The Turkish Journal of Occupational / Environmental Medicine and Safety

2017; Volume 2, Issue 1(3):103-110 Web: http://www.turjoem.com ISSN : 2149-471

WATER QUALITY AND HEAVY METAL CONCENTRATIONS OF KÜTAHYA WATER RESOURCES

Duygu MERCAN[1], Müge GİDİŞ [2]

[1] Dumlupınar University, Institute of Science, Department of Biochemistry

[2] Dumlupınar University, Kütahya School of Health

ABSTRACT

Water resources are considered to be a vital part of the environment and impacted from pollution. This pollution affect the entire ecosystem. Aquatic ecosystems form the richest part of biological diversity. Kütahya is located in the Inner West Anatolian part of Aegean Region and has many rivers, lakes and underground spring waters. This review aims to put together the studies that have been done about the concentrations of heavy metals in Kütahya region water resources. Regarding high concentration of heavy metals in several areas, particularly around industrial and agricultural locations more study should be done. The relevant legal arrangments should be made in the regions close to the agricultural land and situations that do not comply with the laws on water should be removed to protect the environment and living organisms.

INTRODUCTION

The issue of environmental pollution, which is getting more and more important internationally every passing day, has begun to be a problem for all living organisms (1). Most of the water environments are polluted as a result of current production activities, population increase from rural areas, migration to urban areas, distorted urbanization, destruction of natural areas. This pollution affect the entire ecosystem (2). Aquatic ecosystems are the most important ecosystem in the world. However, aquatic ecosystems are cheap and easy to discharge for many factory wastes (3). Aquatic ecosystems form the richest part of biological diversity.

Biological resources, which are included in natural resources, are important elements that direct the economy of the country (4). Wetlands are important ecosystems in the world. Carboniferous marsh swamps form the basis of fossil deposits such as petroleum and coal that we have used in the present century (5). Lakes, rivers, seas and oceans have long been ignored by humans and seen as waste zones on unlimited capacities. As a result, the pollution of the water environments in coastal and inland areas has increased rapidly (2). At the forefront of industrial establishments that increase environmental pollution and play an important role in the degradation of ecological balance, there are heavy metal containing organizations in waste water (6). Heavy metals are naturally compounds in earth, they can not be destroyed. Some heavy

metals (copper, selenium, zinc) called trace elements which are necessary for the metabolism of the human body. But sometimes these elements can cause toxic effects when taken in high concentrations and lead to poisoning (7).
Leaving polluters as the last stop, especially in the aquatic environment, deteriorates the quality of the waters and adversely affects the aquatic organisms and also affect people who are fed from these organisms. In the aquatic environment, heavy metals are in equilibrium at a certain value under normal conditions and they are absorbed by sediments or biota, which are more intense in urban areas (8, 9, 10). Sediment contaminated with heavy metals in aquatic ecosystems is a major source of stress threatening ecosystem health. This stress is a major source of risk for water organisms in and on sediment (11, 12).
Tissue samples taken from living organisms in the ecosystem are used as bioindicators to determine pollution grades. In recent years, these studies have become quite widespread in order to determine the increase in pollution and risk in the ecosystem (13, 14, 15, 16). For example, Gastropoda species, the richest class of Mollusca phylum in terms of species, are widely used detecting metal pollution (17). The biomonitor shows the degree of ecological variability with the biological-chemical-physical or behavioral variability, such as respiration rate of the organism, changes in growth (18).

As invertebrates exhibit a large concentration of heavy metal accumulation, they are placed in the first order among the heavy metal accumulating organism (19). Mussels and oysters absorbs the heavy metals dissolved in water because they feed on epibentic suspension(20). Microalgae and sea grasses, marine algae, crabs, lobsters, Talitrid amphipods, Polychataes are the first examples of biomonitor living organisms that accumulate heavy metals. While Talitrid amphipods provide heavy metal accumulation from solutions and nutrients, Polychaetes can take the metal in the water by respiration(2). Biosorption experiments with yeast and especially fungi are more efficient, because the ability of the yeasts and fungi to accumulate and remove heavy metals is more than other organisms(6).

