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Evaluation of Selected Water Quality Parameters Examined from Different Sources in Niğde Province, Türkiye

Avşar, E.[1*], Kara, E. [2], Özdilek, H. G.[3], Kara, E. E.[4]

[1]*Department of Environmental Protection Technologies, BlecikŞeyh Edebali University, 11000, Bilecik, Türkiye*
[2]*Department of Internal Medical Sciences, Çukurova University, 01330, Adana, Türkiye*
[3]*Department of Environmental Engineering, Çanakkale Onsekiz Mart University, 17100, Çanakkale, Türkiye*
[4]*Department of Environmental Engineering, Niğde Ömer Halisdemir University, 51240, Niğde, Türkiye,*

Abstract: In addition to air, water is the most essential matter for human survival. Development and intensive agriculture have managed to contaminate both surface and groundwater resources all around the globe. Ever increasing human population and changing lifestyle have caused stress on water resources. Both physical as well as chemical (such as arsenic) and microbiological (such as pathogenic bacteria) are responsible for 250 to 300 million cases of waterborne diseases each year all around the World. It is also estimated that between 3.5 million (Water Dome, 2002) and 5 million (Johannesburg Summit, 2002) deaths occur due to waterborne diseases/problems in the World in a year. In this study, water resources (both surface and groundwater) in Nigde city located in TÜRKİYE were analyzed in terms of chemical composition and microbiological quality. It was found that arsenic, microbiological agents and ammonia are the principal pollutants that jeopardize public health in Niğde province TÜRKİYE.

Keywords: Water quality, Niğde, Microbiological water contamination, Health.

Introduction

Water pollution continues to be a principal challenge in the context of population growth, land use, and sustainable development. Niğde/Türkiye, is a growing province facing water quality due to agricultural activities and global climate change. The analysis presented here identifies causes of water quality problems and sustainable water quality management strategies in Niğde. These efforts shall assist ongoing efforts by the governmental agencies of Niğde to protect water quality.

The province of Niğde is situated in the south-eastern edge of the Central Anatolian Region of Türkiye, between the latitudes of 37° 10′ N and 38° 58’ N and between the longitudes of 33° 10’ E and 35° 25’ E. Niğde has a total population of about 351,468 − 24 % living in rural areas (villages), as of 2015. The province occupies 7,400 km^2 (average elevation: 1,229 m above mean sea level) and is divided into six administrative units (districts). It has a semi-humid climatic regime with cold winters and hot-dry summers (average annual precipitation: 347 mm per year), exhibiting a form of semi-arid continental climate. Long-term precipitation data of Niğde are given in Table 1. The general terrain is mountainous (peak elevation above mean sea level: 3,756 m − Demirkazık Mountain) with few plateaus (NPDEU 2016, NPDEU 2017, NPDEU 2018, NPDEU 2019).

Table 1: Precipitation of Niğde between 1935 and 2019

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
No of Days	10.9	10.4	11.3	11.2	11.9	6.9	1.8	1.5	2.9	6.6	7.5	10.8	93.7
Precipitation (mm)	35.4	33.2	35.6	41.9	48.7	27.9	5.2	6.6	10.5	26.9	31.2	41.4	344.5
Precipitation (% to total)	10.3	9.6	10.3	12.2	14.1	8.1	1.5	1.9	3.1	7.8	9.1	12.0	

The elevation of Niğde is from 1100 to 3756 meters with average elevation of 1229 meters above mean sea level. About 20% of Niğde’s area, notably in the north, is plain type. Floods do not occur annually in the province. Population growth in Niğde is a major factor contributing to increasing water related problems. Surface water pollution in Niğde comes from residential and commercial wastewater, industry, agriculture, solid waste landfills and leakage from septic tanks (NPDEU 2016, NPDEU 2017, NPDEU 2018, NPDEU 2019).

