Levels of Heavy Metals and Certain Macro Elements in Potable and Tap Water at Van City Center

Van Şehir Merkezindeki İçme ve Musluk Suyunda Bulunan Ağır Metaller ve Bazı Makro Element Seviyeleri

Research Article

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ABSTRACT

In this study, conducted on 100 samples of potable water and tap water taken from 10 different water stations selected randomly from various locations within Van City center, levels of heavy metals (lead, manganese, cadmium, zinc, copper, iron, nickel, cobalt) and certain macro elements (magnesium, sodium, calcium) were determined with Atomic Absorption Spectrophotometer (AAS). Heavy metal concentrations of water samples were found to be as follows: Pb 0.016-0.082 mg/L, Mn 0.007-0.015 mg/L, Cd 0.001-0.005 mg/L, Zn 0.03-0.40 mg/L, Cu 0.006- 0.11 mg/L, Fe 0.001-0.18 mg/L, Ni 0.012-0.046 mg/L, Co 0.007-0.014 mg/L; and macro element concentrations were as follows: Mg 6.78-6.81 mg/L, Na 3.88-6.68 mg/L and Ca 31.06-38.49 mg/L. According to the above data, lead levels in all water samples are found to be over national and international standards.

Key Words
Water, Heavy Metal, Macro Element, Van

ÖZET

Van şehir merkezinde bulunan değişik yerlerden rastgele seçilen 10 farklı istasyondan alınan 100 içme ve musluk suyu numunesi üzerinde yapılan bu çalışmada ağır metal (kurşun, mangan, kadmiyum, çinko, bakır, demir, nikel, kobalt) ve bazı makro element (magnezyum, sodyum, kalsiyum) seviyeleri Atomik Absorbsiyon Spektrometresiyle (AAS) belirlendi. Su numunelerinin ağır metal seviyeleri şöyle bulundu: Pb 0.016-0.082 mg/L, Mn 0.007-0.015 mg/L, Cd 0.001-0.005 mg/L, Zn 0.03-0.40 mg/L, Cu 0.006- 0.11 mg/L, Fe 0.001-0.18 mg/L, Ni 0.012-0.046 mg/L, Co 0.007-0.014 mg/L; makro element seviyeleri ise şöyleydi: Mg 6.78-6.81 mg/L, Na 3.88-6.68 mg/L ve Ca 31.06-38.49 mg/L. Bu verilere göre tüm su numunelerindeki kurşun seviyesi ulusal ve ulus→lar arası standartların üstünde bulunmaktadır.

Anahtar Kelimeler:
Su, Ağır Metal, Makro Element, Van

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INTRODUCTION

All living beings need water to survive. That is because the cells constituting the living organism need water to be able to sustain life functions. Drinking (potable) water forms up the principal source of water necessary for the organism. Therefore, cleanliness of water consumed is very important in terms of health. Water pollution is seen when exogenous impurities mix with water. Organic, inorganic, biologic and radioactive substances which may be found in water at levels negatively affecting the utilization of water sources and thus decreasing their quality indicate water pollution. Since water possesses dissolving power, certain organic and inorganic substances dissolve in water by means of contact, changing the taste and smell of water. Water pollution affects human health as a result of water utilization for drinking and other various purposes [1].

Among inorganic pollution parameters, heavy metals are the most important. Heavy metals are compounds found naturally in earth crust. They do not degrade and can not be destroyed. They enter, up to a small amount, into human body by means of food, potable water and air. Some heavy metals (e.g. copper, selenium, zinc) are essential to sustain human metabolism. However, although they are significant for living beings, they create a toxic effect by means of accumulating within the structure of organisms after a certain concentration [2]. Metals having a strong toxic effect in general even at tiny amounts can be found in waters in forms of free ions, organic or inorganic compounds and as absorbed by particulates of substances [3]. It is stated that heavy metal ions and compounds absorbed and settled down (sediment) transform into ionic forms with different upgrade stages through various physical and chemical events and impose toxic effects [4].

Inorganic pollution can arise from natural contamination and residues from industry and mining. Copper, lead, cadmium, mercury, arsenic and zinc are the most important ones among metals which can be damaging even at small amounts. Consequent pollution by iron, sulfate and hydrogen ions from acid mine drainage may also create problems. Some elements are already existent in water and main factors are the mineral texture from where water springs or through which it passes along with soil structure and water basin bed.

Some harmful items (such as elements and bacteria) may come from environmental sources (contaminated soil, waste areas, fertilizers and areas with chemical texture). Also, increase in concentrations of minerals in water such as calcium, sodium, manganese, which naturally exist in nature and water is also seen as a reason for pollution. Natural aggressive water as well as water chemically processed may wear down transmission facilities and may dissolve and include metals such as iron, copper and lead. Pipes, valves, pumps, fittings and end point installation materials (faucets, basins, fountains, coolers, distributors) are all potential sources of contribution. Undesired heavy metals and other impurities in water mostly come from such resources [5].

