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Groundwater quality in Körfez Municipality (Kocaeli), northwest of Turkey

Ali Bozkurt [1] and Cengiz Kurtuluş*

*[1]ABM Engineering Company, İzmit,Kocaeli, Türkiye. [2] Kocaeli University, Engineering Faculty, Department of Geophysics,Umuttepe Campus, 41380 İzmit, Kocaeli, Türkiye. *e-mail: cengizk@kocaeli.edu.tr, alibozkurt@abmjeo.com*

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Abstract

Community wells in rural areas of Körfez Municipality of Izmit-Kocaeli, north of Turkey, were tested in 2007 to determine the contamination from iron, sulphate, fluoride, organic matter and coliform bacteria. Other quality parameters such as pH, hardness, dissolved oxygen (DO), conductivity and nitrate were also tested for 22 water supplies. pH values of the water samples ranged between 6.61 and 7.9 indicating that the well waters are acidic and do not pose any health risk. The hardness of the well waters tested soft (11-43) and the amount of sulphate (SO_4) was detected very low (20.2-24 mg L^{-1}). Nitrate and ammonia were not detected in the water samples collected from the wells but iron was detected in most of the water samples at levels not exceeding the recommended limit. Total coliforms were tested to measure the microbial quality of the groundwater. The water samples from the wells tested positive for total coliforms. Fluoride was detected in all water samples at concentrations less than recommended health based guideline value. More than 105.000 people reside in the rural areas where testing was conducted and 30% of them depend upon groundwater for their drinking water. The study employed water quality testing and GIS analysis to identify rural communities at greater risk of exposure to contaminants so that treatment strategies can be prioritized and implemented to reduce that risk. However, the water quality results indicated that the quality parameters of the samples collected from 22 wells were below the Turkish government drinking water standard and WHO (2000) permissible limits.

Key words: Coliforms, contamination, groundwater, heavy metals, organic matter, quality, rural area.

Introduction

Water is essential for life and for sustainable development. Although surface water provides most of the drinking water for the major centers, groundwater is also used in rural areas and industries. Groundwater is the primary source of drinking water for 30% of Körfez people, many of whom live in rural areas where they rely on private wells to supply their water needs. Water availability has been and will continue to be a major long-term subject in Körfez basin. The important characteristics of groundwater are determined by its source. The source materials throughout which it flows determine parameters such as odor, hardness and color. The effects of drinking contaminated water result in thousands of deaths every day mostly in children less than five years in developing countries [12]. The water quality refers to the physical, lithological and chemical state of water bodies [1, 2]. The physical and chemical parameters are immense indicators used in the characterization of water quality [3, 4]. A biological assessment is done to verify the condition of water bodies by the measurement of resident organisms [5-7].

We collected and analyzed groundwater samples in rural communities of the municipality in 2007. Water samples were collected from each well in January, June and October 2007 to determine contamination from organic matter and heavy metals. Other water quality parameters such as pH, alkalinity, hardness, DO, conductivity and nitrate were also determined. Other pertinent data regarding well depth, well log and storage of water were also collected.

Physical Setting

The Körfez municipality is located in the NW of Anatolia, Turkey. The investigation area is a plain area with a slope rising north. The location and geologic map of Körfez and vicinity is shown in Fig. 1. The Sopalý formation and old and new alluviums are observed in the investigation area.

The Sopalý formation consists of arkosic conglomerate, sandstone and slates. The conglomerate and sandstone are colored purple and grey whereas the slates are pinkish. The lowermost unit of the Sopalý formation lying above the metamorphic basement association is a red arkosic conglomerate sandstone and mudstone unit of Lower Ordovician age [9]. This unit is cut by quartz veins with the thickness varying from mm to 25-30 cm. Upward in the section an alternating sandstone, slate and conglomerate become dominant. The arkosic sandstone is formed of 80% sand and 20% matrix. Of the sand 65% is quartz and 35% feldspar. In some quartz samples the quartz grains are surrounded by iron oxide envelopes. The Sopalý formation does not include any fossils and is formed in hot and cool climatic conditions [10].

Methods

Well water samples were collected from 22 water supply wells throughout the community. The annular spaces of the wells were sealed and the casings of them moved below the water table. Field measurements of conductivity, temperature and dissolved oxygen (DO) were conducted on-site using YSI Model 85 meter.

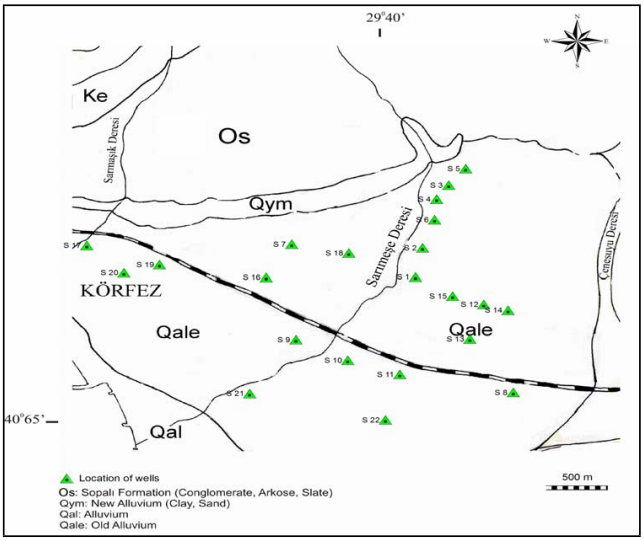

Figure 1. Geologic map of the research area [8].

