Desalination and Water Treatment
www.deswater.com
doi: 10.5004/dwt.2019.24622

168 (2019) 235–242
November

Assessment of cemetery effects on groundwater quality using GIS

Salman Jafarpoor Kandoli[a], Hosein Alidadi[b], Ali Asghar Najafpoor[b], Marjan Mehrabpour[a,*], Ahmad Hosseinzadeh[a], Fatemeh Momeni[c]

[a]*Student Research Committee, Department of Environmental Health Engineering, School of Health, Mashhad University of Medical Sciences, Mashhad, Iran, Tel. +98-51-38552610; Fax: +98-51-38550611; emails: marjanmehrabpour@gmail.com (M. Mehrabpour), sjafarp@gmail.com (S.J. Kandoli), Hosseinzadeh26@gmail.com (A. Hosseinzadeh)*
[b]*Social Determinants of Health Research Center, Department of Environmental Health Engineering, Mashhad University of Medical Sciences, Mashhad, Iran, emails: alidadih@mums.ac.ir (H. Alidadi), najafpooraa@mums.ac.ir (A.A. Najafpoor)*
[c]*Student Research Committee, Department of Environmental Health Engineering, School of Health, Birjand University of Medical Sciences, Birjand, Iran, email: fatememomeni76@yahoo.com*

Received 27 June 2018; Accepted 26 June 2019

ABSTRACT

Groundwater pollution is a global challenge with potentially serious outcomes. Therefore, the main resources of water pollution such as cemetery should be considered to control this challenge. The main objective of the present study was to investigate the contamination potential of a cemetery with Islamic culture by detection of various chemical and biological factors in higher depth and show the results in geographic information system. During this study, nine wells were selected from the cemetery area, the vicinity of the cemetery and upstream of the cemetery groundwater flow. After sampling in three time periods, hydro-chemical and biological factors including electrical conductivity (EC), pH, total dissolved solids (TDS), phosphorous, nitrates, nitrites, chemical oxygen demand (COD), fluoride, potassium, sodium, sulfate, chloride, lead, *E. coli*, heterotrophic plate count and fecal streptococci were detected. Analysis of the obtained data revealed that there was a direct relationship between measured pH, EC, chloride, sodium, phosphate, TDS, and lead as heavy metal in taken samples from cemetery wells and blank wells. However, this relationship was not statistically significant for potassium, alkalinity, COD, nitrite, nitrate, sulfate, and phosphate ($p < 0.05$). According to the obtained data, cemeteries have a great potential to contaminate aquifers.

Keywords: Cemetery; Decomposition; Groundwater quality

1. Introduction

With respect to the water shortage, the pollution of most water resources has been turned into a serious global problem. Therefore, the main water pollution resources such as cemetery should be considered to tackle this problem and its outcomes such as environmental concerns [1,2]. The human corpse is a complex matrix that contains 50% water, 15% bones and 35% organic substance [3–5]. In other words, this complex matrix is composed of 17% w/w protein; 17% w/w fat, and 6% w/w carbohydrate coupled with some inorganic and trace elements such as Ca, P, N, and Na^+. Consecutive processes of autolysis, putrefaction, and decay

* Corresponding author.

are decomposition stages of a corpse. Ideally, human corpse decomposition is completed over a 15- to 25-year period and leads to the corpse complete skeletonization [6,7].

During the decomposition process, the formed gaseous and liquid products such as CO, CO_2, H_2S, CH_4, NH_4, NO_3, and biogenic amines are accumulated in the grave area or released into the environment [6,8]. In order to prevent pollution emissions from the cemetery area into the atmosphere, it is necessary to cover up the buried corpse with a suitable thickness of the soil layer [9]. Apart from features of corpses (cause of death, age, and sex), burial method (individual or mass grave, depth of grave and material of the coffin) along with burial time and the conditions of the resting place (soil properties, topography and geology) are regarded as the most important effective factors on the contamination of groundwater [10,11]. According to the results of accomplished studies, cemeteries can be similar to a particular kind of municipal solid waste landfill site. Therefore, cemeteries can be a pollution source for groundwater and a potential danger for human health [6,12].

The study of Van Haaren [13] in 1951 revealed that the adverse effects of cemeteries on groundwater quality by increasing the concentrations of chlorides, sulfates, bicarbonates, and electrical conductivity (EC). Also, Engelbrecht [14] in 1998 established the infiltration of hazardous substances from the cemetery into groundwater and the increase of infectious diseases in society. Moreover, studies in South Africa demonstrated the adverse effects of the cemetery on groundwater resource quality [15]. In addition, an investigation showed the impacts of the cemeteries on soil pollution by the accumulation of certain substances and elements in the soil [6].