Studies had been made previously by Ekin and Bildik [6] and Ağaoğlu et. al. [7] on heavy metal levels in waters of Van region. However, whether obtained from surface waters like dams and rivers or from underground waters, chemical composition of all waters may undergo changes depending on their natural and anthropogenic processes. Therefore, it is important to regularly monitor the element ingredient of utility water, which may also be used as potable water from time to time. With this purpose, in this study potable and tap water obtained from Van City center was analyzed with respect to heavy metals and macro elements and compliance of such data with national and international standards was investigated.

Standards for potable and tap waters determined by international organizations such as World Health Organization (WHO), Environmental Protection Agency (EPA) and European Community (EC) are accepted by many countries. With the recent changes made in our country, standards and regulations were also made compliant with such organizations. National [8,9] and international [10-12] standards as well as macro elements and heavy metals in potable waters are given in Table 1.

Table 1. Heavy metal concentrations of water samples in Van N=10, x±SE: average ± standard deviation.

Station	Lead (mg/L)	Mangan (mg/L)	Cadmium (mg/L)	Zinc (mg/L)	Copper (mg/L)	Iron (mg/L)	Nickel (mg/L)	Cobalt (mg/L)
Maraş Cad.	0.038±0.007	0.007±0.001	0.002±0.00	0.07±0.02	0.009±0.003	0.007±0.001	0.029±0.007	0.012±0.002
Ordu Cad.	0.071±0.012	0.008±0.001	0.001±0.00	0.40±0.2	0.01±0.006	0.008±0.002	0.039±0.006	0.007±0.002
Sıhke Cad.	0.064±0.007	0.01±0.002	0.001±0.00	0.39±0.3	0.009±0.002	0.013±0.006	0.048±0.01	0.009±0.001
Cumhur.	0.082±0.008	0.01±0.001	0.001±0.00	0.05±0.02	0.007±0.002	0.001±0.002	0.053±0.009	0.009±0.003
İki Nisan	0.016±0.003	0.01±0.001	0.002±0.00	0.03±0.02	0.006±0.001	0.015±0.004	0.009±0.003	0.007±0.002
İskele cad 1	0.027±0.004	0.01±0.001	0.002±0.00	0.06±0.03	0.007±0.002	0.014±0.003	0.015±0.004	0.01±0.004
İskele cad2	0.022±0.006	0.015±0.001	0.004±0.001	0.06±0.03	0.011±0.002	0.018±0.004	0.021±0.004	0.009±0.003
İpekyolu	0.029±0.008	0.012±0.002	0.003±0.001	0.17±0.1	0.008±0.002	0.015±0.004	0.012±0.003	0.009±0.003
Erciş yolu	0.029±0.005	0.011±0.002	0.004±0.001	0.11±0.07	0.009±0.002	0.017±0.002	0.046±0.02	0.009±0.004
Kale yolu	0.019±0.003	0.013±0.001	0.005±0.001	0.07±0.03	0.008±0.004	0.016±0.006	0.024±0.007	0.014±0.006

MATERIAL AND METHOD

A total of 100 samples obtained from potable and tap water in Van City center were used as the material of this study. With this purpose, predetermined 10 stations were selected as pilot regions and 10 different sample taking points were determined within each region. Water samples were collected periodically during February–March 2010 period. Rules indicated in were used for taking samples [13]. Samples brought to Main Discipline Laboratory at cold chain were analyzed in terms of certain heavy metals (lead, manganese, cadmium, zinc, copper, iron, nickel, cobalt) and macro elements (magnesium, sodium, calcium) and kept at +4ºC until analyses are finalized [14].

Element measurements were executed in Atomic Absorption Spectrophotometer (PYE UNICAM SP 2900) [15]. Concentration method was used in the analyses [16]. Preparation of sample containers: Plastic containers of 1 L were used for sample taking. Containers were washed with pure water and kept soaked in nitric acid (20%) for 24 hours. They were then made ready for sample taking by being rinsed with bi-distillated water for a few times [17-20].

DISCUSSION AND CONCLUSION

Heavy metal levels of 100 samples collected from Van City center are shown in Table 1 and macro element levels are shown in Table 2. In case certain rules are not observed and sufficient care is not taken whilst distributing treated waters within the city and to houses, they may well get polluted (within water mains) meanwhile. For this reason, water supply network pipes must be made of appropriate materials and should not release any toxic substances into the water. Particularly waters saturated with CO_2 are acidic and therefore aggressive due to the carbon dioxide contained. This acid transforms metals into water-soluble bicarbonate salts (such as lead bicarbonate, copper bicarbonate) and causes them to mix into water. In such a case, chronical metal poisoning is observed with people who consume these waters.

