Investigation of the Effects of Land Use on Chemical Water Quality Parameters; A Case Study of Başkonuş-Meydan Dam Lake in Kahramanmaraş

Emre Babur1, Ömer Süha Uslu2, Cafer Hakan Yılmaz3, M. Raşit Sünbül3

Cite this article as: Babur, E., Uslu, O.S., Yilmaz, C.H., & Sunbul, M.R. (2021). Investigation of the effects of land use on chemical water quality parameters; a case study of Başkonuş-Meydan Dam lake in Kahramanmaraş. Aquatic Sciences and Engineering, 36(1), 22-28.

ABSTRACT

Water quality is in constant interaction with and changed according to time and place through natural and anthropogenic factors. It is also known that land use has a significant impact on water quality parameters. In this study, it was aimed to determine the effects of different land-use types (Forest, range and riparian) on water quality and which land-use type supports the most suitable drinking water for watersheds in the Başkonuş Plateau in Kahramanmaraş Province. The field studies were carried out in May 2019, and 2 sampling points were selected from each of the land-use types. Chemical properties (pH, EC) and some element concentrations (19 elements such as Al, As, Cu, B, Zn, Fe, Cd, Ca, Co, Cr, Pb, Mg, Mn, Mo, Ni, K, Na, and S) were investigated by using an ICP-OES. According to the results, the water obtained from forest areas is more suitable for drinking, having drinking water quality standards with a high pH value (7.59), and the Sulfur concentration of water obtained from range area (26.72 μg S /L) exceeded and did not comply with drinking water quality standards. When the chemical characteristics of the Meydan Dam were examined according to the regulated water quality standards declared in water pollution laws, it is clear that the dam basin has a high water quality standard (Class I). Therefore, a larger dam that can be built in this basin would be able to supply quality water that the Kahramanmaraş metropolitan municipality needs. Consequently, before deciding on the construction of the dam for drinking water, land-use maps would be created in the basins, and the selection of basins that have dense and qualified forestland would provide quality water.

Keywords: Chemical water quality, forest, Kahramanmaraş, Land use, parameters, range, riparian

INTRODUCTION

Water quality is in constant interaction with and changed by natural and anthropogenic factors. Among the natural phenomena, the amount of precipitation, river bed and basin characteristics (slope, length, etc.), geological structure, soil type, plant species, and stand closure are major factors that significantly affect water quality. Many of these factors are also changed by humans, causing negative effects on water quality in rivers or lakes. For example, conversion of forests to agriculture or settlements prevents access to quality water due to using pathogens, pesticides, domestic waste, heavy metals, oils, salts, and road construction in agriculture and settlements areas.

Land-use types in a catchment basin significantly affect the water quality of the basin. It is well-known that there is a strong relationship between land use (agriculture, range, forest, settlement, etc.) and water quality. Moreover, some studies have reported that forest land in-
increases the water quality and quantity in a watershed basin (Altun, Kezik, Kara, & Babur, 2016; Babur & Kara, 2017). On the other hand, the studies investigating the relationship between land use and water quality due to the need for quality and a sufficient amount of water are gradually increasing as a result of pollution or the reduction of water resources because the increase in human activities in different land-use leads to changes in water quality (Silva & Williams, 2001; Ngoye & Machiwa, 2004; Tokatlı, Solak, & Yılmaz, 2020). However, land-use changes (such as removal or change of vegetation) and management practices (the establishment of road and settlement areas, agricultural management, etc.) are also important factors affecting water quality (Yong & Chen, 2002). Guo, Ma, & Zhang (2009) revealed that land use and vegetation cover the effects of water quality. This study stated that there is a significant amount of total nitrogen and phosphorus transitions from meadows to streams. Cao, Li, Wang, Zhao, & Wang (2012) examined the relationship between land-use type and water quality. They noticed that there are significant differences in the water quality parameters of cultivated areas, meadows, and forest areas in terms of TN (total nitrogen), TP (Total phosphate) coliform bacteria. Huang et al. (2013) found significant differences in some water quality indicators among settlement areas, meadows, and forests in their study. In all of these studies, the effects of land use in watersheds on water quality were specifically investigated.