World Health Organization (WHO) suggested that drinking water supplies such as wells and springs should be away from cemetery areas at least 30 m. Furthermore, it has been mentioned that the burial of animal or human corpses is not permissible in wells with 250 m depth from which potable water is provided [16,17]. In addition, the high levels of microbial contamination including total and fecal coliform, fecal streptococcus, heterotrophic bacteria (22°C and 36°C), clostridia and proteolytic bacteria were found in most of the taken groundwater samples from three cemeteries [18]. Apart from all adverse effects of cemeteries on groundwater quality, in a study in 2004, Hart and Casper [19] came to the conclusion that higher burial depth of human corpses can increase the adverse effects of cemeteries on groundwater quality. Therefore, the depth of sampling from wells can be an important factor in the survey of cemetery effects on groundwater quality. On the other hand, in contrast to Islamic culture, human corpse burial in some non-Islamic culture is conducted with a coffin. The coffin can transfer considerable proportions of pollutants into groundwater after degradation. In addition, there are some differences between these two types of cultures in human corpse burial. With respect to the fact that most of the accomplished investigations in this regard belonged to non-Islamic cultures, it is an important necessity to survey the effects of cemeteries on groundwater in different conditions. Thus, the present study aimed to survey the contamination potential of a cemetery with Islamic culture burial on groundwater quality and in higher depth with measuring a wide range of hydro-chemical and biological parameters and show the obtained results using geographic information system.

2. Materials and methods

2.1. Environmental situation

The under research cemetery was established in 1985 in Mashhad city where is the capital of Khorasan Razavi province, Iran, with a cool and dry climate (Fig. 1). The total surface area of the cemetery is 180 ha and is located in 59° 41′ of longitude, 36° 9′ of latitude and about 4,300 m southeast of the city between 1,150 and 950 m (1,050 m above sea level). The maximum and minimum temperatures of Mashhad are 43° above zero in summer and 23° below zero in winter, respectively.

2.2. Sampling

In this study, sampling was performed from nine wells, three (No. 1–3) and five (No. 4–8) of which were in the cemetery and non-cemetery sites as real and blank sampling wells, respectively. The location of well No. 9 was in the upstream of the cemetery groundwater flow. Sampling was performed in February, May, and June 2013. The depths of wells sampled were between 85 and 110 m. Burial depth was 1 m.

According to the results of the accomplished studies in countries with different burial conditions, heavy metals are regarded as some high potential risk pollutants; however, lead was studied as the only heavy metal in the present study. Lead as a heavy metal that can be accumulated in the human body over the lifespan and is measurable was studied in this study [20].

2.3. Analysis of the samples or the analytical methods

All of the used chemical materials were purchased from Merck, Germany. Geographic coordinates of the studied wells were recorded with GPS receivers. Taken groundwater samples were analyzed to determine the proportions of the mentioned hydro-chemical parameters. Following methods were applied to measure the considered parameters [21]. It is worth highlighting that the samples were stored at 4°C ± 2°C before reaching the laboratory [8,17].

- Sodium and potassium by flame photometric method
- chemical oxygen demand (COD) by open reflux method
- Chloride by argentometric method
- Alkalinity by titration method
- Sulfate by turbidimetric method
- Nitrate by ultraviolet spectrophotometric screening method
- Nitrite by colorimetric method
- Phosphate by stannous chloride method
- Fluoride by SPANDS

Taken samples were analyzed for fecal-indicator organisms including *E. coli* and fecal streptococci using most probable number method and heterotrophic bacteria by heterotrophic plate count (HPC). These indicators, which are easier to detect in drinking water than pathogens, can display the presence of pathogens in drinking waters [18].