The most well known among such is heavy lead poisoning. For this reason, care must be taken to avoid water pipes from containing lead and pumps from containing copper [21].

Ekin and Bildik determined the following heavy metal level intervals within waters from Van City center: lead: 0.005-0.024 mg/L; zinc: 0.005-0.220 mg/L; iron: 0.01-3 mg/L; copper: 0.005-0.035 mg/L; cadmium: < 0.005 mg/L [6]. In the study conducted by Ağaoğlu et.al.[22] average levels within tap water from Van region were found to be as 0.19 mg/L for iron, 0.06 mg/L for copper, 0.10 mg/L for zinc, 0.09 mg/L for manganese, 0.07 mg/L for cadmium, 0.03 mg/L for chromium, 0.04 mg/L for nickel, 0.12 mg/L for cobalt. Ağaoğlu et.al. [7] also found the following average levels within tap water from Van region: 1.69 mg/L for sodium, 10.80 mg/L for magnesium and 11.117 mg/L for calcium [7]. Soylak et.al found the following level intervals within potable water from Yozgat region: 15-120 mg/L for calcium, 3-47 mg/L for magnesium, 0.17- 1.19 μg/l for copper, 16.1- 79.3

Table 2. Macro element levels of water samples in Van N=10, x±SE: average ± standard deviation

Station	Magnesium (mg/l)	Sodium (mg/l)	Calcium (mg/l)
Maraş Cad.	0.038±0.007	0.007±0.001	0.002±0.00
Ordu Cad.	0.071±0.012	0.008±0.001	0.001±0.00
Sıhke Cad.	0.064±0.007	0.01±0.002	0.001±0.00
Cumhur.	0.082±0.008	0.01±0.001	0.001±0.00
İki Nisan	0.016±0.003	0.01±0.001	0.002±0.00
İskele cad 1	0.027±0.004	0.01±0.001	0.002±0.00
İskele cad2	0.022±0.006	0.015±0.001	0.004±0.001
İpekyolu	0.029±0.008	0.012±0.002	0.003±0.001
Erciş yolu	0.029±0.005	0.011±0.002	0.004±0.001
Kale yolu	0.019±0.003	0.013±0.001	0.005±0.001

μg/l for iron, 0.18- 0.99 μg/l for lead, 0.15-2.56 μg/l for manganese [23]. Lead amounts were found to be varying between 0.07-0.66 mg/L (average 0.24 mg/L) as a result of the study conducted by Koçak and Güner on potable and tap waters at Erzurum City center [24].

Lead levels in potable and tap waters of Van City center were determined to be between 0.016-0.082 mg/L and this amount is found to be above national and international standards. Lead is a toxic metal which performs no duty within human body at all. Major sources for lead contamination in potable water are water tanks and transportation tankers [25].

Lead used in city and hose water installations, particularly at junction points, is one source for lead contamination. Moreover, lead oxide densely contain within the air due to various reasons contaminates into water sources and therefore may create harmful effects on human health by being consumed via food products. It is shown that this element plays a role in significant carcinogenesis, particularly including mouth, esophagus, lung, breast, colon cancers. It is also shown that lead used in old water distribution systems has negative effects on neurodevelopment and growing up of children and causes behavioral disorders [26]. Cumhuriyet, Ordu and Sıhke are the streets with highest lead levels. Such high levels in waters from these streets could probably originate from water network pipes. Manganese level interval determined in this study is 0.007-0.015 mg/L and manganese levels in samples of potable water taken from İskele and İpekyolu streets and Erciş and Kale roads are above TSI, EPA, EC and I.T.A.S.H.Y. standards but below WHO standards. Manganese and iron are considered to be the least toxic among heavy metals. However, levels higher than 0.1 mg/L in drinking water causes a bad flavor [27-29].

Cadmium levels determined in this study is between 0.001-0.005 mg/L. Although these values do not exceed TSI, EPA, EC and İ.T.A.S.H.Y. standards, cadmium levels in water samples taken from İskele street and Erciş and Kale roads were above the standards indicated by WHO. Cadmium is a heavy metal with its carcinogenic effect in humans approved as certain by UNEP (United Nations Environment Program). Cadmium causes cancer in lungs, reproduction system, excretory system and prostate. It also creates kidney damages and emphysema [30].