Kütahya is located in the Inner West Anatolian part of Aegean Region. Kütahya province, which holds an important place in history and tourism in our country, is also important for wetlands. There are many rivers, lakes and underground spring waters in and around the province. The river which has the maximum length within the province borders is Emet River with 90 Km. Ponds are also available within the provincial borders. Ponds can be used for irrigation, flood protection and potable water according to need. The largest dam is the Kayaboğazı dam. The irrigation area is 7080 ha. The Kütahya groundwater potential is a total of 107.6 meters per year. In Kütahya province, geothermal resources are available in almost every district including the city center. Recreational water use is not available throughout the city. The most important water source in terms of potable water in Kütahya is Porsuk. Waters used by the industry throughout the province are generally provided from underground waters. The industrial wastewater of Kütahya province is the rivers and dams. The names of some establishments and wetlands are given in Table 1.

Table 1: Some Industrial Facilities Discharging Wastewater to the Receiving Water Environment in Kütahya Province (21)

Facility name	Flow Rate	Waste Water Discharge Location	Discharge Standard Values in the Regulation (Composite Sample 2 Hours / Composite Sample 24 Hours mg/L)	Measurement (Wastewater Analysis) Resultant Discharge Standard Values
Besler Süt Mamülleri San. Ve Tic. Ltd. Şti.	40 m^3/day	Badger Continues To Work To Determine Special Provision	KOİ: 170 Oil and grease: 60 pH:6-9	
Akyüz Süt Ürünleri Gıda San. Ve Tic. Ltd. Şti.	30 m^3/day	Emet Creek	KOİ: 170 Oil and grease: 60	19.06.2012 The Results Of Analysis Of Samples Dated KOİ:139.68 Oil and grease:10.6
Güral Porselen Heriş Seramik A.Ş	600 m^3/day	Porsuk Creek	KOİ:80 AKM:100 Pb:1 Cd:0.1 Zn:3 pH:6-9	
Mutlu Akü	50 m^3/day	Terrain and Road Watering	KOİ:80 AKM:70 (b:0.5 Total CN: 0.1 Fe:3	

It is known that industrial plants are polluting with the reason that their wastewater treatment systems are inadequate. The wastewater treatment facilities of Kütahya Municipality are available. The resulting wastewater is biologically treated. In addition, nitrogen and phosphorus removal is done and it is discharged to Porsuk River. However, despite the fact that the air pollution in 2011 was the first degree environmental problem for Kütahya Province, it has been observed that the pollution of water has passed to the first place by checking the Environmental Status Reports over the years.(21).

	WATER QUALITY CLASSES			
WATER QUALITY PARAMETERS	I	II	III	IV
A) Physical and inorganic-chemical parameters				
1) Temperature (°C)	25	25	30	> 30
2) pH	6.5-8.5	6.5-8.5	6.0-9.0	6.0-9.0 outside
3) Dissolved oxygen (mg O_2/L)	8	6	3	< 3
4) Oxygen saturation (%)[a]	90	70	40	< 40
5) Chloride ion (mg Cl^-/L)	25	200	400[b]	> 400
6) Sulphate ion (mg $SO_4^=$/L)	200	200	400	> 400
7) Ammonium nitrogen (mg NH_4^+-N/L)	0.2[c]	1[c]	2[c]	> 2
8) Nitrite nitrogen (mg NO_2^--N/L)	0.002	0.01	0.05	> 0.05
9) Nitrate nitrogen (mg NO_3^--N/L)	5	10	20	> 20
10) Total phosphorus (mg P/L)	0.02	0.16	0.65	> 0.65
11) Total dissolved matter (mg/	500	1500	5000	> 5000
12) Color (Pt-Co birimi)	5	50	300	> 300
13) Sodium (mg Na^+/L)	125	125	250	> 250
B) Organic parameters				
1) Chemical oxygen demand (KOİ) (mg/L)	25	50	70	> 70
2) Biological oxygen requireme (BOİ) (mg/L)	4	8	20	> 20
3) Total organic carbon (mg/L)	5	8	12	> 12
4) Total kjeldahl-nitrogen (mg/	0.5	1.5	5	> 5
5) Oil and grease (mg/L)	0.02	0.3	0.5	> 0.5
6) Surfactants reacting with methylene blue (MBAS) (mg/L)	0.05	0.2	1	> 1.5
7) Phenolic substances (volatil (mg/L)	0.002	0.01	0.1	> 0.1
8) Mineral oil and derivatives (mg/L)	0.02	0.1	0.5	> 0.5
9) Total pesticide (mg/L)	0.001	0.01	0.1	> 0.1
C) Inorganic contamination parameters				
1) Mercury (µg Hg/L)	0.1	0.5	2	> 2
2) Cadmium (µg Cd/L)	3	5	10	> 10
3) Bullet (µg Pb/L)	10	20	50	> 50
4) Arsenic (µg As/L)	20	50	100	> 100
5) Virgin (µg Cu/L)	20	50	200	> 200
6) Chromium (total) (µg Cr/L)	20	50	200	> 200
7) Chromium (µg Cr^{+6}/L)	ND	20	50	> 50
8) Cobalt (µg Co/L)	10	20	200	> 200
9) Nickel (µg Ni/L)	20	50	200	> 200
10) zinc (µg Zn/L)	200	500	2000	> 2000
11) Cyanide (total) (µg CN/L)	10	50	100	> 100
12) Fluoride (µg F^-/L)	1000	1500	2000	> 2000
13) Free chlorine (µg Cl_2/L)	10	10	50	> 50
14) Sulfur (µg $S^=$/L)	2	2	10	> 10