To understand water quality in surface and groundwater systems, a reliable analytical system must be developed. Water quality in urban and rural areas can provide detailed information for resource managers to identify causes of and solutions for water pollution problems.

Water quality is an important aspect all over the world and lots of studies were conducted for different aims. Yalcin et al. (2006)studied heavy metal pollution present in Karasu Creek located in Niğde. Results indicated that creek water quality was low and had toxic quality. Positive correlations were determined between some elements and their sources were possibly the same (industrial and residential sources).

Lermi and Ertan (2019)conducted groundwater hydrochemistry study in Niğde Province. According to results groundwater was dominated by Ca^{2+}, SO_4^{2-}, HCO_3^-parameters and suitable for drinking and irrigation aims in terms of most hydrochemical parameters. But in several areas high sulphate, nitrate and arsenic concentrations were detected. This situation constituted major health problem for people. It was concluded that arsenic affected wells should be immediately closed or treatment activities were conducted for preventing arsenic related cancers.

Mine wastes are another water pollution source in Lermi (2009)studied heavy metal pollution which came from acid mine drainages. According to results well waters were more basic than expected near the mine wastes disposal area. Also heavy metal pollution (Fe, Mn, Pb, Zn, As) pollution were determined both for soil and water sources in the region.

Environmental problems and sustainability have been studied in Niğde to find strategies ensuring balanced economic, social, and environmental development. Kara et al. (2013)studied ambient air quality and its relationship with public health in Niğde, while Lermiand Ertan (2019) researched water quality and the interaction between surface and groundwater in the Karasu River. Yalçın et al. (2008)presented results focused on the location of sampling on surface water quality of Karasu in the central district of Niğde. Identifying integrated solutions for droughts and water quality problems in Niğde is also a priority research area. No detailed water quality research, especially domestic water quality, has been conducted for Niğde province wide.

Water pollution is an important problem all around the World. Lots of similar studies were conducted to investigate problems and determine the resolution alternatives. Also several indexes were developed for easy determination of water pollution.

Azizullah et al. (2011)investigated water pollution in Pakistan. Drinking water quality was poor in Pakistan and country was ranked at number 80 among 122 nations in terms of safe drinking water. Coliforms, toxic metals and pesticides were most common polluters for both surface and groundwater. Municipal, industrial effluents and agricultural activities were the common contamination sources.

Gleick (2002)mentioned that safe water provision and adequate sanitation failure were the greatest development failure of the 20^{th} century. Most important result of this failure was high rate mortality among young children due to the preventable water-related diseases. According to examined scenarios of the study, if no actions was taken to meet basic human needs for water as many as 135 million peoples would die from these diseases by year 2020.

Halder and Islam (2015)studied Turag river water pollution and its impact on human health in Dhaka the capital of Bangladesh. According to results river water quality was not suitable for aquatic life and domestic purposes. Dissolved oxygen level were very low and maximum levels of turbidity, BOD, hardness, TDS and COD were much higher than the standard. Several diseases were indicated at the local communities around the river due to water pollution.

Williams et al. (2012) presented a methodology for estimating the point and diffuse pollution loads to water courses across all of pan-Europe in terms of BOD and TDS parameters. According to model results in 2005, annual BOD loads come mostly from domestic effluent and diffuse sources. In terms of TDS loads manufacturing and domestic sources were important.

Tyagi et al. (2013)conducted a research to assess water quality by means of water quality index (WQI). It was a valuable and unique tool for the selection of appropriate treatment technique to meet the concerned issues. Aim of this index was to give a single value to water quality of a source, reducing number of parameters for the easy interpretation of water quality monitoring data. For example between 0 and 25 WQI value characterize excellent water quality. According to results water agencies, users and water managers in different countries may use and adopted it with little modifications.

