The Effects of High Voltage Lines on the Vitality of *Escherichia coli* and Coliform Bacteria in Fresh Water Sources

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Abstract

The aim of this study is to find out whether there is chemical and microbiological degradation in the samples taken from fresh water sources near and far from high voltage lines. The samples were taken from Erfelek Meydan Village location Karasu River, Ayancık Tevfikiye Village location Zindan Brook, Ayancık Türkeli road junction Ayancık Brook, Durağan Yalnız Kavak location Gökırmak Water, Durağan-Boyabat Yalnız Kavak location Gökırmak water and Boyabat Sinecan Village location Kırkgeçit Brook in Sinop province of Turkey. Na^+, K^+, Cl^-, pH and conductivity analysis were conducted chemically, while microbiological tests were made against *Escherichia coli* and coliform bacteria. All the results obtained were assessed according to 06.07.2019 dated and 30823 numbered 'Legislation on the quality and treatment of water from which drinking water is obtained' in T. C. Official Gazette. With this study, it can be said that high voltage lines in the province of Sinop do not have a significant effect on fresh water sources. Na^+, K^+, Cl^- gave results in expected levels and conductivity gave results directly proportional to pH. In microbiological test results, *Escherichia coli* and coliform bacterial growth was found, while no microbiological degradation was found.

Keywords: Bacteria, electromagnetic field, high voltage line, Sinop

Yüksek Gerilim Hatlarının Tatlı Su Kaynaklarındaki *Escherichia coli* ve Koliform Bakterilerinin Canlılığına Etkisi

Öz

Bu çalışmadaki amaç yüksek gerilim hatlarına yakın ve uzak yerlerde bulunan tatlı su kaynaklarından alınan numunelerde kimyasal ve mikrobiyolojik açıdan bir bozulma olup olmadığını belirlemektir. Numuneler Sinop ilinin Erfelek Meydan Köyü mevkii Karasu Irmağı, Ayancık Tevfikiye Köyü mevkii Zindan Çayı, Ayancık Türkeli yol ayrımı mevkii Ayancık Çayı, Durağan Yalnız Kavak mevkii Gökırmak suyu, Durağan-Boyabat Yalnız Kavak mevkii Gökırmak suyu ve Boyabat Sinecan Köyü mevkii Kırkgeçit çaylarından alındı. Kimyasal açıdan Na^+, K^+, Cl^- , pH, iletkenlik analizleri, mikrobiyolojik açıdan ise *Escherichia coli* ve koliform bakteri gruplarına karşı test edildi. Elde edilen tüm bulgular Resmi Gazetenin 06.07.2019 tarihli, 30823 sayılı 'İçme suyu temin edilen suların kalitesi ve arıtılması hakkında yönetmeliğine' göre değerlendirilmiştir. Bu çalışma ile Sinop ilinde bulunan yüksek gerilim hatlarının tatlı su kaynaklarına önemli bir etkide bulunmadığı söylenebilir. Na^+, K^+, Cl^- beklenen seviyelerde, iletkenlik ise pH ile doğru orantılı sonuçlar verdi. Mikrobiyolojik test sonuçlarında ise *Escherichia coli* ve koliform bakteri üremeleri saptandı, herhangi bir mikrobiyolojik bozulmaya rastlanmadı.