15) Iron (µg Fe/L)	300	1000	5000	> 5000
16) Mangan (µg Mn/L)	100	500	3000	> 3000
17) Boron (µg B/L)	1000[e]	1000[e]	1000[e]	> 1000
18) Selenium (µg Se/L)	10	10	20	> 20
19) Barium (µg Ba/L)	1000	2000	2000	> 2000
20) Aluminum (mg Al/L)	0.3	0.3	1	> 1
21) Radioactivity (Bq / L) (Bq/L)				
Alpha-activity	0,5	5	5	> 5
Beta-activity	1	10	10	> 10
D) Bacteriological parameters				
1) Fecal coliform (EMS/100 mL)	10	200	2000	> 2000
2) Total coliform (EMS/100 mL)	100	20000	100000	> 100000

MARERIAL and METHODS

Research on the heavy metal content and water quality of the water environments of Kütahya and surrounding areas has accelerated in recent years.

The pollution problem originating from Kütahya was investigated in Porsuk Dam Basin. The most important pollutant sources in the basin are the wastewater of Kütahya, the wastewater of the city, Nitrogen, Sugar and Magnesite Factory, Seyitömer Thermal Power Factory and agricultural origin polluters. In 1947, a dam was built on the Porsuk river to protect the center of Eskişehir from floods due to domestic wastes and industrial wastes coming from Kütahya. In 1972 the capacity of the dam was increased by 18m. In recent years, too much domestic and industrial waste has been loaded in Porsuk Creek from Kütahya and Eskişehir provinces and has become unable to control this pollution (22).

The Simav Stream has identified 4 locations in the study of the pollution problem. There is no comprehensive study of the cause of pollution in the past. Pollution ratios were determined in the study carried out in 2004 and suggestions were made about the removal of pollution. The Simav Stream, considered as an area of investigation, is located in the South Marmara Region on the north-western side of Turkey. Despite the fact that, the survey area has not remained so far in terms of environmental pollution until the last years, the rate of pollution has increased due to the growing population, the development of the industry and the physical conditions (23,1).

Heavy metal (copper (Cu), zinc (Zn), manganese (Mn), iron (Fe), cobalt (Co), magnesium (Mg), nickel (Ni), chromium (Cr) and boron (B)) concentrations of *Cyprinus carpio* in Kütahya Enne Dam were studied by Uysal et al. (2009) using an atomic absorption spectrophotometer (24).

Aslan et al. (2011) determined the water and sediment quality of, Kütahya Yedigöller region. In this study, methods used to determine water quality in Kütahya and its surroundings were used and the results were recorded in the literatüre (3).