Avsar et al. (2014)and Avsar et al. (2015)investigated physical and chemical characterization of dissolved organic matter in Büyükçekmece and Ömerli Water Dams in İstanbul/Türkiye. Dissolved organic matter (DOM) treatment capacity of coagulation flocculation process utilized was low and DOM was an important precursor

compound, it reacts with chlorine and produce disinfection by products (DBPs). In terms of physical characterization <1kDa fraction and in terms of chemical fraction hydrophobic phase were dominant in both waters examined.

This study uses analysis of water quality to generate an overview of water quality for Niğde. The overall objective of this research is to provide resources to improve water quality through designation of water usage, establishment of criteria to protect water resources, and development of water quality management plans. The results of this study provide an analytical foundation for stakeholders to better understand water quality conditions in urban and rural areas. Understanding water conditions in Niğde will yield strategies for future water management in the province and beyond.

We present a research process for water quality assessment in Niğde. Initially, previous research and government reports were gathered. The research process begins with collection of urban growth data (e.g. population and land use) and observed water quality data. Second, statistical analysis is carried out to identify water quality and water conditions. The review assessment is conducted to understand the water environment and identify the factors contributing to water pollution problems in sampling locations. Finally, review assessments are used to make recommendations about sustainable water and environmental management.

We investigated twenty one water quality parameters: pH, Electrical conductivity (EC), arsenic, lead, fluoride, ammonium, nitrate, boron, oxidation potential, nickel, sulphate, chloride, chromium, aluminium, sodium, iron, manganese, microbiological parameters (E. coli, coliform bacteria, enterococcus, and total germination). We use 62 observed water quality stations with data from 2016 to 2019.

Materials and Methods

Sampling locations

In the context of the study water samples taken from monitoring stations. Total 62 water samples (belonging to surface and groundwater resources) were investigated in this research. Sampling points were given in Figure 1.

Parameters and Methods

Samples taken from sampling points were chemically and biologically investigated. Water quality parameters, measurement methods, detection limits and devices used in the experimental study were given by Table 2 and Table 3. Also in one sample at Koyunlu Village synthetic chemicals (pesticides) were analysed. Since no pesticide type was detected, these measurements were not included in the study.