Several studies have emphasized that land use has a significant impact on the chemical properties of water quality (Peierls, Caraco, Pace, & Cole, 1991; Hunsaker & Levine, 1995; Puckett, 1995; Howarth et al., 1996; Allan, Erickson & Fay, 1997). For example, the nitrogen and nitrate concentrations in water increased due to the increase of meadow areas in a basin (Jordan, Correl, & Weller, 1997). However, Allan et al. (1997) stated that the best properties in terms of habitat quality and biotic integrity are in agricultural land. Urbanization and intensive agricultural practices is a large portion of the negative relations between land use and water quality (Baker, 2005). The decrease of plant communities covering the soil surface in an area increases the sediment loss with the surface flow in the catchment basin while decreasing the infiltration capacity (Walling & Fang, 2003). Considering that such studies are lacking in developing countries, it is important to develop models that reveal the relationships between land use and water quality.

Kahramanmaraş/BAşkonuş Plateau has great importance for the region in terms of climate, ecology, natural beauty, and very rich vegetative biodiversity. Since the areas where the research was conducted are far from anthropogenic effects, they can be used as drinking water basins if needed in the future. In this study, the most suitable land-use type will be determined, and the study will contribute to the preference of water collection basins through the construction of drinking water reservoirs.

MATERIALS AND METHODS

Study area
The field study was carried out in the forest, range and riparian areas around the Meydan pond located within the boundaries of the Başkonuş Forest Operation of Kahramanmaraş Forest Regional Directorate (Figure 3a, 3b, and 3c). The research area is approximately 50 km from Kahramanmaraş Province. In this study, the areas where topographic, geological, climatological, and geomorphological features are similar were chosen to reveal the effects of different land uses on water quality. The water collection basin of the study site, which is selected from typical karstic areas, covers an area of 105 hectares in total (37° 34' 12"–37° 34' 51" N; 36° 35' 13"–36° 35' 22" E). The average elevation of the area is 1200 m, the general aspect is north, and the average slope is 50%. The study site is shown on the map in Figure 1.

The vegetation type of the research area consists of black pine (Pinus nigra Arn.), fir (Abies cilicica subsp. cilicica), and cedar (Cedrus libani A. Rich.) forest trees. There are Salvia, Trifolium, Cynodon plants, etc. in range areas and reeds in riparian areas (Anonymous, 2012). The field studies are shown in Figure 2.

Field study and sampling
In this research, field studies were carried out in May 2019. In order to carry out this research, 2 sampling points were selected from each of the forest, range, and riparian areas. At the sample points, a 25x25x15 soil section was removed without disturbing the litter layer and structure and placed in the fit size plastic containers with bottom leaking filters (Figure 3 and 4). 2 lt of ultra-pure distilled water was added to each soil section with an artificial rain system. Then, the water leaking into the boilers placed under the buckets was collected. Afterward, the water samples were filtered in such a way as to make their volumes to 100 ml with ultra-pure distilled water.

Chemical and elemental parameters
The pH values of water samples were measured with an Orion 250A meter, electrical conductivity (EC) with an Amber Science
2052 meter with the method of glass electrode (Gülçür, 1974). The element levels (Al, As, Cu, B, Zn, Fe, P, Cd, Ca, Co, Cr, Pb, Mg, Mn, Mo, Ni, K, Na, and S) in the samples were determined by using the “Agilent 5100 ICP-OES” device at the East Mediterranean Transitional Zones Agricultural Research Institute. The element analyses were recorded as means triplicate measurements (EPA, 1998; 2001).

Statistical analysis
The average, maximum, and minimum values and standard errors of the water samples values were determined by using the SPSS 15.0 program. The average values of different water samples obtained from the different land-use types were compared by using ANOVA and Duncan test.