Tokatli and his colleagues examined the water quality, biotic and abiotic trace elements of Felent Stream in 2012 (25). About 35 km long, the Felent river rise in the northwest of the Köprüören Basin, reaches Enne Dam Lake and is poured into the Porsuk Stream in the north of Kütahya (23). Tokatli and his colleagues began their work in 2009 by setting three stations on the Felent Stream, Köprüören Village, which is very close to the source station of the first station Felent Stream, Yoncalı Village, which is close to the second station thermal facilities and exposed to thermal pollution, and the third station is located in the center of Kütahya in the center of the Felent Stream just before the Porsuk Creek. Physicochemical analyzes; Ph, temperature, dissolved oxygen,% oxygen saturation, conductivity, salinity parameters were determined in the field with Multi Measuring Device (HQ40D). Nitrite, Nitrate, Chlorine, Phosphate, Sulfate, Ammonium and Chemical Oxygen Demand (COI) were measured by Spectrophotometer (HACH LANGE DR 2800) located in Anadolu University Environmental Problems Application and

Research Center (25). Chemical analysis; in order to determine the elements dissolved in water, firstly the membrane with a pore diameter of 0.45 mm was filtered through the filter. A quantity of water sample from the filtrate (1 + 1) was immediately adjusted to pH <2 with nitric acid and the tube was closed and mixed. After the samples were prepared for analysis, the contents of the dissolved elements were measured by Varian ICP-OES 720 ES (27). Gastropoda specimens gathered with benthic scoops were brought to the laboratory and stored in the fridge at -20 degrees. Frozen samples were dried at 105 degrees and ground. Nitric acid and perchloric acid (3: 1) were added to 0.5 g of the sample and digested in the microwave. The samples which have gone through organic destruction are filtered. Metal analysis was performed with Varian ICP-OES 720 ES (28, 29, 25).
Tokatli and his colleagues examined Emet Çayı water quality in the research they carried out in 2016. 8 different locality were examined. Physicochemical and chemical analyzes were carried out as in previous studies (30) and the findings were recorded in the literature.

RESULTS AND DISCUSSION

Water pollution, which is the most important problem of environmental pollution has become the biggest problem today, and it is intensely threatening the human health and other ecosystems all over the world not only in Kütahya.
Phosphorus analyzes of pH, BOI, KOI, AKM, Lead, Kadmidyum, Oil and Gress, which are the main pollution parameters, were carried out in the study named "Porsuk Dam Basin's Kütahya Origin Pollution Problem". It has been determined that the results obtained are not in accordance with the statistics obtained when compared with the Water Quality Control Regulation data (22).
It has been determined that the Cd ratio in the carp species of the Enne dam, which is mostly fed with hot water sources, is above the standard amount which should be in *Carassius carassius* (24). It has been given that the reason for the high cadmium may be direct water contamination or may have originated from the geochemical structure of the region.
In the study entitled "Determination of some metal levels in water and sediment samples in Yedigöller (Kütahya) Region" samples taken from 2 different locations were examined. As a result of the investigations, it was seen that all metal concentrations in sediment samples in Yedigöller region were higher than water samples (3). According to the sediment quality criteria determined by MacDonald et al. (2000), Cu, Ni and Cr concentrations were quite high at each location in the study area are (31). Besides, it was found that the values of Cd and Hg were below than the values measured in sediment in both locations. Hg metal was the highest toxicity heavy metal among the measured metals (32).
The results obtained in the study "Determination of trace element levels in the Felent Stream biotic and abiotic items and evaluation of water quality" differ in every station. In the years of 2009 and 2010, samples taken from three different locations were examined and trace elements such as Fe, As, B, Zn, Cr, Cb, Pb, Cu levels were determined in water, sediment and gastropoda specimens (*Lymnaea stagnalis*, whole body). The results were evaluated according to the Water Pollution Control Regulation and Turkish Food Codex criteria. In the gastropoda specimens all elements were found to be higher than the water and B and Zn values were higher than the sediment. In addition, in terms of inorganic pollution parameters according to Water Pollution Control Regulation Internal Water Resources Quality Criteria; first location has second class grade water quality; second location has grade water quality third class; and third location has a fourth grade water quality (25). Fe and B values are at the limit value at all stations. According to the Quality Criteria for Inland Water Resources in 2009, the F1 station, which is the first quality in terms of quality, has fallen to second grade water quality in 2010.
A total of 8 different stations were collected and analyzed in the study named "Seasonal Variation of Emet Çayı Water Quality". The obtained data were evaluated statistically and compared with the values determined by various national and international organizations. According to the obtained data, it was observed that the basin was exposed to a significant amount of organic pollution. The nitrite levels found in some of the stations poses a risk for Cyprinid (30).