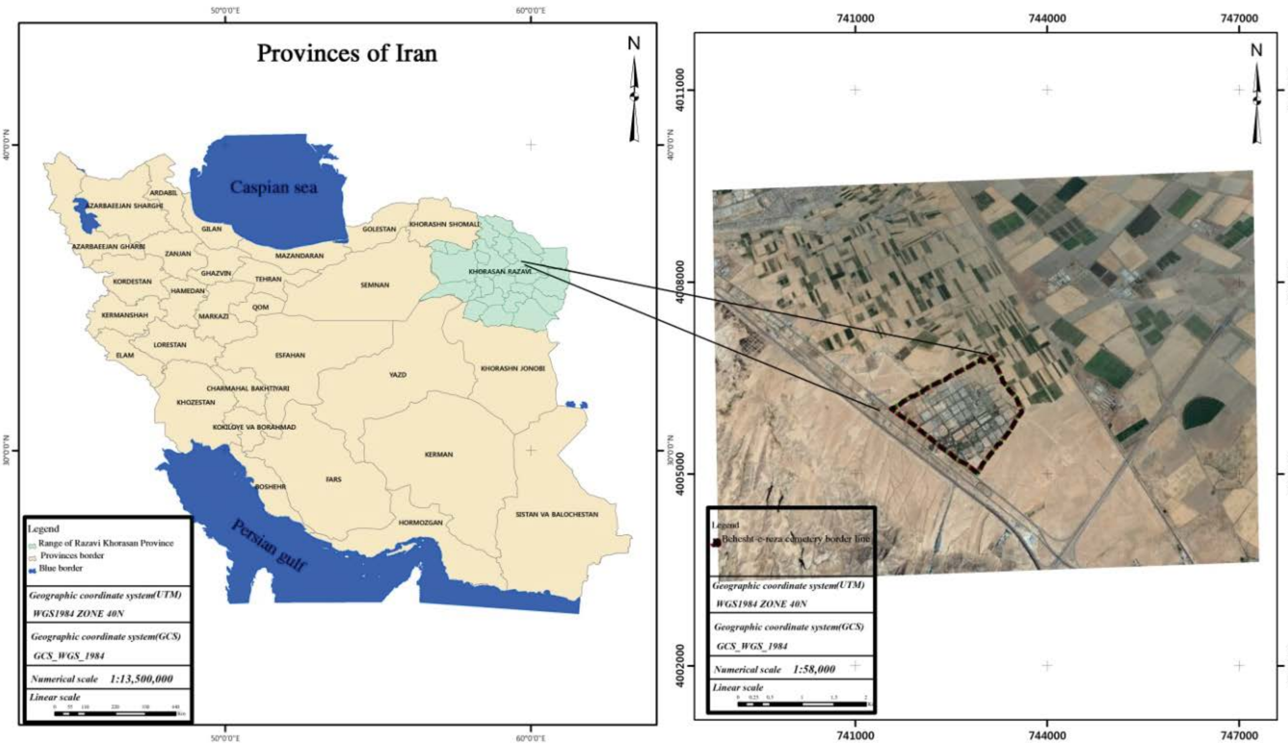

Fig. 1. Location of studied area.

The measurements were repeated three times and the mean values were calculated from the three replicates. All of the methods were used from "Standard Methods for the Examination of Water and Wastewater" version 22, Print 2012 [21]. Statistical analysis was conducted using SPSS software version 20. Mann–Whitney and *T*-Test were applied for statistical analysis of microbial and hydro-chemical parameters results correspondingly.

3. Results and discussion

The experimental results of hydro-chemical parameters in taken samples from the cemetery and blank wells along with the well located on the upstream of the cemetery groundwater flow are presented in Tables 1–3. The lead was in the range of ppb in the tested samples which is lower than the standard level.

Statistical analysis showed that there are significant relationships between measured proportions of EC, pH, chloride, sodium, phosphate, total dissolved solids, fluoride, and lead in the taken samples from wells No. 1 to 3 as the cemetery wells and the wells No. 4 to 8 as blank ones (p-value < 0.05). However, this relationship for potassium, alkalinity, COD, nitrate, sulfate, and phosphate were not significant (p-value < 0.05). With respect to the fact that well No. 8 was in the downstream of the cemetery groundwater flow, the measured proportions for considered parameters in the samples of well No. 8 were approximately as same as the obtained proportions in samples of the cemetery wells (No. 1–3).

Table 4 demonstrates the results of the microbial tests of the taken samples, which can be representative of contamination extent. Fecal streptococcus and *E. coli* in all wells were equal, except for well No. 3. According to the results of HPC, heterotrophic bacteria proportions in the cemetery wells were higher than the proportions in blank ones.

Mann–Whitney analysis of microbial parameters including *E. coli* and fecal streptococcus showed that there was no significant relationship between the cemetery and blank

Table 1
Analyses of groundwater samples of the cemetery area

Number of wells	1	2	3
EC*	868.6	647.0	961.6
pH	8.0	8.0	8.1
K^+	2	2	2
SO_4	81.3	48.5	119.4
NO_2	0.0032	0.0011	3.50E-04
COD	0.0	7.8	21.8
NO_3	3.9	3.5	4.2
F	0.6	0.7	1.2
TDS	561.3	420.5	625.1
P	0.06	0.34	0.24
Alkalinity**	240	196	216
Na^+	184	139	217
Cl	24.5	16.3	28.1
Lead**	29.1	19.4	31.8

*Electrical conductivity is expressed by Micro mhos per cm.
**Alkalinity and lead concentrations were given by milligrams per liter of carbonate (mg/L $CaCO_3$) and ppb, respectively.