RESULTS AND DISCUSSION
The mean values and standard errors of the chemical properties of water samples obtained from different land uses have been determined (Table 1). Comparisons and classifications of the mean values of water chemical parameters were made based on the Surface Water Quality Management Regulation, Water Pollution Control Regulation, Maximum Permissible Value, Recommended Value, and Regulations on Human Consumption Water.

Acidic water or basic water occurs with increasing or decreasing hydrogen ion concentrations in water (Göksu, 2003). It has been determined that there is a significant difference in the pH of the water obtained from different land uses (p<0.001). While the highest pH value was found in riparian areas with a value of 7.63, the lowest pH value was found in range areas with a value of 7.38. However, the pH value of the water samples taken from the Meydan pond was determined to be lower (7.08) compared to other land uses (Table 1). The pH is the most important factor for chemical and biological systems in water ecosystems (Atay and Pulatsü, 2000). According to the inland water quality standards, the high-quality water limits given for the pH parameter are between 6.5 and 8.5 (Table 2). The pH values of water obtained from all three land use types were determined to be in the I. and II. water quality classes of the RCWP and SWQMR. Also, all of these water samples are suitable for drinking-use according to TS-266 and RWHC (Tables 1 and 2).

According to electrical conductivity (EC), the mean EC values of water samples obtained from the different land-use types were found significantly different (p<0.001). The highest EC value was found in riparian areas with a value of 248.74 μs/cm, and the lowest was found in forest areas with a value of 53.25 μs/cm (Table 1). The EC values of water samples were found to be in the I. and II. water quality classes, and they are suitable for drinking-use according to TS-266 and RWHC (Tables 1 and 2).

The Ca²⁺, Mg²⁺, and K⁺ values of the water samples were found statistically different from each other. In terms of Ca²⁺ average values, 62.47 mg Ca²⁺/L, the highest value, was found in the range and 14.39 mg Ca²⁺/L, the lowest, in the forest areas. The concentration of Mg²⁺ was found to be the highest in the riparian areas with a value of 9.27 mg Mg²⁺/L and the lowest concentration in forest areas with a value of 2.03 mg Mg²⁺/L. The K⁺ concentration was found to be the highest in the forest area with a value of 4.98 μg K⁺/L and the lowest in the riparian area with a value of 1.93 μg K⁺/L (Table 1). Ca²⁺, Mg²⁺, and K⁺ concentrations of water samples are below the maximum limit values in all regulations and TS-266 (Table 1 and 2). In terms of human health, Ca²⁺, Mg²⁺, and K⁺ concentrations should be at the recommended levels in drinking water.

In terms of total hardness in the water samples (Ca + Mg), the highest mean value was found in range areas with a value of
The phosphorus concentration of the water samples according to the different land uses were very close to each other. Boron concentrations of water samples from different land uses (p>0.05). Boron concentrations of water were very close to each other. Boron amounts in the water samples obtained from riparian, rangeland, and forest areas are 0.024, 0.030, and 0.029 μg B/L, respectively (Table 1). The boron concentration in water samples were found below drinking water threshold values shown in TS-266 and RWHC (Table 2).

In terms of the concentrations of some heavy metals in water samples, the mean aluminum (Al) amount was found the highest in the forest area with a value of 0.211 mg/L and the lowest in the riparian areas with a value of 0.106 mg/L. These values showed that land-use types statistically affect Al contents (p<0.001; Table 1). Also, it was determined that the Al values of water samples obtained from all land-use types are in the 1st water quality class with all regulations such as TS-266, RCWP, and SWQMR (Table 2).

No statistically significant difference was found in boron concentrations of water samples from different land uses (p>0.05). Boron concentrations of water were very close to each other. Boron amounts in the water samples obtained from riparian, rangeland, and forest areas are 0.024, 0.030, and 0.029 μg B/L, respectively (Table 1). The boron concentration in water samples were found below drinking water threshold values shown in TS-266 and RWHC (Table 2).

