J. Saf. Environ. Health Res. 1(1): 36–39, Autumn 2016
DOI: 10.22053/jsehr.2016.33387

ORIGINAL RESEARCH PAPER

Survey the Nitrate Concentration in Drinking Water Distribution Systems of Kashan County, Iran

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Received 23 September 2016; Revised 23 October 2016; Accepted 10 November 2016; Available online 27 December 2016

Abstract: High concentration of nitrate is a prevalent problem in water resources. Untreated wastewater due to municipal, industrial and agricultural activities is the main potential source of nitrate contamination of groundwater and surface water. The maximum permissible level of nitrate concentration has been established to be 45 mg/L by WHO and US–EPA. Health problems, such as Methemoglobinemia in babies, can occur in the case of exposure with levels more than 45 mg/L. Nitrate concentration was measured in drinking water distribution systems of Kashan and its six surrounding towns in 2013. Samples were taken under standard conditions. 25 sampling points were selected based on the population density and the size of water distribution systems. Nitrate concentration was measured using spectrophotometry. Finally, the data analysis was carried out with SPSS software. The average concentration of nitrate was 17.5 mg/L. Maximum and minimum levels of nitrate in drinking water sources were 27.4 mg/L and 9.5 mg/L, respectively. Also, there were significant differences between the average concentrations of nitrate among sampling points in Kashan and the six neighboring towns ($p<0.05$). The nitrate concentrations in 68% of total samples were below 20 mg/L (i.e. slightly contaminated), 32% were between 20 – 45 mg/L (i.e. contaminated), and nitrate concentrations more than 45 mg/L (i.e. highly contaminated) were not reported. The average nitrate concentration in all sampling points meets WHO guidelines. It can be concluded that nitrate contamination of the water distribution networks in Kashan and other towns neighboring it had the appropriate conditions. But comparing the findings of the present study with those performed in Kashan one decade ago (2006) it can be concluded that the average concentration of nitrate in drinking water sources is increased continuously.

Keywords: *Nitrate, Drinking Water, Groundwater, Human Health*

Introduction

Groundwater and surface water resources are threatened by chemical and biological contaminants. Human activities have an impact on increasing this pollution [1]. According to reports, the drinking water has become the source of infection, especially in the developing countries [2]. World Health Organization (WHO) reported high rate of mortality, especially among the infant population in developing countries, due to consumption of contaminated drinking water [3, 4]. Some studies revealed that in 2004, only 15 percent of the world population were connected to the primary or secondary wastewater treatment systems [5]. The WHO reported that 37% of African population are not covered by healthy drinking water [6]. Only 2 percent of the world population have connected to the advanced water treatment plant with the ability to remove nitrate and nitrite [7]. Numerous industries and agricultural areas are engaged with the entering ammonia nitrogen, nitrite and nitrate into the water bodies [8, 9]. Nitrate is the most stable form of nitrogen compounds in water bodies [10, 11]. Nitrates are being produced during nitrification in the second phase of ammonia oxidation by bacteria [12]. A small amount of nitrate is also being formed in the Anammox process (anaerobic ammonium oxidation) process [13]. Nitrate can stimulate the growing of aquatic fauna. This phenomenon has been called nitrification [14, 15]. High concentrations of nitrates in water can cause health problems for humans and animals [14, 16]. Results confirm the relationship between use of high concentrations of nitrate in drinking water and the incidence of bladder cancer [17]. Methemoglobinemia can be attributed to the common side effects of the presence of nitrate in drinking water resources. Methemoglobinemia in infants is known as a blue baby syndrome. In this disease, nitrate can react with iron (II) of the hemoglobin forming methemoglobin, which has no ability for carrying the oxygen [18]. Furthermore, gastric cancer, meningitis, Parkinson's [19] and abortion are being caused by consumption of high levels of nitrate in drinking waters [20].

