Metallic and Microbial Contaminants in Drinking Water of Cankiri, Turkey

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Abstract: Safe and good quality drinking water is very important for human health. Water provides some heavy metals, such as As, B, Cd, Cn, Cr, Cu, F, Cl, Hg, Ni, Pb, Se, and Sn. These are undesirable substances dangerous to human health and cause chronic diseases and various cancers. Coliform bacteria are a commonly used bacterial indicator of sanitary quality of water. *E. coli*, total coliform and enterococci have been used as indicators of possible sewage contamination might pose a health risk. In this study, water samples were taken from thirty different waterworks in Cankiri, Turkey and metallic and microbial contaminants were investigated. In the drinking tap water samples have been found at concentrations exceeding the Turkish regulations (As and free Cl) and the WHO guidelines (As and B). Our results also indicate that significant microbiological contaminations were found above the guidelines for drinking waters given by the WHO, because of the fact that in the distribution of water is not appropriate.

Keywords: Heavy metal, Drinking water, Microbiological, Arsenic, Boron, Health, Turkey.

Introduction

Safe and good quality drinking water provides some heavy metals, and it is precious resource essential for sustaining human life and health. The ultimate source of these elements is generally rocks. There are different ways of metallic contamination of drinking water such as rainwater and rivers collect metals while passing through the soil or the dangerous products from industry, agriculture and other human activities enter the rivers, lakes, and underground water. The contamination of water is also related to during the treatment, reserving and distribution processes.

Many chemicals and microbes have been reported as pollutants of drinking water. Commonly reported heavy metals include arsenic (As), boron (B), cadmium (Cd), cyanide (Cn), chromium (Cr), copper (Cu), fluorine (F), free chlorine (Cl), mercury (Hg), nickel (Ni), lead (Pb), selenium (Se), and antimony (Sn)¹. Health concerns are also associated with metallic contaminants that have the ability to cause adverse health effects after prolonged

periods of exposure. They cause serious diseases such as, reproductive, cardiovascular and neurological disease or various cancers²⁻⁸.

Commonly found in drinking water microbes include enterococcus, coliform, and *E. Coli*. The main source of microbiological contamination is microorganisms from sewage causing serious digestive tract diseases such as diarrhoea⁹.

The aim of this study is to determine the metallic and microbial contaminants drinking water of Cankiri and its villages and to check compliance with respect to Turkish legislation and WHO guidelines for the occurrence of toxic and/or harmful components in drinking water.

Experimental

The chemical and microbiological dataset of thirty different waterworks were obtained from the Health Directorate of Cankiri for this study. Drinking water samples were collected from centre of Cankiri City and villages from near Cankiri City in August 2009 (Table 1). Samples were collected from residential tap water according to correct sampling techniques to analyze chemical and microbiological them.

Table 1. Water sampling locations.

Location no	Location name
I	Karatekin park
II	100 th year Orphanage
III	Superior reservoir
IV	Inferior reservoir
V	Ahlat village
VI	Akcavakif village
VII	Akoren village
VIII	Alanpinar village
IX	Asagicavus village
X	Asagipelitozu village
XI	Asagiyanlar village
XII	Ayan village
XIII	Ayan village Deliklikaya quarter
XIV	Basegmez village
XV	Civi village
XVI	Civi village Dede quarter
XVII	Degim village
XVIII	Derecati village
XIX	Germece village
XX	Hasakca village
XXI	Hidirlik village
XXII	Icyenice village
XXIII	Inanc village
XXIV	Inandik village
XXV	Konak village
XXVI	Pasa village
XXVII	Suleymanli village
XXVIII	Tuzlu village
XXIX	Tuney village
XXX	Yukaricavus village

The concentrations of elements As, Cd, Cr, Cu, Hg, Ni, Pb, Se, and Sn were measured using Inductively Coupled Plasma-Optical Emission Spectrophotometer (ICP-OES) (Varian Vista, Australia). As concentration in samples was measured using atomic absorption spectrophotometer (Perkin Elmer HGA 700, USA). B, F, NO_3^- , and NO_2^- were analyzed by using Ion Chromatography technique (Dionex DX-600, USA). Cn was analyzed colorimetrically (Hach) Pyridine-Pyrazalone Metot spectrophotometric kit (Merck) with Hach DR/2500 Spectrophotometer, USA. Determination in water of free Cl was also performed colorimetrically using diethyl-p-phenylenediamine. Detection and enumeration of coliform bacteria, *E.coli* and Enterococci was performed using membran filtration method¹⁰. The all data were analyzed descriptive statistically by software program (SPSS 15.0 for Windows).