Anahtar Kelimeler: Bakteri, elektromanyetik alan, Sinop, yüksek gerilim hattı

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INTRODUCTION

Electromagnetic field refers to the electric and magnetic field emitted by the electrical devices around us. High voltage lines carry electricity with high voltage and thus generate electromagnetic field. We are also exposed to electromagnetic waves with all kinds of electronic devices we use in daily life (Türkkan ve Kayıhan, 2009). Studies conducted on the effects of magnetic field are mostly related to health of humans and living beings. In a study, Varkey et al., (2017) showed that by using magnetic field (10- 65 Militesla, mT), deionised water contaminated with *E. coli* could be decontaminated from *E. coli* with a rate of 90%. In a study they examined the effect of 16 Gauss magnetic field on the growth rate of E. coli, Haghi et al., (2012) found that it increased logarithmic phase in the first 4 hours of the trial, while it decreased in the next 16 and 18-hour period. They stated that magnetic field could be effective in the sterilization of products such as food products, etc. In a study they conducted, Mousavian-Roshanzamir and Makhdoumi-Kakhki (2017) exposed E. coli to different periods (minutes 0, 15, 30, 45, 60, 75 and 90) and different magnetic intensities (2, 4, 6, 9, 14, 16, 18 and 20 mT) and a significant decrease was found in their survival rates only when they were exposed to 18 and 20 mT.

There are a great number of studies examining the effects of magnetic field on human health. Kroll et al., (2010) stated that high voltage lines and cancer could be associated in children younger than 15 who were born in England and Wales, but they also stated that no statistical significance was found between the results.

It is known that magnetic field affects the growth of bacteria present in water. However, our knowledge on how magnetic field affects the chemistry of water is very limited. The aim of this study was to find out whether there is chemical and microbiological degradation in fresh water sources near and far from high voltage lines.

MATERIALS AND METHODS

Water samples were taken from rivers close to various high voltage lines in the province of Sinop and from rivers which were off the electromagnetic field. Water samples taken from fresh water sources off the electromagnetic field were assessed as the control group. Na^+, K^+, Cl^-, pH, conductivity, *E. coli* (ATCC 25922), coliform and Total coliform (including fecal coliform) analyses of the samples were conducted in Eskişehir Public Health Laboratory. Water samples were taken in previously autoclaved (Biobase BKQ-Z30I) sample containers (100 ml, Simax) as 100 ml. The samples were taken from 5 points where there were no high voltage lines (control group) and 5 points which were close to (about 600 meters) high voltage lines (experimental group). The regions of these 10 points are as in Table 1. Na^+, K^+, Cl^-, pH and conductivity of the water samples taken were measured (Thermo Orion 4 Star). Next, 100 ml water was filtered with filters of 0.45 µm. They were planted in growth cultures including Chromocult Coliform Agar (chromogenic coliform, Merck-Millipore, Cat. No: 1.10426) and Mueller Hinton Agar CE (Merck, Cat: No: 1.05437) and incubated for 24 hours at 36 ± 2 ^{O}C. The presence of bacteria was understood by the formation of colonies on membrane filter at the end of

Table 1. Points where water samples are taken
Çizelge 1. *Su örneklerinin alındığı noktalar*

Sample points	Names of locations
1	Sinop Erfelek Meydan Village location Karasu River
2*	Sinop Erfelek Meydan Village location Karasu River
3	Sinop Ayancık Tevfikiye Village location Zindan Brook
4*	Sinop Ayancık Tevfikiye Village location Zindan Brook
5	Sinop Ayancık Türkeli road junction Ayancık Brook
6*	Sinop Ayancık Türkeli road junction Ayancık Brook
7	Sinop Durağan Yalnız Kavak location Gökırmak Water
8*	Sinop Durağan-Boyabat Yalnız Kavak location Gökırmak Water
9	Sinop Boyabat Sinecan Village location Kırkgeçit Brook
10*	Sinop Boyabat Sinecan Village location Kırkgeçit Brook

*Control group: Water samples taken from fresh water sources away from high voltage lines

incubation. The pink-red colored coliform bacteria that formed; dark blue-purple colored colonies were detected as *E. coli* bacteria. Total coliform bacteria number was assessed as the total number of all pink-red and blue-purple colonies seen in the Petri dishes.

Data Analysis

Na+, K+, Cl-, conductivity, *E. coli*, coliform and T. coliform bacteria analysis of water samples was conducted by using SPSS 21.0 program. Mann-Whitney-U test was used in the analysis of data and 0.05 error margin was taken as basis. SPSS. (2013). IBM SPSS Statistics 21.0 for Windows. Armonk, NY.