As a result, the toxic substances obtained in the studies of water quality and heavy metals in Kütahya and its surroundings and studies conducted in the vicinity of Felent Stream show an increase according to years. Likewise, Yedigöller has been became Kütahya Solid Waste Storage, and industrial waste discharging to the Porsuk River are increasing day by day. Besides this pollution, both the water ecosystem and the populations of organisms living in the environment are in danger. The areas where Kütahya and its surroundings are least contaminated are areas were where the population is low and the water source is high.

More study should be done around the water sources of Kütahya, and the relevant legal arrangments should made in the water areas in the regions close to the agricultural land and situations that do not comply with the laws on water should be removed. There is no protected area under the "Wetland Protection Regulations" in Kütahya province nor under the Protection of Wetlands with International Preference as an Environment for Living Water Birds (RAMSAR Convention).

REFERENCES

1. Gülüm, K., Akgün, A. Simav Çayı Aşağı Çığırında (Çaygören Baraj Çıkışı İle Kepsut Boğazı Arasında) Su Kirlenmesi Sorunu Ve Çözüm Önerileri, e-Journal of New World Sciences Academy 2011; ISSN:1306-3111.
2. Taylan, S.Z., Özkoç, B.H. Potansiyel Ağır Metal Kirliliğinin Belirlenmesinde Akuatik Organizmaların Organizmaların Biokullanılabilirliği, BAÜ FBE Dergisi 2007; 9,2: 17-33.
3. Arslan, N., Tokatlı, C., Çiçek, A. ve Köse, E. Yedigöller (Kütahya) Bölgesinde Su ve Sediment Örneklerinde Bazı Metal Seviyelerinin Belirlenmesi, Review of Hydrobiology 2011; 4,1: 17-28.
4. Kışlalıoğlu, M., Berkes, F. Biyolojik Çeşitlilik 1987; Türkiye Çevre Sorunları Vakfı Yayını, Önder Matbaası. 1987 122 s.
5. Mitsch, W. J and Gosselink, J. M. Wetlands, John Wiley & Sons, Inc., New York, U.S.A. 2000: 3 920 pp.
6. Sağlam, N. ve Cihangir, N. Ağır Metallerin Biyolojik Süreçlerle Biyorbsiyonu Çalışmaları, Hacettepe Üniversitesi Eğitim Fakültesi Dergisi 1995; 11: 157-161.
7. Anonim Water Products Law and Regulations, Turkish Ministry of Agriculture and Rural Affairs, 63-78 pp.
8. Wildi, W., Domink, J., Thomas, R. L., Favarger, P., Haller, L., Perroud, A. ve Peytremann, C. River, reservoir and lake sediment contamination by heavy metals downstream from urban areas of Switzerland. Lakes & Reservoirs, Research and Management , 9: 75-87.
9. Kılıç S., Çavuşoğlu K., Kılıç M. The effects of lead (Pb) pollution caused by vehicles on the pollen germination and pollentube growth of apricot (Prunus armeniaca cv. Sekerpare); Biological Diversity and Conservation (BioDiCon)2009; 2,3: 23-28.
10. Yücel, E., Edirnelioğlu, E., Soydam, S., Çelik, S., Çolak, G. Myriophyllum spicatum (Spiked water-milfoil) as a biomonitor of heavy metal pollution in Porsuk Stream/Turkey. Biological Diversity and Conservation (BioDiCon) 2010; 3,2 : 133-144.
11. Del Valls, T. A., Blasco, J., Sarasquete, M. C., Forja, J. M. and Gomez-Parra, A. Evaluation of heavy metal sediment toxicity in littoral ecosystems using juveniles of the fish Sparus aurata. Ecotoxicology and Environmental Safety 1998; 41: 157-167.
12. Türkoğlu, M. (2008) Van Gölü'nden alınan Su, Sediment ve İnci Kefali (Chalcalburnus tarichi, PALLAS 1811) Örneklerinde Bazı Ağır Metal Düzeylerinin Araştırılması, Yüksek Lisans Tezi, 45 s.
13. Özmen, H., Külahçı, F., Çukurovalı, A. ve Doğru, M. Concentrations of heavy metal and radioactivity in surface water and sediment of Hazar Lake (Elazığ, Turkey) Chemosphere 2004; 55:401–408.
14. Hongyi, N, Wenjing, D, Qunhe, W. ve Xingeng, C. Potential toxic risk of heavy metals from sediment of the Pearl River in South China, Journal of Environmental Sciences 2009; 21: 1053–1058.