Results and Discussion

The chemical values of the drinking water samples including As, B, Cd, Cn, Cr, Cu, F, free Cl, Hg, Ni, NO_3^- , NO_2^- , Pb, Se, and Sn from Cankiri-Turkey were given in Table 2. Several quality assessment studies on drinking tap water have been carried out¹²⁻¹⁴.

Table 2. Chemical values of the drinking water samples from Cankiri, Turkey ($\mu\text{g/L}$).

Location	As TR ^a = 10 WHO ^b = 10	B TR ^a = 1000 WHO ^b = 500	Cd TR ^a = 5 WHO ^b = 3	Cn TR ^a = 50 WHO ^b = 50	Cr TR ^a = 50 WHO ^b = 50	Cu TR ^a = 2000 WHO ^b = 2000	F TR ^a = 1500 WHO ^b = 1500	Free Cl TR ^a = 500 WHO ^b = 5000	Hg TR ^a = 1 WHO ^b = 0.6	Ni TR ^a = 20 WHO ^b = 70	NO_3^- TR ^a = 50000 WHO ^b = 50000	NO_2^- TR ^a = 500 WHO ^b = 200	Pb TR ^a = 25 WHO ^b = 10	Se TR ^a = 10 WHO ^b = 10	Sb TR ^a = 5 WHO ^b = 5
I	10.7	160	< 1.4	< 1.0	< 7.0	< 3.2	240	1000	< 0.2	4.90	4630	< 50	< 7.0	< 0.5	< 2.0
II	8.92	280	< 1.4	1.0	< 7.0	< 3.2	240	< 50	< 0.2	6.20	6330	< 50	< 7.0	< 0.5	< 2.0
III	8.19	360	< 1.4	< 1.0	< 7.0	11	240	< 50	< 0.2	5.10	6860	< 50	< 7.0	< 0.5	< 2.0
IV	13.1	200	1.40	1.0	< 7.0	< 3.2	300	< 50	< 0.2	5.10	5020	< 50	< 7.0	< 0.5	< 2.0
V	9.96	130	< 1.4	1.0	15.7	3.3	260	< 50	< 0.2	< 3.7	1050	< 50	< 7.0	< 0.5	3.10
VI	8.16	130	< 1.4	< 1.0	< 7.0	11	370	< 50	< 0.2	< 3.7	8850	< 50	< 7.0	< 0.5	< 2.0
VII	4.32	400	< 1.4	1.0	7.90	< 3.2	1140	< 50	< 0.2	< 3.7	26300	< 50	< 7.0	< 0.5	< 2.0
VIII	1.25	60	< 1.4	< 1.0	< 7.0	8	190	< 50	< 0.2	< 3.7	760	< 50	< 7.0	< 0.5	< 2.0
IX	7.45	130	< 1.4	1.0	10.7	5	190	< 50	< 0.2	6.10	4360	< 50	< 7.0	< 0.5	< 2.0
X	3.96	210	1.40	1.0	< 7.0	< 3.2	690	100	< 0.2	< 3.7	38400	< 50	< 7.0	< 0.5	< 2.0
XI	1.57	110	< 1.4	1.0	18.5	10	150	< 50	< 0.2	5.60	5570	< 50	< 7.0	< 0.5	< 2.0
XII	7.73	130	< 1.4	1.0	10.5	5	230	< 50	0.32	4.50	4290	< 50	< 7.0	< 0.5	< 2.0
XIII	55.7	480	< 1.4	1.0	< 7.0	7	310	< 50	< 0.2	5.10	6200	< 50	< 7.0	< 0.5	< 2.0
XIV	3.13	65	< 1.4	1.0	< 7.0	11	320	< 50	< 0.2	< 3.7	410	< 50	< 7.0	< 0.5	< 2.0
XV	1.65	100	< 1.4	1.0	< 7.0	4	150	< 50	< 0.2	5.60	11400	< 50	< 7.0	< 0.5	< 2.0
XVI	1.69	100	< 1.4	1.0	8.40	15	140	< 50	0.36	5.40	11400	< 50	< 7.0	< 0.5	< 2.0
XVII	27.6	160	< 1.4	1.0	< 7.0	5	200	< 50	< 0.2	5.10	1430	< 50	< 7.0	< 0.5	< 2.0
XVIII	4.0	< 60	< 1.4	1.0	< 7.0	3.2	90	< 50	< 0.2	< 3.7	1810	< 50	< 7.0	< 0.5	< 2.0
XIX	3.39	460	1.70	1.0	< 7.0	12	220	< 50	< 0.2	< 3.7	2130	< 50	< 7.0	< 0.5	< 2.0
XX	1.55	110	< 1.4	1.0	10.1	6	160	< 50	0.24	6.30	11500	< 50	< 7.0	< 0.5	< 2.0
XXI	5.72	680	< 1.4	< 1.0	< 7.0	24	240	< 50	< 0.2	< 3.7	3340	< 50	< 7.0	< 0.5	< 2.0
XXII	7.65	360	< 1.4	< 1.0	< 7.0	7	300	< 50	< 0.2	< 3.7	14200	< 50	< 7.0	< 0.5	< 2.0
XXIII	1.79	100	1.40	1.0	< 7.0	10	170	< 50	< 0.2	4.80	11400	< 50	< 7.0	< 0.5	< 2.0
XXIV	3.01	430	< 1.4	1.0	< 7.0	< 3.2	260	< 50	< 0.2	< 3.7	2060	< 50	< 7.0	< 0.5	< 2.0
XXV	3.87	450	< 1.4	1.0	< 7.0	29	220	< 50	< 0.2	4.10	2030	< 50	< 7.0	< 0.5	< 2.0
XXVI	5.98	230	< 1.4	1.0	< 7.0	7	280	< 50	0.20	< 3.7	3120	< 50	< 7.0	< 0.5	< 2.0
XXVII	1.52	110	1.60	1.0	17.2	34	160	< 50	< 0.2	5.70	5510	< 50	< 7.0	< 0.5	< 2.0
XXVIII	12.4	210	< 1.4	1.0	< 7.0	13	260	< 50	0.20	6.90	5060	< 50	< 7.0	< 0.5	< 2.0
XXIX	3.95	910	< 1.4	1.0	< 7.0	< 3.2	220	< 50	< 0.2	5.30	8270	< 50	< 7.0	< 0.5	< 2.0
XXX	4.06	120	< 1.4	< 1.0	< 7.0	5	150	< 50	< 0.2	< 3.7	140	< 50	< 7.0	< 0.5	< 2.0