The nitrate pollution in water resources has been observed in several investigations. The results of a survey of 201 wells in united states showed that 22 percent of this wells haven't had the nitrate standards [21]. A research conducted in Denmark proved that 8% of the samples that were taken from groundwater, containing over 50 mg/L of nitrate [22]. Furthermore, nitrate concentrations in many cases were reported to be above 50 mg/L in wastewater of agricultural areas in Spain [23]. Hence, WHO have established the maximum concentration of nitrate in drinking water as 50 mg/L [24]. EPA has suggested the amount of the permissible level of 45 mg/L (based on nitrate) [25]. Because of the importance aspects engaged with the monitoring of nitrate concentration in drinking water distribution systems, this study aimed to measure nitrate concentrations in drinking water networks in Kashan and its surrounding towns.

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Note. Discussion period for this manuscript open until January 31, 2017 on JSEHR website at the "Show Article"
http://dx.doi.org/10.22053/jsehr.2016.33387

Materials and methods

As shown in Fig. 1, the study area is located in Kashan and six surrounding towns. During the project, based on the population of the region and the network line of 25 points (the central part of the city of Kashan and six surrounding towns) random sampling was conducted in containers with a volume of 200 mL under standard conditions. The selected area included Kashan (10 samples), Aran Bidgol (4 samples), Shahrak–e Gharb including Khazaqh, Ravand and Taherabad (3 samples), Ghamsar (2 samples), Niasar (2 samples), Barzak (2 samples), and Sefidshahr (2 samples), which have been shown in Fig. 1. Samples of drinking water networks –after being taking– were transported to the laboratory and to be measured. Measurement of Nitrate was done by a spectrophotometer (Hatch Company DR 2800 made in U.S.) at the wavelength of 500 nm. Nitravar 5 nitrate reagent was adopted for this test. 10 mL of samples was taken and after adding a certain amount Nitravar 5 to it, the sample was mixed for one minute. After this, cell containing the sample was placed for 5 minutes. Then, the level of nitrate was measured by DRM (Direct Reading Method) in DR2800 system. The data were analyzed by SPSS software.

Result and discussion

The mean and standard deviation of nitrate concentrations for various regions of Kashan County are presented in Table 1. The average concentration of nitrate was 17.52 mg/L (Max= 24.6, Min= 10.6 mg/L, CI= 95%). Results showed that samples taken from Ghamsar (27.4 mg/L) contained more amounts of nitrate than other locations and the lowest concentrations were reported in Sefidshahr (9.5 mg/L). The ANOVA test with SPSS software showed the significance differences ($p<0.05$) between the average concentrations reported in 7 sampled regions (Kashan and six surrounding towns).

Table 2. Classification the nitrate concentration (mg/L) in drinking water sources of Kashan county

Nitrate concentration (mg/L)	Classified	Percent
Below 20 mg/L	Slightly contaminated	68
Between 20 – 45 mg/L	Contaminated	32
Above 45 mg/L	Highly contaminated	0

A comparison between the average concentrations of nitrate between sampling locations is presented in Fig. 2. Table 2 shows a classification of the sample taken from Kashan drinking water network in three groups based on the level of nitrate concentration including nitrate concentrations of less than 20 mg/L, between 20 – 45 mg/L, and more than 45 mg/L. As illustrated in Table 2, 68% of samples contain the amounts less than 20 mg/L (slightly contaminated), 32% were between 20 – 45 mg/L (contaminated) and there was no sample containing nitrate concentration more than 45 mg/L (highly contaminated).