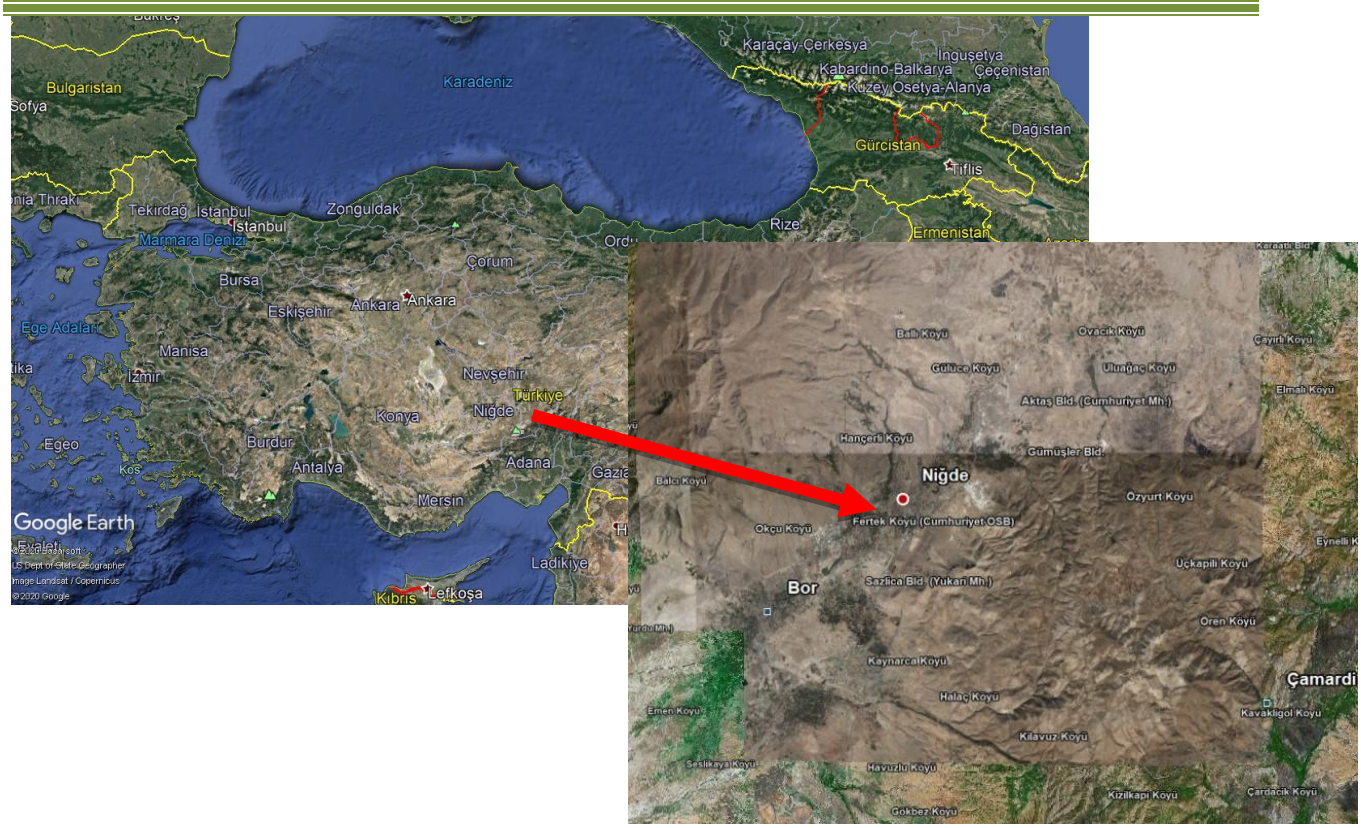

Figure 1: Niğde aerial images (Google Earth, 2020; Map General Directorate of Türkiye, 2016).

Table 2: Chemical parameters investigated in the context of the study

Parameter	Unit	Device	Method	Detection Limit (LOQ)
pH	-	Multimeter	TS EN ISO 10523	2
Electrical Conductivity (EC)	µS/cm		SM 2510 B	5
Oxidation Potential	mg/L	Titrimetric	TS 6288 EN ISO 8467	0.5
Arsenic	µg/L	ICP-MS	TS EN ISO 17294-2	1
Lead				1
Nickel				1
Boron				0.1
Chromium				2
Aluminium				1
Sodium				0.5
Iron				10
Manganese				1
Sulphate	mg/L	Liquid Chromotography (LC)	TS EN ISO 10304-1	0.5
Chloride				1
Fluoride				0.15
Nitrate				0.5
Ammonium		Spectrophotometer	DIN 3806-E5-ISO 7150	0.02

Table 3: Biological parameters investigated in the context of the study

Biological Parameters	Unit	Method
E. coli	mpn/100mL	TS EN ISO 9308-1
Coliform Bacteria		TS EN ISO 9308-1
Enterococcus		TS EN ISO 7899-2
Total Germination (at 22 ^{0}C)	mpn/mL	TS EN ISO 6222

Results and Discussion

According to results, only one sample (from Niğde province center) was found to be violating pH standard in Türkiye. It is acidic (6.30); whereas average pH of the samples was computed as 7.28. Standard deviation of pH parameter was computed to be 0.40. The violating sample (in terms of pH) has an electrical conductivity (19 mmhos cm^{-1}) which was found low compared to the EC level of other samples. Average EC of all samples was computed to be 313 mmhos cm^{-1}. Standard deviation of samples' EC was calculated to be 119.5 mmhos cm-1. All samples were found to be safe in terms of EC according to the Turkish potable water quality standards.