RESULTS AND DISCUSSION

Na^+, K^+ , Cl^-, pH and conductivity values of water samples are given in Table 2. As can be seen in Table 2, Na^+, K^+ and Cl^- values were found to be in expected levels (T. C. Official Gazette, 2019) and no statistical difference was found between the values. Conductivity results were found to show a proportional change with pH results. However, no significant difference was found between the values (Man-Whitney U, $p>0.05$).

Table 3 shows *E. coli*, coliform and T. coliform values of water samples at the end of 24 hours. Although there were differences between *E. coli*, coliform and T. coliform values, no significant difference was found between these values (Man-Whitney U, $p>0.05$).

All the results obtained were assessed according to 06.07.2019 dated and 30823 numbered 'Legislation on the quality and treatment of water from which drinking water is obtained' in T. C. Official Gazette. According to the results of the present study conducted, no statistical difference was found chemically or microbiologically in samples taken from rivers close to or far away from high voltage lines in the province of Sinop. As can be seen in Table 2, although there are numerical differences between values in terms of Na^+ and K^+, there is no statistical difference. Similar conclusions were made between samples in terms of Cl^- contents (Table 2). As can be seen in Table 2, it can be said that there was an increasing graph between pH values from the first sample to the last sample and that this resulted from the decrease in the rate of carbon dioxide dissolved in water. The pH results meet the pH value that is required in drinking water (Official Gazette, 2019) and when examined with conductivity table, it was found to be directly proportional to pH values and no statistical difference was found. It is known that electromagnetic frequency affects the formation of hydrogen peroxide in water and also oxygen formation indirectly; however, this formation is also influenced by environmental conditions such as temperature and lighting (Baghdasaryan et al., 2012).

There are a great number of studies showing that magnetic field has biological effects on living organisms (Draper et al., 2005). Bacteria, which are

Table 2. Chemical analysis of water samples
Çizelge 2. *Su örneklerinin kimyasal analizi*

Sample No	(me/l)			pH	Conductivity
	Na^+	K^+	Cl^-		
1	6	0.2	4	7.61	361
2*	6	0.2	4	7.77	370
3	6	0.2	4	7.83	368
4*	5	0.2	4	7.86	370
5	7	0.2	5	7.87	374
6*	6	0.2	4	7.89	376
7	6	0.2	4	7.89	374
8*	7	0.2	5	7.90	369
9	6	0.2	4	7.91	371
10*	6	0.2	4	7.90	374
Mean±S.D	6.10±0.56		4.20±0.42	7.84±0.09	370.7±4.29
p	0.606		1.000	0.674	0.596
U	10.500		12.500	10.500	10.000

Table 3. E. coli, coliform and T. coliform values of water samples at the end of 24 hours
Çizelge 3. *24 saat sonunda su örneklerinden alınan E. coli, koliform ve T. coliform değerleri*

Sample No	E. coli	Coliform	T. coliform
1	2.200	1.200	3.400
2*	2.150	1.000	3.150
3	2.300	1.050	3.350
4*	2.250	1.100	3.350
5	2.400	1.100	3.500
6*	2.500	1.050	3.550
7	2.350	1.150	3.500
8*	2.150	1.400	3.550
9	2.100	1.100	3.200
10*	2.050	1.250	3.300
Mean±S.D	2.245±142.30	1.140±117.37	3.385±141.51
p	0.463	1.000	1.000
U	9.000	12.500	27.500

