basin in Turkey and monitoring activities should be conducted periodically in order to detect the trends of pollutants that are not soluble in water. Also, contamination of sediment by heavy metals should be further investigated in order to understand the source of heavy metals in sediment. This study is needed to distinguish the natural background concentration of heavy metals from anthropogenic impacts in sediment. Finally, it is clear that good water body status cannot be achieved without good sediment status. By emphasizing water and sediment linkage, sediment management plans should be prepared or sediment management issues should be included in river basin management plans.

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Extended Turkish Abstract
(Genişletilmiş Türkçe Özet)

Beyşehir Gölü Sedimanında Kimyasal İzleme Parametrelerinin Seçimi

Suda çözünmeyen hidrofobik maddelerin, zaman içerisinde çökerek dipte bulunan sedimentte birikme potansiyeli vardır. Sadece su kolonunda yapılan izleme çalışmaları ile bu hidrofobik maddelerin tespiti yapılamamaktadır. Ayrıca, su kalitesi ne kadar iyileştirilirse iyileştirilirsin zaman içerisinde bu kimyasal maddelerin tekrar su kolonuna geçerek su kalitesini kötüleştirme ihtimali vardır. Bununla birlikte, sedimentte yapılan dikey örnekleme ile geçmişe dönük kirlilik hakkında da bilgi sahibi olunabilmektedir. Bu sebeple, etkin su yönetimini sağlamak için sedimentte de kimyasal izlemeye yer verilmesi gerekmektedir.

Göllerin ve nehirlerin bütüncül bir parçası olması ve su kalitesindeki önemine rağmen, sedimentte kimyasal izlemenin önemi Avrupa Birliği Su Çerçeve Direktifinde (SÇD) yeterli şekilde vurgulanmamıştır. SÇD de, sedimente çoğunlukla Çevre Kalite Standartlarında (ÇKS) yer verilmiştir. SÇD açıkça ÇKS'lerin su, sediment ve biyota için belirlenmesi gerektiğini belirtmektedir. Ayrıca, Avrupa Sediment İzleme Ağı (SedNet) havza yönetim planlarında sedimente de yer verilmesi gerektiğini vurgulamaktadır.

SÇD'de sediment izleme sıklığı net bir şekilde belirtilmemektedir; fakat 2013/39/EU Direktifinde ÇKS'lerin uygulanabilirliği için izlemenin yılda bir kez yapılması gerektiği bildirilmektedir. Bu sıklık sediment için sedimentasyon oranı ve su kütlesinin hidrolojik rejimine göre değişiklik gösterebilmektedir. İzleme zamanı olarak ise sedimentasyon hızının en fazla olduğu, akış hızının ise en az olduğu zamanlar olan yaz dönemleri seçilmelidir.

Sediment izleme istasyonlarının seçimi, su kütleleri izleme istasyonları ile benzerlik göstermektedir. Seçilen izleme noktaları su kütlelerini temsil edici özellikte olmalı ve izleme noktaları seçilirken noktasal kirletici kaynaklar dikkate alınmalıdır.

Bu çalışma ile Beysehir Gölü sedimentinde izlenmesi gereken kimyasal maddelerin tespit edilmesi hedeflenmiştir. Öncelikle göl etrafında yer alan baskı türleri incelenmiş olup, baskıların başlıca tarım ve hayvancılık kaynaklı olduğu gözlemlenmiştir. Ayrıca, göl etrafında organize sanayi bölgesi ile gölün yakınında şeker fabrikası olduğu görülmüştür. Organize sanayi bölgesi içerisinde yer alan tesis türleri de incelenmiş, bu tesislerin çoğunlukla makina imalatı, otomotiv ve silah endüstrisi üzerine olduğu tespit edilmiştir. Bu tesislerden kaynaklanan kirleticiler incelenerek sedimentte birikme potansiyeli olanlar tespit edilmiştir. Ayrıca, Konya Havzasında yetiştirilen bitkilerde kullanılan pestisitlerin listesi ile öncelikli maddeler de incelenerek hidrofobik olanlar belirlenmiştir.

Sedimentte izlenmesi gereken kimyasal maddeler tespit edilirken oktanaol-su ayrışım katsayısından (K_{ow}) yararlanılmıştır. Kural olarak; log K_{ow} değeri 5'ten büyük olan kimyasal maddeler sedimentte izlenmesi gereken kimyasal maddeler olarak tespit edilmiştir. Sedimentte izlenmesi gereken metallerin seçiminde ise; log K_{ow} değeri, organik maddelerin hidrofobik özelliğin belirlenmesinde kullanılması sebebiyle dikkate alınmamıştır. Ağır metaller hidrofobik özelliğe sahip oldukları için sedimentte izlenmesi gereken kimyasal maddeler listesine eklenmiştir.

Beyşehir Gölü sedimentinde izlenmesi gereken kimyasal maddeler seçilirken, 2014 yılında Havza İzleme ve Referans Noktalarının Belirlenmesi Projesi kapsamında Beyşehir Gölünde dört dönem gerçekleştirilmiş olan su kalitesi izleme sonuçları ile sedimentte gerçekleştirilmiş olan ağır metal izleme sonuçları birarada incelenmiştir. Sonuçlar değerlendirildiğin de su kolonunda konsantrasyon değeri düşük olan ağır metallerin sedimentte daha yüksek konsantrasyon değerine sahip olduğu gözlenmiştir. Ayrıca, izleme sonuçları değerlendirilirken, sedimentte alüminyum konsantrasyon değerinin çok yüksek olduğu gözlemlenmiştir. Bu konsantrasyon değerinin sedimentin doğal yapısından kaynaklandığı, kirlilik göstergesi olmadığı yorumu yapılmıştır. Bu sebeple, sedimentte izlenmesi gereken kimyasal maddelerin seçiminde sedimentin doğal yapısından kaynaklanan maddelerin belirlenmesinin önemi vurgulanmıştır.

Sonuç olarak, “Tehlikeli Madde Kirliliğinin Kontrolüne İlişkin Proje”, “Ülkemiz Kıyı ve Geçiş Sularında Tehlikeli Maddelerin Tespiti Projesi”, “Ekolojik Kıyı Dinamiği Projesi” ve “Bitki Koruma Ürünlerinin Kullanımı Neticesinde Meydana Gelen Su Kirliliğinin Tespiti ve Madde veya Madde Grubu Bazında Çevresel Kalite Standartlarının Belirlenmesi Projesi” ile Türkiye için saptanan 117 belirli kirletici ve 133 bitki koruma ürünleri arasında Beyşehir Gölü sedimentinde izlenmesi gereken 16 belirli kirletici ve 10 pestisit belirlenmiştir. Ayrıca, 18 öncelikli maddenin de sedimentte izlenmesi önerilmiştir. Bu kimyasal maddelerin Beyşehir Gölünde yapılacak olan izleme çalışmalarına dahil edilmesi ve Türkiye için diğer havzalarda da sedimentte izlenmesi gereken kimyasal madde listesinin oluşturularak havza izleme programlarına sedimentte izlemenin de dahil edilmesi önerisinde bulunulmuştur. Ayrıca iyi su durumunun iyi sediment durumu olmadan mümkün olmadığı belirtilerek Türkiye için sediment yönetim planlarının hazırlanması ya da havza yönetim planlarına sediment konusunun dahil edilmesi önerilmiştir.