Ammonium was measured to be 0.096 mg L^{-1} as the average value. All samples were found to be safe in terms of ammonium standards based on the Turkish Water Quality Standards. Standard deviation of samples' ammonium concentration was calculated to be 0.341 mg L^{-1}.

Mean nitrate concentration was detected as 15.16 mg L^{-1}. Standard deviation of samples' nitrate concentration was calculated to be 8.945 mg L^{-1}.

Mean fluoride concentration was calculated as 0.258 mg L^{-1}. Standard deviation of fluoride was computed to be 0.086 mg L^{-1}. Fluoride causes serious health problems, for example mottling of the teeth, if it is greater than critical concentration of 0.05 millimole per litre. This critical level is approximately 1 mg L^{-1}. None of the samples examined in this study was found violating the optimum fluoride concentration for mouth health.

Mean arsenic concentration was found to be 5.195 µg L^{-1}. Two samples were found to be violating the arsenic standard of the Turkish legislation, which limits total arsenic concentration in potable waters with 10 µg L^{-1}. Standard deviation of arsenic concentration in samples was calculated to be 5.61 mg L^{-1}. Arsenic is a problem in groundwater resources in general. Bangladesh is one country that has been experiencing arsenic problem in well waters.

Boron was found to be 0.11 mg L^{-1} as mean concentration. Standard deviation of samples' boron concentration was computed to be 0.06 mg L^{-1}. Baba et al. (2008) studied chemical composition of 12 different bottled water brands and found that average boron concentration is 0.156 mg L^{-1}. The results found in this study is comparable to the bottled water composition study.

Nickel and chromium mean concentrations were calculated to be 4.19 µg L^{-1} and 5.39 µg L^{-1} respectively. Standard deviations of these two trace metals were computed to be 1.98 µg L^{-1} and 3.51 µg L^{-1} respectively. Nickel concentration was reported as 0.029 mg L^{-1} in selected bottled water samples in TürkiyeBaba et al. (2008). Our result showed that Niğde water samples do not contain high amount of nickel.

Chloride concentration was computed to be 8.283 mg L^{-1}. There is a high variability in water samples because standard deviation of chloride was computed to be 8.226 mg L^{-1}. Mineral waters that are marketed as bottled had 102 mg L^{-1} (standard error 343 mg L^{-1}) in 12 different samples in TürkiyeBaba et al. (2008).

Iron concentration was computed to be 17.45 µg L^{-1} as average value and standard deviation was found 9.97 µg L^{-1} in our samples. Baba et al. (2008)reported that mineral bottled waters (n=12) contain 0.006 mg L^{-1} iron on average (and the standard error of the dataset was calculated 0.0014 mg L^{-1}) in Türkiye. Since Niğde province has old volcanic mountains (such as Hasan Mountain, Golludağ and Melendiz Mountain), water samples in Niğde show a higher amount of iron.

E. coli is a serious problem in examined samples. 21% of samples were detected E. coli pollution. Turkish water quality standards mandate that potable water sources must not contain E. coli. According to Nazemi et al. (2018)fecal E. coli was determined as an important problem for Sista, Iran. Mean number of MPN of fecal E. coli in nonpotable and drinkable water were detected, 6.1×10^2 and 2.4 coliforms per 100 mL. This results indicated an important public health problem like this study.

Coliform (total coliform) was found to pose a real threat because of the fact that 48% of samples were found to have total coliform. Similar to the standard ofE. coli in potable water, water sources must not contain total coliform in Türkiye. However, it is a serious issue in Niğde. Hiraishi et al. (1984)determined that there were

statistically positive correlation between total coliform (TC), fecal coliform (FC) and BOD levels ($p<0.01$) from samples taken from Tamagawa River and its tributaries in Tokyo. Our study had similar findings. The proportion of thermotolerant coliforms and E. coli constituting the TC population increased with increasing BOD (biochemical oxygen demand) levels, whereas the relative concentration of E. coli to the FC population decreased with increasing BOD levels. Also results indicated that FCs and thermotolerant coliforms in the river were related with sewage and human waste pollution.