easy to produce in the laboratory and which have many effects on the health of living organisms, are important research models in the field. It is known that being exposed to magnetic field has a great number of physiological effects such as the permeability of ion channels in cytoplasmic membrane, formation of free radicals and active oxygen and degradation of cell wall. In addition, it has been shown in a great number of studies that the electromagnetic field used has antibacterial effect in bacteria cell through cell wall synthesis, protein synthesis, nucleic acids, essential enzymes and inhibition of the change in membrane permeability (Balaji, 2015). In this study, when the results were compared with the control group, it was found that the bacteria (*E. coli*, coliform, Total coliform) existed in the samples taken first and that they were approximately the same rate with the samples 24 hours later (Table 3). There are no settlements around the brooks and streams, in Sinop, water samples were taken from. Thus, it is not possible for city sewage to blend in underground water, brooks and streams. It is thought that the presence of these bacteria in the water resulted completely from the animals in natural life and the wastes of the cattle villagers brought for grazing. It can be said that this water is not suitable for drinking microbiologically (T. C. Official Gazette, 2019).

In recent years, studies about the effect of magnetic field in laboratory medium on the health of living organisms and the sterilization of contaminated water are standing out. Samarghandi et al., (2016) found that using magnetic field caused a significant increase in the number of coliform, Total coliform and Heterotrophic bacteria, while it did not cause a significant change in temperature, pH and degree of opacity. The results of this study are similar to the results of our study in terms of pH results. Salmen et al., (2018) examined the effect of high frequency electromagnetic fields (HF-EMF at 900 and 1800 MHz) on the growth speed and antibiotic susceptibility of *Staphylococcus aureus, Staphylococcus epidermidis* and *Pseudomonas aeruginosa.* In the study, the bacteria were exposed to 900 and 1800 MHz up to 12 hours; however, it was found that electromagnetic field did not have a significant effect on growth speed and antibiotic susceptibility. This study is similar to our study in terms of antibiotic susceptibility. In our study, magnetic field transmitted by high voltage line was not found to have any effect on the number of bacteria. Unlike our study, in a study conducted by Nascimento et al., (2003), a significant increase was found in the growth rate and glucose consumption of *E. coli* bacteria exposed to electromagnetic field in laboratory medium. Al-Khaza'leh and Al-Fawwaz (2015) researched the effect of magnetic field on the growth rate of three different bacteria strains (*E. coli, Staphylococcus aureus* and *Bacillus subtilis*). The results showed that the growth rate of *E. coli* and *S. aureus* bacteria decreased 24 hours after they were exposed to magnetic field (30, 50 and 80 mT), while the growth of *B. subtilis* was found to increase. In a study they conduced to examine the effect of magnetic field on antibiotic susceptibility, Gaafar et al., (2006) stated that antibiotic susceptibility increased 6 hours later. It is possible

to increase these studies. In our study, there was no decrease or increase in *E. coli*, coliform and *T. coliform* samples kept for 24 hours and similar results to the initially obtained results were found. The reason for this can be the fact that the other studies were conducted by exposing the bacteria to different frequencies and periods of magnetic field under laboratory conditions. In addition, the magnetic field transmitted by high voltage lines in the areas from where we took the samples may have not influenced the biology of these bacteria.

CONCLUSION

With this study, the effects of high voltage lines in the province of Sinop on fresh water sources were examined and it was concluded that there were no significant differences. No statistically significant difference was found in all of the parameters examined. In the light of the parameters examined, it can be said that the high voltage lines in areas from where samples were taken did not degrade the chemistry of the water and microbial degradation was not observed.

Since studies conducted so far were conducted under laboratory conditions and with limited frequency, it is not possible to say something definite about the effects of electromagnetic fields on living organisms and non-living matters (Redlarski et al., 2015). At the same time, there are no studies discussing the effects of magnetic field on the chemistry and biology of water. For this reason, the number of studies conducted is increasing every day and becoming more important. More extensive scientific studies should be conducted on this topic and the society should be warned against possible effects.

Note: This study is a summary of the Master's Thesis titled "Analysis of the Effects of Existing High Voltage Lines in the Province of Sinop on Fresh Water Sources" (Sinop University, Department of Interdisciplinary Environmental Health).

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