Zinc levels determined in this study in Van City potable waters is between 0.03-0.40 mg/L. This level interval is compliant with national and international standards. Zinc is the metal ion with the highest permissible level within potable water. It does not cause significant damages in terms of human health. However, in cases of excess zinc consumption, formation of lung emphysema, arteriosclerosis, anemia, hemorrhage points in liver, kidneys, spleen, heart and brain and degenerative disorders have been reported [31,28].

Existing levels of zinc in tap waters are around 0.01-1 mg/L. In case these levels exceed 5 mg/L in surface waters into which industrial wastes leak, a harsh to sour taste in the mouth, acid reflux and a greasy layer formation when boiled can be observed [30].

Copper and iron levels found in the examined water sources are 0.006-0.11 mg/L and 0.001-0.18 mg/L, respectively. These levels determined are compliant with national and international standards. Copper and iron are essential elements for the organism. Low levels in waters do not constitute any risk of damage. However, excess levels of copper may ruin aesthetic quality of water, may create color formation and may yield an unpleasant and harsh flavor. Furthermore, this may increase the corrosion in pipes made of aluminum, zinc, etc. Copper mixes into potable water by means of underground and surface waters, due to copper sulfate placed in

water reservoirs within the framework of industrial, agricultural, pesticide, fertilizer and algae fighting programs [30]. Moreover, it may mix into potable waters via the corrosion seen in water pipes with brass, copper and bronze contents [27,32]. In case copper is taken in excess amounts, mucus membrane infections, vascular diseases, liver and kidney diseases and central nervous system irritations associated with depression can be observed. On the other hand, excess amounts of iron causes undesired coloring and blur in potable water. It is found in small amounts within the content of natural waters despite it exists in high amounts in nature [33]. The reason for this is rapid withdrawal of iron from water by means of precipitation. Iron is significant in terms of being a functional part of hemoglobin found in human metabolism, particularly in red blood cell structure. Apart from this, iron is a vital mineral taking part in myoglobin of muscles, cytochrome, peroxidase and catalase systems. However, excess amounts of iron is toxic for humans since excess ferrous iron creates free radicals through reacting with peroxides contained within human body [34,35].

Nickel levels determined during the study were between 0.012-0.046 mg/L. Nickel levels in samples taken from İki Nisan, İskele and İpekyolu streets were the only ones compliant with national and international standards, while all other samples were found to be compliant with standards indicated by WHO.

Most nickel salts can dissolve in water therefore contamination is rather easy and particularly compounds discharged into rivers and containing nickel take part in this contamination [33]. Although nickel does not have an identified biological function, it is possible to pronounce that it has a medium level toxicity [36].

Cobalt levels in water samples analyzed in this study were found to be between 0.007-0.014 mg/L. No comparison could be made since limit values for cobalt levels are not provided in national and international standards. Cobalt plays a role in hemoglobin biosynthesis since it is contained in vitamin B_{12} composition. Excess amounts of cobalt cause a disease called "polycythemia" and characterized by excess red blood cell formation [37,38].

Magnesium, sodium and calcium levels found in the examined samples in this study were 6.78-6.81 mg/L, 3.88-6.68 mg/L and 31.06-38.49 mg/L, respectively, and these levels are compliant with national and international standards. Sodium, calcium, magnesium and chloride are macro minerals which can be found in variable amounts in natural waters. Sodium can be found in waters in forms of CO_3, HCO_3, SO_4 and mostly as Cl. Excess amounts create flavor problems, giving a salty feeling. Excess sodium may originate from domestic and industrial pollution, soil structure and contributions from sea waters. Calcium mixes into waters through dissolution of limestone by rain, underground and surface waters and being washed off the soil. Water containing excess amounts of Ca is not convenient for drinking and industrial usage purposes. Calcium does not have any direct toxic effect for human body. In fact, it is even argued that it could be useful for bone structure. However, it may create a problem in terms of drinking. On the other hand, water potential for causing kidney stone formation increases. Magnesium mixes into waters as a result of river, rain and underground waters dissolving limestone and dolomites. High levels in water (> 0.1 mg/L) creates flavor changes and it has a laxative effect. Waters with such characteristics are not convenient for drinking purposes [32,39]. Lead levels determined during this study showed an increase compared to lead levels but a decrease compared to those of zinc and iron determined by Ekin and Bildik [6].

Cadmium levels were found to be compliant. Copper, zinc, manganese and nickel levels were found to be compliant with copper, zinc, manganese and nickel levels determined in the study by Alemdar et.al. [7] while iron, cadmium and cobalt levels were higher than those determined in this study. Na and Ca levels determined by Ağaoğlu et.al [22] were lower and Mg levels were higher compared to the respective levels determined during this study [7].

According to the results of this study, it is important for public health that sources of high lead levels determined in the study be found and respective necessary measures be taken as soon as possible.

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