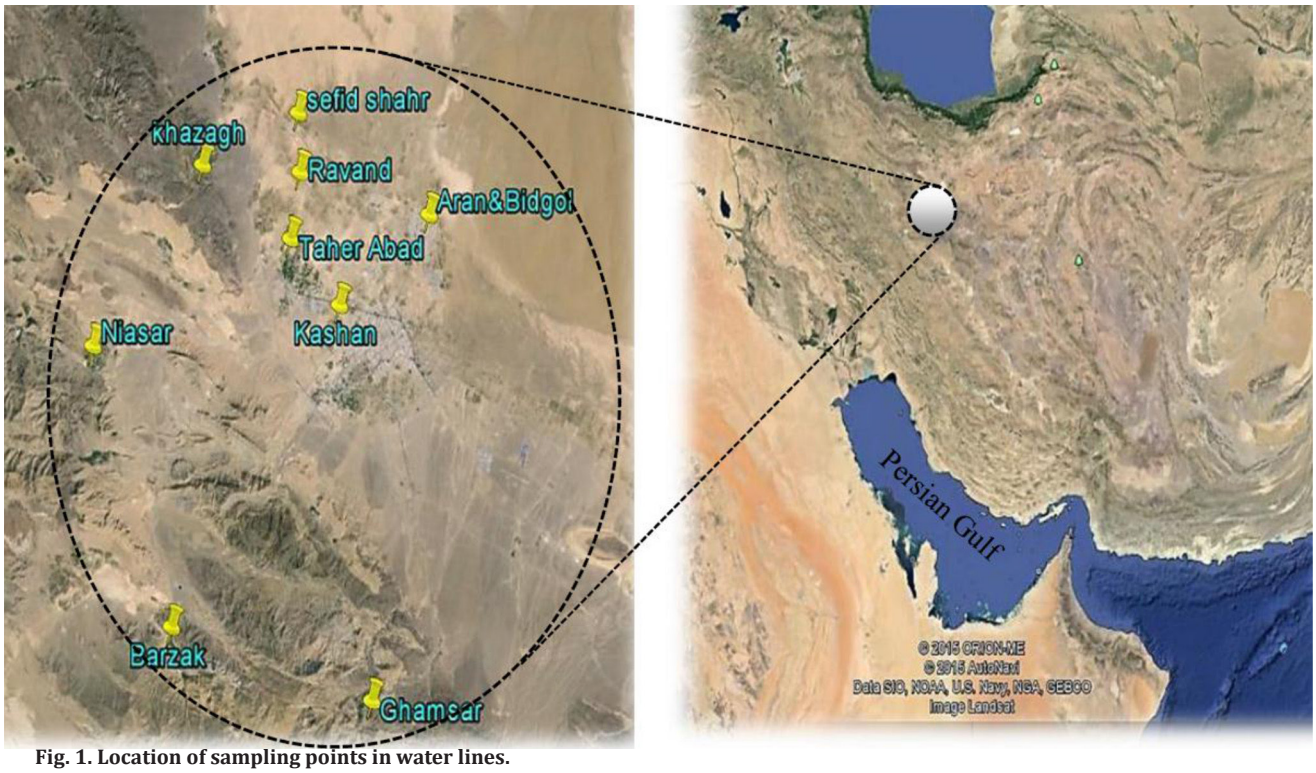

Fig. 1. Location of sampling points in water lines.

Table 1. Nitrate concentrations (mg/L) obtained for Kashan and six surrounding towns (Mean (SD))

Kashan	Aran& Bidgol	Shahrak–e Gharb	Niasar	Ghamsar	Barzak	Sefidshahr
16.8(4.8)	15.0(4.0)	24.4(4.4)	20.5(2.7)	24.6(3.9)	12.5(2.5)	10.6(1.6)

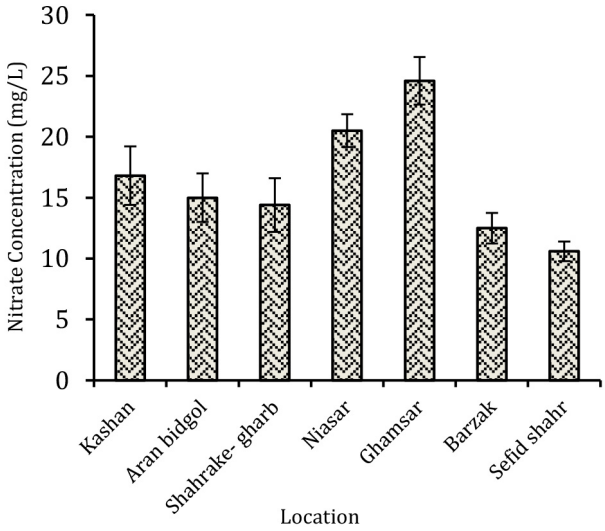

Fig. 2. Concentration of nitrates in different location.