Table 2
Analyses of the groundwater blank samples

Number of wells	4	5	6	7	8
EC*	443.6	486.3	456.6	462.6	636.0
pH	7.2	7.4	7.7	7.9	7.7
K^+	2	2	2	2	2
SO_4	47.9	54.7	54.7	48.2	51.3
NO_2	5.00E-05	3.50E-04	0.0014	0.0024	0.0021
COD	0.0	0.0	0.0	6.27	15.7
NO_3	3.1	2.9	2.7	2.1	5.1
F	0.3	0.4	0.3	0.5	0.3
TDS	285.4	316.1	296.8	300.7	413.4
P	0.08	0.03	0.12	0.13	0.04
Alkalinity**	179.3	222.6	206.3	210.0	194.0
Na^+	52	93	78	100	109
Cl	5.20	5.06	4.53	4.26	12.4
Lead**	6.03	7.61	5.33	5.35	14.3

*Electrical conductivity is expressed by Micro mhos per cm.
**Alkalinity and lead concentrations were given by milligrams per liter of carbonate (mg/L $CaCO_3$) and ppb, respectively.

Table 3
Analyses of the taken groundwater samples from well located in the upstream of the cemetery water flow

Number of wells	9
EC*	475
pH	7.8
K^+	2
SO_4	60.92
NO_2	4.00E-04
COD	12.54
NO_3	6.29
F	0.05
TDS	
P	0.102
Alkalinity**	130
Na^+	39
Cl	4.6
Lead**	6.23

*Electrical conductivity is expressed by Micro mhos per cm.
**Alkalinity and lead concentrations were given by milligrams per liter of carbonate (mg/L $CaCO_3$) and ppb, respectively.

wells. However, *t*-test analysis for HPC showed a significant relationship between these two groups of studied wells (Fig. 2).

3.1. Dynamics of pH and EC

As can be seen in Figs. 1, 2a and b, the proportions of pH and EC in the taken samples from the cemetery wells were higher than the others. The increase of the proportions of these parameters can be attributed to the decomposition of human bodies and releasing nutrients into the groundwater [22]. The attained results agreed with numerous other studies Fineza et al. [22] observed the same results. Mentioned standard values for these parameters are 6.5–8.5 and 25 μs/cm, respectively, by the WHO [23].

Table 4
Groundwater microbial contamination

Wells No.	Fecal streptococci	*E. coli*	Heterotrophic plate count
1	<1.1	<1.1	11
2	<1.1	<1.1	150
3	1.1	2.2	44
4	<1.1	<1.1	0
5	<1.1	<1.1	5
6	<1.1	<1.1	1
7	<1.1	<1.1	27
8	<1.1	<1.1	4
9	<1.1	<1.1	51

3.2. Dynamics of nitrite and nitrate

According to Figs. 2c and d, there were no distinct relationships among the amounts of nitrite and nitrate in the upstream, cemetery, and blank wells. Nitrogen is one of the main components of human body proteins and some amino acids; therefore, nitrogen can enter into groundwater through leachate after human body decay. Freedman and Fleming [24] demonstrated that there is a direct relationship among ammonium nitrogen (NH_4–N) and nitrate concentrations in groundwater flowing under the cemetery. However, the cause of this non-significant relationship between the considered wells may be due to locating the upstream and blank wells in agricultural area and application of nitrate fertilizers for agriculture at upstream of the studied blank wells. Also, a high depth of sampling can be another plausible reason [25,26]. According to the WHO guideline, the standard level of nitrate in drinking water is 50 mg/L (as NO_3) [23].

3.3. Dynamics of sodium and potassium

In contrast to potassium, the proportions of sodium in the cemetery wells were higher than blank ones (Figs. 2e and f). It can be owing to the fact that sodium is regarded as one of the components of human bodies and may be released after decomposition into the groundwater [27], whereas the proportion of sodium in the human body is higher than the proportion of potassium, increase of sodium in the cemetery wells can be more justifiable [28]. However, with respect to the fact that potassium is one of the components of human bodies as well, and the obtained results by another study demonstrated that a cemetery can increase the amount of potassium in groundwater, a plausible justification for this can be differences in depth of sampling in the present and accomplished studies [22]. It is worth highlighting that the