^a Guide values established by Turkish legislation for drinking water¹¹. ^b Guideline values established by the World Health Organization for drinking water¹.

Arsenic in the investigated water samples were found in the range of 1.25-55.77 µg/L. The arsenic values in Karatekin park and inferior reservoir at the centre of Cankiri, Ayan village Deliklikaya quarter, Degim village near Cankiri were found above the Turkish and WHO recommended value for drinking water (10 µg/L)^{1,11}. Concentrations of arsenic in drinking water samples were found to be ranging between 10 and 50 µg/L in 22 points and were found to be >50µg/L in 5 stations of Aksaray in Turkey¹⁵. The presence of arsenic in water sources resulted from leaching of arsenic from rocks and sediments. It is known that long time absorption of arsenic can cause neurological, dermal, hematopoietic, reproductive, and carcinogenic (dermis and lung) diseases^{16,17}; whereas positive relationships between low-dose As exposures and cumulative incidence ratios of bladder, lung and urinary-related cancers were recently found¹⁸.

The boron concentrations were found in the range of <60-480 µg/L. B in Hidirlik and Tuney village's samples was above according to the limit of 500 µg/L permitted by WHO in drinking waters; whereas the values of stations of 7, 13, 19, 24, 25 (400-480 µg/L) were slightly below that limit¹. Col and Col (2003) found higher boron levels in waters of Kutahya-Turkey resulted from rich boron mine areas¹⁹. Boron is found naturally in groundwater, but its presence in surface water is frequently a consequence of the discharge of treated sewage effluent, in which it arises from use in some detergents, to surface waters. In laboratory animals, chronic low-level boron exposure has demonstrated to cause reduced growth, cutaneous disorders and suppression of male reproductive system function²⁰.

Fluoride in the drinking water samples were found in the range of 90-1140 µg/L. F concentrations in Akoren village sample (1140 µg/L) slightly below the Turkish regulation and WHO guidelines established for drinking water (1500 µg/L)^{1,11}. Ruiz-Payana et al.²¹ found fluoride content in wells and tap water samples of Villa Ahumada-Mexico ranged from 5000 to 5700 µg/L. Fluoride is present in many waters, with higher concentrations often associated with underground sources in areas rich in fluoride-containing minerals. Epidemiological evidence about exposure to high concentrations of fluoride can carry an increasing risk of dental fluorosis, and progressively higher concentrations lead to increasing risks of skeletal fluorosis²².