Significant differences were found in iron concentrations of water samples in different land uses (p<0.001). While the highest Fe concentration was found in forest areas with a value of 0.218 μg Fe/L, the lowest concentration (0.093 μg Fe/L) was found in riparian areas. However, no significant difference was found be-
between manganese concentrations and land use differences (P>0.05). In water samples, manganese concentrations were observed from highest to lowest in rangeland, forest, and riparian areas, respectively (Table 1). The iron, manganese, and potassium concentration in water samples found are in the 1st water quality class for drinking water according to all regulations like TS-266, RCWP, SWQMR, and RWHC (Table 2).

As a result of comparing average values of arsenic, copper, zinc, cadmium, cobalt, molybdenum, nickel, chromium, and lead of the water samples obtained from different land uses; the concentrations of copper, zinc, cadmium, cobalt, nickel, and chromium are affected by land-use differences, but those of arsenic, lead, and molybdenum are not.

The highest heavy metal concentrations were found in the riparian area with values of 0.003 μg Cd/L, 0.110 μg As/L, and 0.021 μg Ni/L; these values in rangeland were 0.147 μg Cu/L, 0.039 μg Zn/L, 0.0004 μg Co/L, and 0.0089 μg Pb/L, and the value in forest land was 0.0012 μg Cr/L (Table 1). All these heavy metal values comply with the average values reported in the international water quality regulations and TS-266. This study noticed that the water samples obtained from different land-use types were found in the 1st water quality class in terms of the heavy metal concentrations (TS-266, RCWP, SWQMR, and RWHC).

Tokatlı (2019) noticed that some heavy metals such as cadmium, lead, and arsenic were found to be the highest ecological risk factors for the basin reservoirs in the Thrace Part of the Marmara Region of Turkey. This situation was caused by the medicines and fertilizers used in agricultural areas from land use in the basin. Also, they are known as agricultural origin toxicants. Cd is one of the most present toxicants because many fertilizers used in Turkey were found to be over the limit values (Tokatlı, 2019). Since there is no agricultural land in our study area, heavy metal concentrations were found low in all water samples.

It has been determined that different land uses statistically affect sodium and sulfur concentrations from chemical water quality parameters (p<0.001). The highest concentrations of sodium (6.56 μg Na/L) and sulfur (26.72 μg S/L) were found in water samples obtained from range areas while the lowest amounts (1.90 μg Na/L and 0.76 μg S/L) were found in forest areas. The Na concentration in the water samples obtained from all three land-use types is in the 1st water quality class. The sulfur concentration of water samples obtained from the forests is I. quality water, but riparian areas are found in class III water quality. However, it was found to have an intense concentration above the quality standards in the rangeland water sample. Increased sulfur concentration causes the taste and smell of the water to deteriorate and not to be of the standard of drinking and utilities (Öztürk & Fakıoğlu, 2017).

### Table 2. Regulations about Water Quality Parameters (Anonymous 2016a; 2016b; 2016c; TSE, 1997).

| Water quality parameters | RCWP, SWQMR | TS-266 | RWHC |
|--------------------------|-------------|--------|------|
| A) Chemical parameters   |             |        |      |
| 1) pH (H2O)              | 6.5-8.5     | 6.5-8.5| >6.0-9.0|
| 2) EC (μs/cm)            | -           | -      | -    |
| B) Inorganic chemical parameters |           |        |      |
| 1) Aluminium (mg Al/L)   | 0.3         | 0.3    | >1   |
| 2) Arsenic (μg As/L)     | 20          | 50     | 100  |
| 3) Copper (μg Cu/L)      | 200         | 50     | 200  |
| 4) Boron (μg B/L)        | 2000        | 500    | 2000 |
| 5) Zinc (μg Zn/L)        | 200         | 500    | 2000 |
| 6) Iron (μg Fe/L)        | 300         | 1000   | 5000 |
| 7) Phosphorus (mg P/L)   | 0.02        | 0.16   | >0.65|
| 8) Cadmium (μg Cd/L)     | 3           | 5      | >10  |
| 9) Calcium (mg Ca²⁺/L)   | -           | -      | -    |
| 10) Cobalt (μg Co/L)     | 10          | 20     | >200 |
| 11) Chromium (μg Cr⁶⁺/L) | Çok az      | 20     | 50   |
| 12) Lead (μg Pb/L)       | 10          | 20     | >50  |
| 13) Magnesium (mg Mg²⁺/L)| -           | -      | -    |
| 14) Manganese (μg Mn²⁺/L)| 100         | 500    | >3000|
| 15) Molybdenum (μg Mo/L) | -           | -      | -    |
| 16) Nickel (μg Ni/L)     | 20          | 50     | >200 |
| 17) Potassium (mg K+/L)  | -           | -      | -    |
| 18) Sodium (mg Na/L)     | 125         | 125    | >250 |
| 19) Sulfur (mg S/L)      | 2           | 2      | >10  |