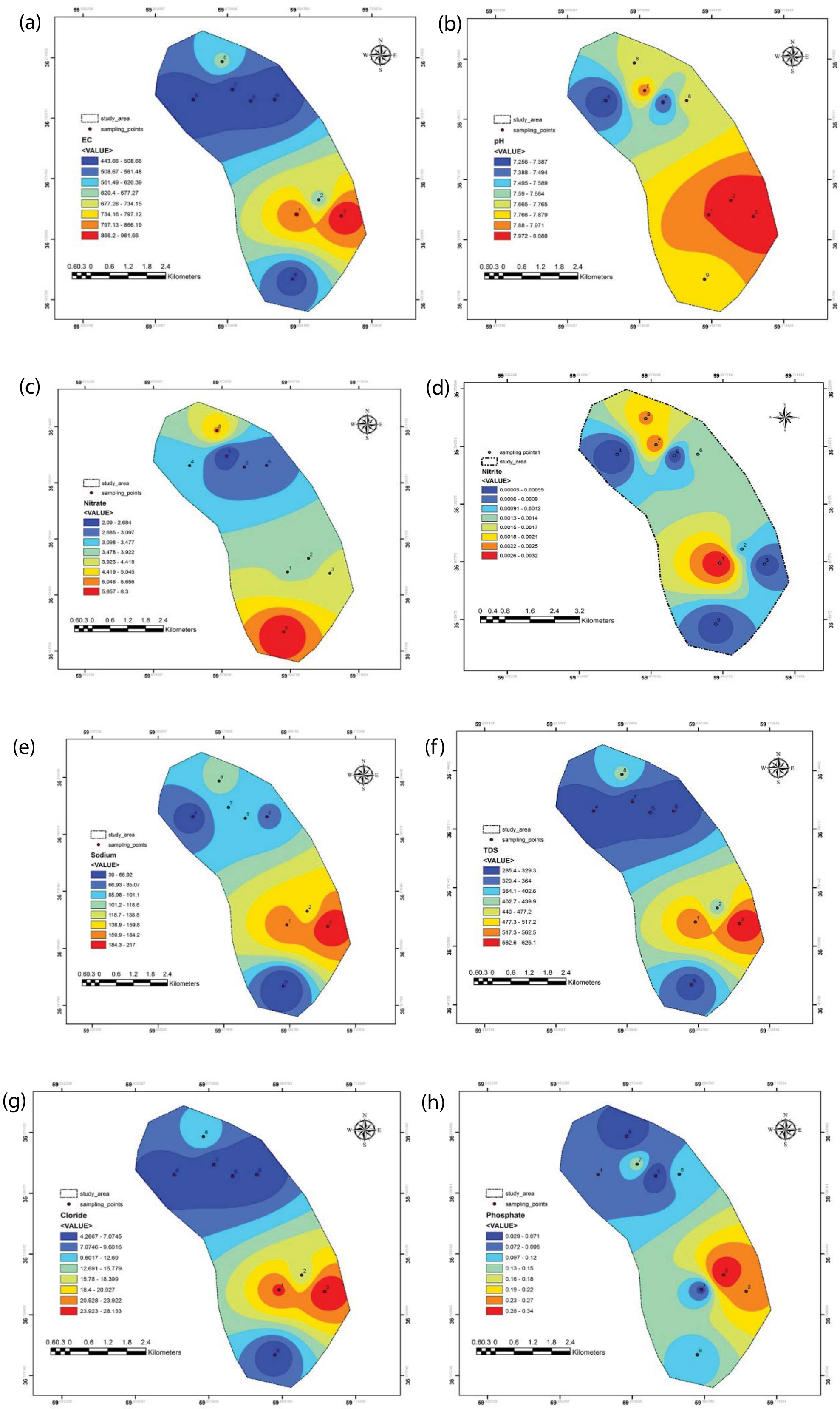

Fig. 2. *T*-test analysis for HPC. (a) EC, (b) pH, (c) nitrate, (d) nitrite, (e) sodium, (f) TDS, (g) chloride, (h) phosphate, (i) sulfate, (j) fluoride, (k) COD, (l) alkalinity, (m) lead, (n) *E. coli*, and (o) heterotrophic.