Disinfection of drinking water in developing countries is done primarily with free chlorine, commonly available as chlorine bleach. The concentration of free chlorine should normally be such that it should not give rise to unacceptable tastes and should not normally exceed Turkish regulation (500 µg/L) and WHO (5000 µg/L) guidelines values for free chlorine^{1,11}. Removing excess chlorine is important to prevent taste problems. The levels of free Cl in the samples were found in the range of <50-1000 µg/L. The value of Karatekin Park at the centre of Cankiri was above the Turkish regulation criteria. In Nakhon Pathom Municipality-China, Panyakapo et al.²³ found residual concentration of chlorine in tap water and swimming pool water ranged from nondetectable to 900 µg/L and from nondetectable to 8510 µg/L, respectively. Chlorine reacts with natural organic matter and/or inorganic substances occurring in water to form various chlorination by-products (CBPs) such as trihalomethanes (THMs), haloacetic acids (HAAs) and other undesirable compounds²⁴. Toxicological and epidemiological studies have been carried out to establish relationships between levels of CBPs in drinking water and various carcinogenic, genotoxic and adverse reproductive health effects²⁵.

The nitrate levels in all stations were ranged from 410 to 38400 µg/L. The values of Akoren and Asagipelitozu village were slightly below Turkish and WHO recommended limits^{1,11}. In 2003, the nitrate levels were found in the water supply Tenerife island-Spain (maximum concentration 57300 µg/L²⁶). The important source of human exposure in drinking water to nitrate by rain and irrigation water washing through soils that have been

treated excessively with nitrated fertilizers. Nitrates are involved in the origin of highly toxic compounds like nitrites and nitrosamines. Nitrite can produce metahaemoglobinaemia, and nitrosamines are known to cause certain cancers, adverse pregnancy outcomes, diabetes, and thyroid disorders²⁷.

The antimony content of the samples was in the range of <0.2-3.10 µg/L. Sb was found in the water sample of Ahlat village (3.10 µg/L) and it was slightly below the recommended limits of Turkish legislation and WHO^{1,11}. Sb is present in the aquatic environment as a result of rock weathering, soil runoff and human activities. There is some evidence for the carcinogenicity of certain antimony compounds by inhalation, but there are no data to indicate carcinogenicity by the oral route²⁸.

Table 3. Microbiological values of the drinking water samples from Cankiri, Turkey (cfu/100 ml).

Location	Coliform bacteria TR ^a = 0; WHO ^b = 0	<i>E.coli</i> TR ^a = 0; WHO ^b = 0	Enterococci TR ^a = 0; WHO ^b = 0
I	0	0	0
II	0	0	0
III	0	0	1
IV	1	1	2
V	0	0	0
VI	0	0	56
VII	0	0	0
VIII	0	0	1
IX	0	0	1
X	0	0	0
XI	0	0	1
XII	0	0	2
XIII	0	0	14
XIV	1800	1800	90
XV	0	0	0
XVI	3	3	0
XVII	0	0	2
XVIII	0	0	110
XIX	0	0	32
XX	2	0	0
XXI	0	0	1
XXII	0	0	3
XXIII	1	1	0
XXIV	100	100	126
XXV	0	0	0
XXVI	500	0	3
XXVII	600	0	116
XXVIII	0	0	0
XXIX	0	0	2
XXX	0	0	2

Table 3 shows microbiological contamination values found in the drinking water collected from thirty location of Cankiri. The highest *E. Coli* and total coliform value (1800 cfu/100 mL) were detected in drinking water collected from Basegmez village of Cankiri, while the highest Enterococci value (126 cfu/100 mL) was found in samples collected from

Inandik village of Cankiri. The presence of *E. coli* is indicative of a fecal contamination and the highly probable presence of pathogens²⁹. In addition, the presence of these microbial contaminants in drinking water must at least be considered as a possible threat or indicative of microbiological water quality deterioration.

Conclusion

The concentrations of the investigated heavy metals (As, B, and free Cl) in the drinking water samples from Cankiri/Turkey were found above the guidelines for drinking waters given by the Turkish legislation and WHO. However, it was concluded that drinking waters in Cankiri contain low other investigated heavy metal levels. This study, therefore, recommends the government and other responsible authorities to prevent any kind of metallic and microbial contaminants into water sources that supply domestic drinking water.

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