RCWP: Regulation on Control of Water Pollution, SWQMR: Surface Water Quality Management Regulation, RV: Recommended Value, MPV: Maximum Permissible Value, RWHC: Regulation on Waters for Humanitarian Consumption.
Usta (2011) found the effects of different land use on water quality in the Galyan Watershed Basin. The study stated that the pH, EC, TN, TP, Ca++, Mg++ and Na+ amounts in the waters decrease with the increase of range areas in a basin. Also, the pH, EC, Ca, and Mg amounts in the water decrease when the Coniferous Forest areas increase. However, it was stated that pH, EC, TN, Ca, Mg, and Na in water increased with the increase in the broadleaf forest areas. As mentioned earlier, several anthropogenic activities (tillage, fertilization, etc.) in the agriculture area firstly change the soil characteristics, and then this change is reflected in the stream water (Tong & Chen, 2002). Bhat, Jacobs, Hatfield, & Prenger (2006) noticed that the amounts of TN carried to stream water are expected to be high in broadleaf forest. More organic matter and microorganism activities in forest areas cause more element transition to soil and water (Türüdü, 1981).

CONCLUSION

In this study, the effects of land use differences on the chemical water quality were examined. The rain falls into the catchment basin where there are forest, range and riparian areas, and the rainwater mixes with groundwater by leaching organic and inorganic elements in the plant, root, litter layer and soil. These waters also join the drinking water reservoirs from here. When the chemical parameters of waters obtained from different land uses were examined, it was determined that the water obtained from the forest and riparian areas are more suitable for drinking and meet drinking water quality standards. However, the Sulfur concentration of water obtained from the range area (26.72 µg S /L) exceeded drinking water quality standards and cannot be considered as drinking water. When the chemical characteristics of the Meydan Dam were examined according to the regulated water quality standards declared in water pollution laws, it is clear that the dam basin has a high water quality standard (Class I). A larger dam that could be built in this basin which would be able to supply quality water to meet the needs of the Kahramanmaraş metropolitan municipality. Land-use maps of the basin should be created before choosing the location to build dams for drinking water. In the selection of the catchment basin, authorities need to choose natural areas with vast forest lands, specifically away from any mining sites. The management and sustainability of different land uses (forest, agriculture, range and settlement) should be taken jointly by the competent authorities by considering the integrated watershed management approach in the basins that are supposed to supply drinking water.

Conflict of interests: The authors have no conflicts of interest to declare.

Ethics committee approval: -

Funding: -

Acknowledgments: This study was presented as an oral presentation at the 3rd Water and Health Congress.

Disclosure: This study was presented at the "3rd International Water and Health Congress will be held 12th-15th November 2019 in Antalya".

REFERENCES

Allan, J. D., Erickson D. L. & Fay J. (1997). The influence of catchment land use on stream integrity across multiple spatial scales. *Freshwater Biology, 37*, 149-161. [CrossRef]

Altun, L., Kezik, U., Kara, U. & Babur, E. (2016). Potential of water purification of macka forest ecosystems in northeastern Turkey. *J Environ Prot Ecol, 17*(2), 557–565.