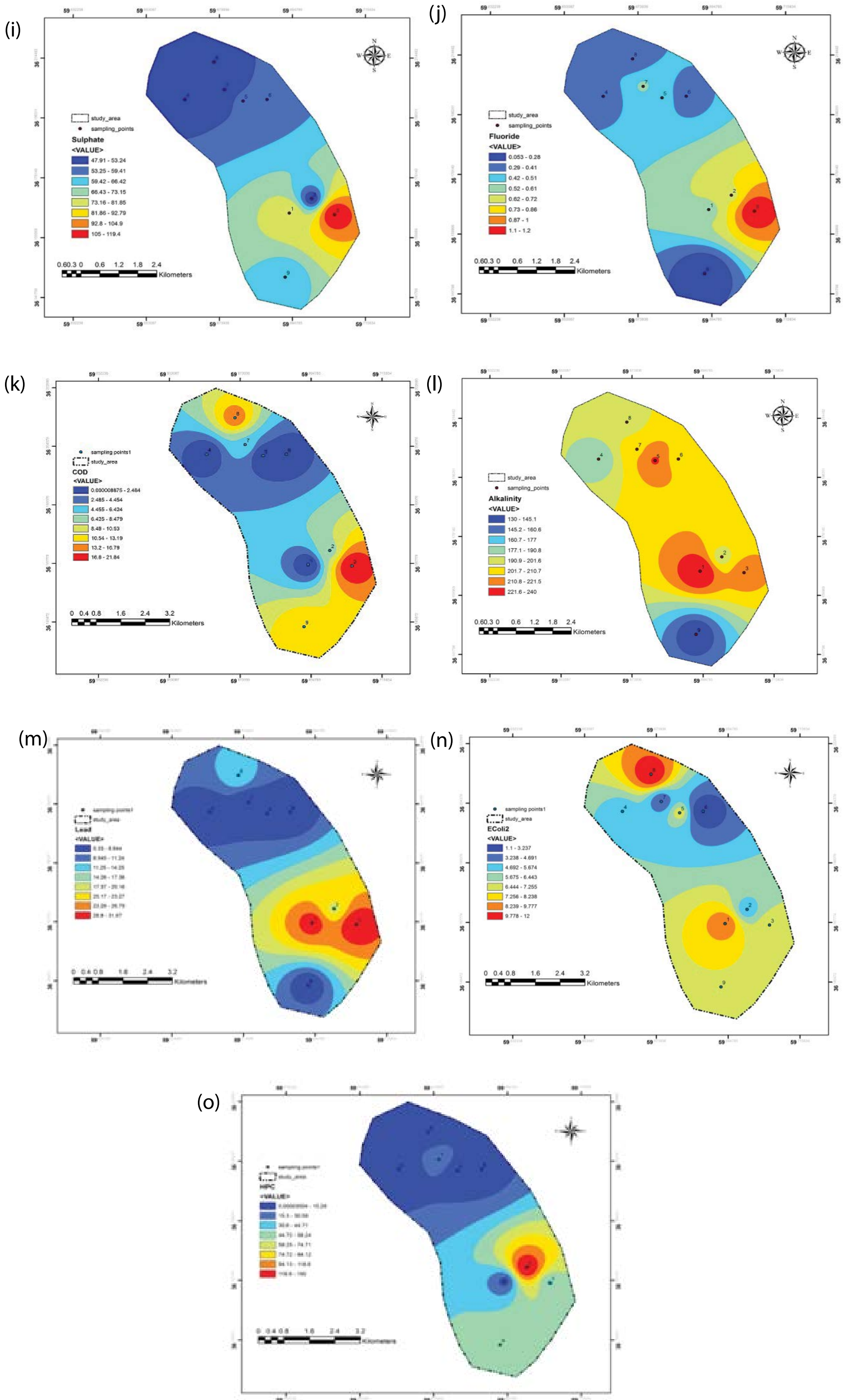

Fig. 2. *Continued*

WHO guidelines mentioned that the average taste threshold for sodium is 200 mg/L. Also, no health-based guideline has been considered for potassium in drinking water [23,29].

3.4. Dynamics of phosphate, sulfate, fluoride, and chloride

As can be observed in Figs. 2g–j, differences among the proportions of these parameters in the cemetery and blank wells are considerable. With respect to the fact that all of these factors are regarded as components of human bodies; therefore, these can be released into groundwater after the decay of human corpse. In addition, the attained results in the present study agreed with the results of other different studies [14,22,24]. So, the adverse effects of the cemetery on these parameters in groundwater can be obvious. The mentioned standard values by WHO for sulfate, fluoride, and chloride are 250, 1.5, and 250 mg/L, correspondingly [23]. Although all of the measured proportions for these factors are lower than WHO standards, the adverse effects of the cemetery on groundwater quality cannot be denied.

3.5. Dynamics of COD and total dissolved solids

Based on the obtained results, Figs. 2k and l, the observed significant relationships between the proportions of these parameters in the cemetery and blank wells are clear. These parameters can demonstrate the contamination potential of the cemetery. COD can especially be so worthwhile in a depth of 120 m.