15. Xiaobo, L., Linzhi, J., Yunlong, Z., Wang, Q. and Yongxu, C. Seasonal bioconcentration of heavy metals in Onchidium struma (Gastropoda: Pulmonata) from Chongming Island, the Yangtze Estuary, China. Journal of Environmental Sciences 2009; 21:255–262.

16. Mendil, D., Ünal, F. O., Tüzen, F. ve Soylak, M. Determination of trace metals in different fish species and sediments from the River Yes_ilırmak in Tokat, Turkey. Food and Chemical Toxicology 2010; 48: 1383–1392.

17. Başçınar, S. Bentik Canlılar ve Biyoindikatör Tür. Yunus Araştırma Bülteni, 2009 1, 5-8 s.

18. Rainbow, P.S.Biomonitoring of Heavy Metal Availability in the Marine Environment, Marine Pollution Bulletin 1995; 31:183-192.

19. Rainbow, P.S. Trace Metal Concentrations in Aquatic Invertebrates: Why and so What?, Environmental Pollution 2002; 120:497-507.

20. Rainbow, P. S., Phillips, D.J.H. "Cosmopolitan Biomonitors of Trace Metals", Marine Pollution Bulletin 1993; 26,11: 593-601.

21. Çevre Durum Raporu, Kütahya İl Çevre Durum Raporu, Kütahya Çevre ve Şehircilik İl Müdürlüğü 2012.

22. Özyurt, M.S., Dayıoğlu, H., Bingöl, N., Yamık, A. Porsuk Baraj Havzası'nın Kütahya Kökenli Kirlilik Problemi , Dumlupınar Üniversitesi Fen Bilimleri Enstitüsü Dergisi 2004; 6.

23. Çevre Durum Raporu Balıkesir Valiliği Çevre Orman İl Müdürlüğü 2005

24. Uysal, K., Kose, E., Bülbül, M., Dönmez, M., Erdoğan, Y., Koyun, M.,Ömeroğlu, C.,Özmal, F. The Comparison of Heavy Metal Accumulation Ratios of Some Fish Species in Enne Dame Lake (Kütahya/Turkey). Environ. Monit. Assess 2009; 157:355–362.

25. Tokatlı, C., Köse, E., Çiçek, A., Arslan, Emiroğlu, Ö. Felent Çayı (Kütahya , Sakarya Nehir Havzası) Biyotik ve Abiyotik Öğelerinde İz Element Seviyelerinin ve Su kalitesinin Değerlendirilmesi, Biyolojik Çeşitlililik ve Koruma 2012; 5:2;73-78.

26. Çevre Durum Raporu Balıkesir Valiliği Çevre Orman İl Müdürlüğü 2006

27. EPA METHOD 2007. (2001) Determination Of Metals And Trace Elements In Water And Wastes by Inductively Coupled Plasma- Atomic Emission Spectrometry.

28. ASTM Preparation of Biological Samples for Inorganic Chemical Analysis 1. Annual Book of ASTM Standards 1985;19: 740- 747.

29. APHA Standard Methods for the Examination of Water and Wastewater. In A.E. Greenberg, L.S.Clesceri, A.D. Eato (eds.), American Public Health Association, 18th ed., Washington, U.S.A. 1992.

30. Tokatlı, C., Köse, E., Arslan, N., Emiroğlu, Ö., Çiçek, A., Dayıoğlu, H. Emet Çayı Su Kalitesinin Mevsimsel Değişimi Uludağ Üniversitesi Mühendislik Fakültesi Dergisi 2016; 21:2.

31. MacDonald, D. D., Ingersoll, C. G. ve Berger, T. A. Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems. Arch. Environ. Contam. Toxicol. 2000; 39: 20–31.

32. Timmermans, K.R., Accumulation of trace metals in freshwater invertebrates. In Ecotoxicology of Metals in Invertebrates. Dallinger, R. and Rainbow, P.S., Eds. Lewis Publishers, Boca Raton, 1993 ; 133–148.