Anonymous. (2012). Başkanın Orman İşletme Şefliği, Başkanın Orman Amenajman Planı. Kahramanmaraş Orman Bölge Müdürlüğü. Orman Genel Müdürlüğü (2012-2021).

Anonymous. (2016a). “İnsani tüketim amaçlı sular hakkında yönetmelik”, Sağlık Bakanlığı. R. G. Tarihi: 17.02.2005, R.G. Sayısı: 25730. Ek 1 (Değişik ek: R.G.-7/3/2013-28580). (Erişim tarihi: 10.08.2019).

Anonymous. (2016b). “Su Kirilılığı Kontrolü Yönetmeliği”, Çevre ve Orman Bakanlığı, R. G. Tarihi: 31.12.2004, R. G. Sayısı: 25687. Ek 1 (Değişik: R.G.-13/2/2008-26786). (Erişim tarihi: 10.08.2019).

Anonymous. (2016c). “Yüzeysel Su Kalitesi Yönetimi Yönetmeliğinde Değişiklik Yapılmasına Dair Yönetmelik”, Orman ve Su İşleri Bakanlığı, R.G. Tarihi: 15.04.2015, R.G. Sayısı: 29327. (Erişim tarihi: 10.08.2019).

Babur, E. & Kara, O. (2017). Su Kalitesi ve Orman Topraklan Arasındaki İlişkiler. 2nd International Water and Health Congress: Şuşat 2017, Antalya.

Baker, A. (2005). Land Use and Water Quality. Encyclopedia of Hydrological Sciences. [CrossRef]

Bhat, S., Jacobs, J. M., Hatfield, K. & Prenger, J. (2006). Relationships Between Stream Water Chemistry and Military Land Use in Forested Watersheds in Fort Benning, Georgia, *Ecological Indicators, 6*, 458–466. [CrossRef]

Bulut, Ç., Atay, R., Uysal, K., Köse, E. & Çınar, Ş. (2011). Uluabat Gölü Su Kalitesinin Değerlendirilmesi. *Aquat Sci Eng, 36*(1), 9-18.

Cao, F., Li, X., Wang, D., Zhao, Y. & Wang, Y. (2012). Effects of land-use structure on water quality in Xin’ anjiang River. *Environmental Science, 34*, no. 7, pp. 2582–2587.

Emiroğlu, Ö., Uyanoğlu, M., Başturt, S., Süln, Ş., Köse, E., Tokatlı, C., Uysal, K., Ansian, N. & Çiçek, A. (2013). Erythrocyte deformations in *Rutilus rutilus* (Linnaeus, 1758) provided from Pursuk Dam (Turkey). *Biological Diversity and Conservation, 6*(1), 13-17.

Environmental Protection Agency (EPA) METHOD 3051A. (1998). Microwave assisted acid digestion of sediments, sludges, soils, and oils. https://www.epa.gov/ (accessed 03.03.2019).

Environmental Protection Agency (EPA) METHOD 200.7. (2001). Determination of metals and trace elements in water and wastes by inductively coupled plasma-atomic emission spectrometry. https://www.epa.gov/ (accessed 03.03.2019).

Gökşu, M. Z. L. (2003). Su Kirilılığı, Çukurova Üniversitesi Su Ürünleri Fakültesi Yayınları, No:7, Adana, s. 232.

Guo, Q. H., Ma, K. M. & Zhang, Y. (2009). Impact of land use pattern on lake water quality in urban region. *Acta Ecologica Sinica, 29*(2), 776–787 (Chinese).

Gülçür, F. (1974). Toprağın Fiziksel ve Kimyasal Analiz Metodları. i.Ü. Yayınları, Yay No: 1970, Orman Fak. Yay. No: 201. Kurtuluş Matbaası, İstanbul.