3.6. Dynamics of lead

The measured proportions of lead in samples of the cemetery wells were higher than the samples of blank ones (Fig. 2m). This heavy metal not only can accumulate in the body of humans but also is regarded as one of the main components of a coffin. Since coffin along with human corpse is not buried in Iran, the main cause of lead pollution may be because of human body decomposition. The obtained results in the present study agreed with the results of the study by Jonker and Olivier [30]. Since the mentioned lead standard value by the WHO in drinking water is 0.01 mg/L, all of the measured proportions for lead are higher than the acceptable limit [23].

3.7. Dynamics of *E. coli*, fecal streptococci and HPC

Based on the attained results mentioned in Table 3, Figs. 2n and o heterotrophic bacteria were higher in the cemetery wells than blank ones. However, there were no considerable differences among *E. coli* and fecal streptococci in the cemetery and blank wells. It is worth mentioning that the mentioned median standard values for *E. coli* and fecal streptococci are 0 and 0 per 100 mL, respectively. Also, this parameter for heterotrophic bacteria is 100 CFU/mL.

4. Conclusion

Cemeteries have some adverse effects on the environment by increasing the concentrations of some organic and inorganic substances. This study aimed to assess the impact of a cemetery as a pollution resource on groundwater quality.

The obtained results demonstrated that the cemetery increased most of the measured hydro-chemical parameters such as chloride, sulfate, fluoride, pH, EC, sodium, total dissolved solids (TDS), and lead in groundwater in spite of the high depth of sampling. Also, the results of HPC biological test showed an increase in proportions of heterotrophic bacteria in wells No. 1 to 3. However, differences between the proportions of *E. coli* and fecal streptococcus were not significant in the cemetery and blank wells. Thus, the cemetery can be regarded as a potential contamination source of groundwater.

It is necessary to pay more attention to the protection of groundwater resources during the active period of burial and after completion of a cemetery capacity.

More studies are needed to study the contamination potential of the cemeteries and their effects on the environment. The performed studies throughout the world concerning some cemeteries are mostly related to non-Islamic countries in which burial conditions are completely different from Islamic ones. For example, in contrast to Islamic countries, coffins as one of the main sources of heavy metals pollutants along with human corpses are buried in non-Islamic countries. This is implying a cemetery impact on the groundwater quality and surrounding areas.

References

[1] S. Ahmadzadeh, M. Dolatabadi, Electrochemical treatment of pharmaceutical wastewater through electrosynthesis of iron hydroxides for practical removal of metronidazole, Chemosphere, 212 (2018) 533–539.
[2] M. Dolatabadi, M. Mehrabpour, M. Esfandyari, H. Alidadi, M. Davoudi, Modeling of simultaneous adsorption of dye and metal ion by sawdust from aqueous solution using of ANN and ANFIS, Chemom. Intell. Lab. Syst., 181 (2018) 72–78.
[3] D. Schoenen, H. Schoenen, Adipocere formation—the result of insufficient microbial degradation, Forensic Sci. Int, 226 (2013) 301.e1–301.e6.
[4] H. Kiashemshaki, A.H. Mahvi, A.A. Najafpoor, A. Hosseinzadeh, Investigation of the efficiency of the conventional water treatment processes employed to eliminate TOC in Jalaliyeh Water Treatment Plant, Tehran, Health Scope, 6 (2017) 1–5.
[5] A. Najafpoor, H. Alidadi, H. Esmaeili, T. Hadilou, M. Dolatabadi, A. Hosseinzadeh, M. Davoudi, Optimization of anionic dye adsorption onto Melia azedarach sawdust in aqueous solutions: effect of calcium cations, Asia-Pac. J. Chem. Eng., 11 (2016) 258–270.
[6] S. Fiedler, J. Breuer, C. Pusch, S. Holley, J. Wahl, J. Ingwersen, M. Graw, Graveyards—special landfills, Sci. Total Environ., 419 (2012) 90–97.
[7] S. Ahmadzadeh, M. Dolatabadi, In situ generation of hydroxyl radical for efficient degradation of 2, 4-dichlorophenol from aqueous solutions, Environ. Monit. Assess., 190 (2018) 340.
[8] S. Ahmadzadeh, M. Dolatabadi, Removal of acetaminophen from hospital wastewater using electro-Fenton process, Environ. Earth Sci., 77 (2018) 53.
[9] A. Santarsiero, L. Minelli, D. Cutilli, G. Cappiello, Hygienic aspects related to burial, Microchem. J., 67 (2000) 135–139.
[10] A. Santarsiero, D. Cutilli, G. Cappiello, L. Minelli, Environmental and legislative aspects concerning existing and new cemetery planning, Microchem. J., 67 (2000) 141–145.
[11] J. Żychowski, Geological aspects of decomposition of corpses in mass graves from WW1 and 2, located in SE Poland, Environ. Earth Sci., 64 (2011) 437–448.
[12] S. Ahmadzadeh, M. Dolatabadi, Modeling and kinetics study of electrochemical peroxidation process for mineralization of bisphenol A; a new paradigm for groundwater treatment, J. Mol. Liq., 254 (2018) 76–82.