13% of examined samples were found to include enterococcus. It seems that enterococcus is a serious problem in Niğde water sources. Enterococci indicates that fecal material content in water. Also possible presence of disease-causing bacteria, viruses and protozoa (USEPA 2020). Other findings of our study about total coliform and E. coli support this idea.

Water pollution problems in Niğde are serious due to the limited WWTP capacity and limited water availability. Turkish environmental regulation legislation regulated water pollution control and water quality management. According to the regulation, pollutant load capacity, water quality monitoring, and wastewater discharge determination should be identified and carried out by the national government. Data will help for building construction permits, spatial planning of water source management, wastewater discharge permits, and water quality identification.

The provincial and city governments are responsible for cross-city and cross-district water pollution problems and must provide a report of water pollution conditions every year to the Ministry of Environment and Urbanization. Water use is also increasing, driving enormous challenges for WWTP development, planning and management. The improvement of water quality may come from water pollution control actions and the construction of WWTPs by the provincial and city government. However, there are some stations which still show poor water quality, possibly due to rising residential populations and lack of sewerage and WWTPs. Most sewerage is disconnected and discharged directly to surface waters. Addressing environmental challenges requires complete sewerage connected to WWTP. Construction of a comprehensive sewage system is essential to connect to WWTP in urban areas to control water pollution problems. Ancillary problems include rural wastewater collection, animal husbandry, and solid waste management. Sustainable urban water environments require managing flood risk exacerbated by land subsidence due to groundwater overdraft. Urban inundation can drive solid waste and polluted water into surface waters exacerbating pollution problems. Limiting groundwater overdraft is essential to addressing flood risk as is managing groundwater recharge, construction of pump stations and underground water storage. Government has the responsibility to regulate the private sector and build sewage systems connected to WWTP. Collaboration between citizens and government is a powerful way to improve water quality.

Best practice dictates that improving water quality requires wastewater collection and connection to sewerage and ultimately to the WWTP. WWTPs must be designed considering population growth and urban development. Water pollution controls must be implemented to eliminate overexploitation of ground water and use ecological measures to clean the urban waters according to comprehensive urban development plans. Improved water quality and water environment can lend value to Niğde and improve the aesthetic quality of the province as well as living conditions. Clean river water confers human health, tourism development, real estate value, and commerce, in addition to human happiness. The limitation of this paper is that the sampling times are not long (2015-2019), and the data quantity is insufficient. The water quality parameters are also insufficient, and other factors such as COD, BOD_5, temperature, etc. should also be fully considered. Future research should consider (1) the effect of precipitation on water quality; (2) groundwater pollution (province-wide); and (3) field surveys on pollution sources.

Conclusion

Rapid population growth and unplanned urbanization are serious problems contributing to the pollution of water resources all over the world. Populations, especially urban populations, are increasing rapidly in many countries around the world. However, the infrastructure that will serve these growing populations often cannot be built at the same speed. In this case, the existing infrastructure is insufficient for the disposal of urban wastewater.

This basic problem, encountered in developing countries, affects the province of Niğde in the same way. Water resources are polluted due to insufficient infrastructure. This situation manifests itself via the deterioration in biological parameters in Niğde's water resources. Rapid urbanization also causes excessive consumption of groundwater in Niğde. In this case, local subsidence occurs in some places. Water resources in the province are under stress. Plans should be made for adequate provision of water-related services in the province and for a balanced and sustainable development in the province. All users should have equal access to water, and the

environmental sustainability of resources should be ensured. The existing facilities used for water supply in the province are generally not operated effectively due to the high investment required to do so, and operating and maintenance costs. Agricultural applications of fertilizers and other materials (such as pesticides, herbicides, insecticides, etc.) as well as the discharge of untreated domestic and industrial wastewaters must be better controlled so that water resources will not be jeopardized.

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