Howarth, R. W., Billen, G., Swaney, D., Townsend, A., Jaworski, N., & Lajtha K. (1996). Regional nitrogen budgets and riverine N & P fluxes for the drainages to the North Atlantic Ocean. *Natural and human influence. Biogeochemistry, 35*, 75-139. [CrossRef]

Huang, J., Zhan, j., Yan, H., Wu, F. & Deng, X. (2013). Evaluation of the Impacts of Land Use on Water Quality: A Case Study in The Chaohu Lake Basin. *Hindawi Publishing Corporation. http://dx.doi.org/10.1155/2013/329187*. [CrossRef]

Hunsaker, C. T. & Levine, D. A. (1995). Hierarchical approaches to the study of water quality in rivers. *Bioscience, 45*, 193-203. [CrossRef]

Jordan, T. E., Correl, D. L. & Weller, D. E. (1997). Effects of Agriculture on discharge of nutrients from coastal plain watersheds of Chesapeake Bay. *Journal of Environmental Quality, 26*, 836-848. [CrossRef]
Ngoye, E. & Machiya, J. F. (2004). The influence of land-use patterns in the Ruvu river watershed on water quality in the river system, Physics and Chemistry of the Earth A, B, C, vol. 29, no. 15-18, pp. 1161–1166, 2004. [CrossRef]

NSTC. (2003). An Assessment of Coastal Hypoxia and Eutrophication in U.S. Waters, National Science and Technology Council, Committee on Environment and Natural Resources, (accessed 05.01.2018).

Öztürk, I. & Fakıoğlu, M. (2017). İçme Sularında Tat ve Koku Giderimi. Teknik Kitaplar Serisi, ISKI.

Peierls, B. L., Caraco, N. F., Pace, M. L. & Cole, J. (1991). Human influence on river nitrogen. Nature, 350, 386-387. [CrossRef]

Pers, B. C. (2005). Modeling the Response of Eutrophication Control Measures in a Swedish Lake, Ambio, 34, 552-558. [CrossRef]

Puckett, L. (1995). Identifying the Major Sources of Nutrient Water Pollution. Environmental Science and Technology, 29, 408A-414A. [CrossRef]

Sliva, L. & Williams, D. D. (2001). Buffer zone versus whole catchment approaches to studying land use impact on river water quality,” Water Research, vol. 35, no. 14, pp. 3462–3472. [CrossRef]

Tokatlı, C. (2019). Use of the potential ecological risk index for sediment quality assessment: A case study of Dam Lakes in the Thrace part of the Marmara Region. Aquatic Sciences and Engineering, 34(3), 90-95. [CrossRef]

Tokatlı, C., Solak, C. N., & Yılmaz, E. (2020). Water quality assessment by means of bio-indication: A case study of ergene river using biological diatom index. Aquatic Sciences and Engineering, 35(2), 43-51. [CrossRef]

Tong, S. T. Y. & Chen, W. (2002). Modeling The Relationship Between Land Use and Surface Water Quality. Journal of Environmental Management, 66, 377-393. [CrossRef]

TSE. (1997). TS-266, Türk İçme Suyu Standartları, Türk Standartları Enstitüsü, Ankara.

Türüdü, Ö. A. (1981). Trabzon İli Hamsiköyü Yöresindeki Yüksek Arazide Aynı Bakıda Bulunan Ladin Ormanı, Kayın Ormanı, Çayır ve Mısır Tarlası Topraklarının Bazı Fiziksel ve Kimyasal Özelliklerinin Karşılaştırmalı Olarak Araştırılması, KTÜ Orman Fak. Yayınları Yayın No: 13, Trabzon.

Usta, A. (2011). Galyan-Atasu Barajı Havzasında Arazi Kullanımının Su Ve Toprak Etkilerine Etkilerinin Araştırılması. Doktora Tezi, Karadeniz Teknik Üniversitesi, Fen Bilimleri Enstitüsü. Trabzon.

Walling, D. E. & Fang, D. (2003). Recent Trends in the Suspended Sediment Loads of the World’s Rivers. Global and Planetary Change, 39(1-2), 111-126. [CrossRef]

Yong, S. T. Y. & Chen, W. (2002). Modeling the relationship between land use and surface water quality,” Journal of Environmental Management, vol. 66, no. 4, pp. 377–393, 2002. [CrossRef]