[13] F. Van Haaren, Cemeteries as sources of groundwater contamination, Water, 35 (1951) 167–172.
[14] J. Engelbrecht, Groundwater Pollution from Cemeteries, The Water Institute of Southern Africa, Biennal Conference and Exhibition, 1998, pp. 1–8.
[15] G. Fisher, L. Croukamp, Ground Water Contamination and it's Consequences, Resulting from the Indiscriminate Placing of Cemeteries in the Third World Context, Africa Needs Groundwater Convention, Johannesburg, 1993.
[16] A.S. Ucisik, P. Rushbrook, W.H. Organization, The Impact of Cemetaries on the Environment and Public Health: An Introductory Briefing, 1998.
[17] M. Davoudi, H. Alidadi, M. Mehrabpour, M. Dolatabadi, Competitive removal of cationic dye (BR 46) and heavy metal (copper II) from synthetic textile effluent using adsorbent of Melia azedarach sawdust, Desal. Wat. Treat, 118 (2018) 326–335.
[18] L. Rodrigues, A. Pacheco, Groundwater Contamination from Cemeteries Cases of Study, International Symposium Environment, 2010.
[19] A. Hart, S.T. Casper, Potential Groundwater Pollutants from Cemeteries, Environment Agency, 2004.
[20] P. Massányi, F. Tataruch, J. Slameka, R. Toman, R. Jurík, Accumulation of lead, cadmium, and mercury in liver and kidney of the brown hare (Lepus europaeus) in relation to the season, age, and sex in the West Slovakian Lowland, J. Environ. Sci. Health., Part A, 38 (2003) 1299–1309.
[21] WEF, APHA, Standard Methods for the Examination of Water and Wastewater, American Public Health Association (APHA), Washington, D.C., USA, 2005.
[22] A. Fineza, E. Marques, R. Bastos, L. Betim, Impacts on the groundwater quality within a cemetery area in southeast Brazil, Soils Rocks, 37 (2014) 161–169.
[23] WHO, A Global Overview of National Regulations and Standards for Drinking-Water Quality, 2018.
[24] R. Freedman, R. Fleming, Water Quality Impacts of Burying Livestock Mortalities, Livestock Mortality Recycling Project Steering Committee, Ridgetown, Ontario, Canada, 2003.
[25] H. Alidadi, A. Hosseinzadeh, A.A. Najafpoor, H. Esmaili, J. Zanganeh, M.D. Takabi, F.G. Piranloo, Waste recycling by vermicomposting: maturity and quality assessment via dehydrogenase enzyme activity, lignin, water soluble carbon, nitrogen, phosphorous and other indicators, J. Environ. Manage., 182 (2016) 134–140.
[26] W.-j. Liu, J.-h. Wu, Z.-f. Peng, Research on nitrate to negative effect of soil and groundwater environment at different groundwater depth with sewage irrigation, Water Saving Irrig., 93 (2012) 13–21.
[27] K.H. Kim, M.L. Hall, A. Hart, S.J. Pollard, A survey of green burial sites in England and Wales and an assessment of the feasibility of a groundwater vulnerability tool, Environ. Technol., 29 (2008) 1–12.
[28] H.Q. Huang, R.G. Guan, T. Zhao, Z.Y. Zhao, F.R. Cao, Preparation of HA-Coated Mg-4.0 Zn-1.0 Ca-0.6 Zr (wt.%) Alloy and its Biodegradation Behaviors, Materials Science Forum, Trans Tech Publications, 2012, pp. 498–503.
[29] World Health Organization, Potassium in Drinking-Water: Background Document for Development of WHO Guidelines for Drinking-Water Quality, World Health Organization, Geneva, 2009.
[30] C. Jonker, J. Olivier, Mineral contamination from cemetery soils: case study of Zandfontein Cemetery, South Africa, Int. J. Environ. Res. Public Health, 9 (2012) 511–520.