According to the results, the average concentration of nitrate was reported to be 17.52 mg/L. Miranzadeh et al. (2006) reported that the average concentration of nitrate for Kashan in summer and winter were 15.4 and 13.2 mg/L, respectively [26]. Ghadermazi et al. (2011) reported that the average concentration of nitrate in drinking water samples taken from Bijar and Qorveh was 27.8 mg/L [27]. Another study in Gorgan (2001) showed the average nitrate concentration of 5.8 mg/L [28] which was obviously less than the findings of current study. Investigations performed in Mexico [29, 30] and Argentina [31] reported the average levels between 6 – 17 mg/L.

Maximum and minimum of nitrate levels in drinking waters were reported to be 27.4 mg/L and 9.5 mg/L for Ghamsar and Sefidshahr, respectively. The maximum and minimum amount of nitrate in Tehran were measured to be 85.65 mg/L and 2.65 mg/L, respectively [32]. A similar study in Alborz province obtained the average levels of 32.53 mg/L and 4.11 mg/L, respectively [33].

In Table 2, the concentration of nitrate in water resources is divided into three categories. Nitrate amount with a concentration less than 20 mg/L, between 45 – 20 mg/L and above 45 mg/L [34]. In this study 68% of the samples had values below 20 mg/L (in the water groups of slightly contaminated), 32% were between 20 – 45 mg/L (in the water group of contaminated) and none of the samples had maximum acceptable limit of 45 mg/L (in the water group of highly contaminated). Considering the classification, the overall average concentration of nitrate is in water groups of slightly contaminated. Due to the survey carried out in 2005 in Kashan, 2.8% of samples were classified into the group of contaminated [26]. Gheisari (2007) with a sampling of groundwater of the south east Isfahan, reported that 90 percent of the wells have concentrations of over 45 mg/L [35]. Mahvi (2005) showed that none of the samples had a concentration above 45 mg/L [36] in Khuzestan. Apart from Iran, 11% of drinking water sources located in Mexico are highly polluted with nitrate (concentrations more than 45 mg/L) [30]. The difference in the results of these studies can be attributed to the distance between water sources and wastewaters collected from urban, agricultural and industrial areas. Groundwaters and surface waters, according to these distances have a different quantity of nitrate. The significant differences between the average concentrations of nitrate in Kashan and other surrounding towns can be also found in the similar investigations like those performed in Tehran [37]. Analysis of variance (ANOVA) has shown the significant differences among the concentration of nitrate in seven sampling sites ($p<0.05$).

Conclusions

Groundwater sources of Kashan, located in a semi–arid region, are scarce and consequently very valuable. Due to the strict water scarcity in Iran, continuous monitoring of these inadequate water sources is vital. The results showed that the nitrate in drinking water distribution network has not exceeded international standards and WHO guidelines. Comparing the findings of the present study with those reported by the similar investigation performed in Kashan one decade ago (2006) it can be concluded that the content of nitrate in drinking water sources is increased continuously. This can be due to the extended agricultural activity during recent years in the vicinity of urban regions and uncontrolled use of chemical fertilizers enriched with high contents of nitrate. In addition, the industrial activities with untreated wastewaters, which may finally enter into the aquifers, are the second important factor regarding dramatically increase in nitrate concentration of Kashan drinking water sources.

Acknowledgment

The authors wish to highly appreciate “Water and Wastewater Company” of Kashan city for their collaboration.

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HOW TO CITE THIS ARTICLE

R. Fouladi Fard, M. Jani Mohammad Abadi, M.R. Hosseini, Survey the Nitrate Concentration in Drinking Water Distribution Systems of Kashan County, Iran, Journal of Safety, Environment, and Health Research, (2016) 36–39.

DOI: 10.22053/jsehr.2016.33387

URL: http://jsehr.net/article_33387.html