DO measurements were calibrated daily for 100% air saturation for the field elevation. Well head coordinates were determined using Garmin Etrex GPS units. HACH 2000-series spectrophotometers were used to determine iron, sulphate and fluoride. Nitrate-N was determined using a HACH Model 4000 ultraviolet absorption spectrophotometer. The instruments were calibrated on a daily basis with de-ionized water and factory prepared standard solutions.

Results and Discussion

The average tests results are summarized in Table 1 and listed in Table 2. Levels of pH range from 1 to 14; the 1-7 range is considered acidic, while results in the 7-14 range are basic or alkaline; 7 is neutral. In general, water with low pH (< 6.5) is acidic, soft and corrosive and could contain metal ions such as iron, copper, zinc, manganese and lead. Metals are more soluble at lower pH values and more toxic as a result. The results indicate that the water samples from 22 wells have a moderate to high pH (6.61-7.92), which lessens the ability of the water to contain metal ions and therefore does not pose any health risk.

Water hardness is a reflection of the amount of ions (calcium and magnesium) in water. Water is considered soft when it contains 0-60 mg L^{-1} hardness, moderately hard from 61 to 120 mg L^{-1}, hard between 121-180 mg L^{-1} and very hard if more than 180 mg L^{-1}.

Table 1. Summary of Körfez well water quality.

Parameter	Low	High	Allowable standard [11, 12]
DO (mgL^{-1})	0.08	4.2	Non-established
pH	6.61	7.92	6.5-9.5
Conductivity (µS cm^{-1})	189	442	1000 at 25^0
Hardness (mg L^{-1})	11	43	-
Organic matter (mg L^{-1})	0.4	3.3	-
Nitrite (NO_2) (mg L^{-1})	0	0	5.0
Ammonia (NH_3) (mg L^{-1})	0	0	0.0
Iron (Fe) (mg L^{-1})	0	0.53	1.0
Sulphate (SO_4) (mg L^{-1})	20.2	24.1	400
Fluoride (F) (mg L^{-1})	0	0.53	1.5

Generally, groundwater hardness is relatively stable and does not change over time. Water samples in the wells were soft (11-43 mg L^{-1}). Total coliforms were tested to measure the microbiological quality of the drinking water. The wells of Körfez tested positive for total coliforms. Nitrite and ammonia were not detected in all wells. Iron was detected in a number of wells at levels not exceeding the recommended limit 0.3 mg L^{-1} for domestic water supply. Fluoride was detected in all samples but at concentrations less than 1.5 mg L^{-1} recommended by TSE 266. Fluoride helps to prevent dental caries when present in drinking water at a concentration of 1.0 mg L^{-1}, but fluoride levels above 1.5 mg L^{-1} can cause dental decay, kidney and physiological damages.

Water quality data were collected to perform water-quality analysis in drilled wells within the Körfez district boundaries. The test results showed that the well water quality parameter levels below the respective Turkish [11] and health-based[12] guideline values.

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Table 2. Körfez water total average results.

Well number	Well depth	Water depth in wells	DO (mg L^{-1})	pH	T °C	Conductivity (µScm^{-1})	Hardness (Fr)	Organic matter (mg L^{-1})	Nitrite (NO_2) (mg L^{-1})	Ammonia (NH_3) (mg L^{-1})	Fe	SO_4	F	Coliforms /100cc
1	140	24	0.08	7.02	15.2	442	37	0.6	0	0	0.0	21.2	0.5	0
2	135	25	0.17	6.76	16.3	225	14	1.1	0	0	0.02	22.4	0.47	0
3	120	20	0.14	6.87	15.6	284	16	0.7	0	0	0.01	20.5	0.28	0
4	130	18	1.71	7.32	17.2	226	22	2.6	0	0	0.038	21.0	0.46	0
5	115	15	1.4	7.67	14.5	312	11	0.6	0	0	0.013	23.2	0.05	0
6	125	16	0.11	7.42	18.2	356	43	3.1	0	0	0.012	24.1	0.26	0
7	125	26	0.63	7.14	17.3	324	21	1.1	0	0	0.014	20.2	0.41	0
8	92	28	0.49	6.61	15.2	318	21	3.3	0	0	0.01	21.1	0.49	0
9	180	25	1.6	7.18	17.5	216	21	2.1	0	0	0.0	21.6	0.4	0
10	170	26	4.2	7.28	17.9	189	23	1.7	0	0	0.011	22.7	0.42	0
11	140	23	1.3	6.86	14.5	298	18	1.6	0	0	0.0	24.1	0.39	0
12	160	24	1.46	7.17	18.6	301	19	1.3	0	0	0.02	23.4	0.41	0
13	130	24	0.86	7.92	13.9	312	17	2.8	0	0	0.012	20.4	0.53	0
14	120	20	1.04	7.26	17.1	256	23	0.5	0	0	0.0	21.8	0.49	0
15	135	24	0.16	7.36	13.8	214	22	0.6	0	0	0.0	21.1	0.21	0
16	61	23	0.13	7.32	15.3	221	14	0.6	0	0	0.0	20.2	0.33	0
17	50	25	0.9	7.76	16.4	242	18	1.3	0	0	0.01	22.0	031	0
18	140	24	1.65	7.76	17.2	284	12	0.8	0	0	0.0	20.6	0.44	0
19	155	25	1.21	7.09	17.6	255	50	3.1	0	0	0.0	21.1	0.21	0
20	125	24	1.8	7.52	14.9	271	19	0.4	0	0	0.012	20.8	0.27	0
21	110	23	1.4	7.62	16.5	248	12	0.9	0	0	0.01	20.4	0.34	0
22	136	25	0.49	7.05	16.7	223	16	1.4	0	0	0.0	21.2	0.39	0