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Distribution of groundwater nitrate in Dehloran, Iran: A case study using GIS

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Original Article

Abstract

Nitrate has been the most common chemical contaminant in water resource. This ion is introduced into the water via different ways, but more items of nitrate pollution was connected with farming-based drainage and sewage effluent. In this descriptive-analytical study, groundwater nitrate and nitrite concentrations of 8 wells on Dehloran, Ilam, Iran, were analyzed in 2015 to determine the causes and zonation of pollutant. Results were compared with national standards and analyzed by SPSS and Arcview GIS 9.3 software. The highest and lowest nitrate concentration were related to Dashte Akbar No. 3 with an average of 11.1 ppm and Bareh bijeh well No. 3 with an average of 8.58 mg/l, respectively. Nitrite level of wells water was measured as zero milligrams per liter. There was no significant difference between nitrate concentrations and depth of wells because of approximately the same depth of wells. There was no significant relationship between the monthly average nitrate concentrations with each well. Likewise, no significant associations were found between the average nitrate concentrations of different wells per month. The nitrate concentration in 100% of the analyzed samples were less than 20 mg/l, thus water wells placed in slightly contaminated water. Given the great distance between residential areas with wells and the existing sewage collection network in Dehloran whereas high density agricultural activity, this amount of nitrate and nitrite was attributed to the widespread use of fertilizers. Therefore, proper management in the use of fertilizers and determining health policy regarding wells should be done.

KEYWORDS: GIS, Groundwater, Nitrates, Nitrites, Water Pollution, Water Wells

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Introduction

Nitrate and nitrite ions are naturally part of the nitrogen cycle. Because nitrate is tasteless, odorless, and colorless, in water, it is undetectable without testing and can attain both surface water and groundwater as an outcome of agricultural activity (including extra utilization of manures and inorganic nitrogenous fertilizers), from sanitary wastewater discharge, as well as some industrial wastewater treatment and from oxidation of organic matter like natural sediments containing nitrates, decomposition of plants, and nitrogenous waste products in human and animal excreta, including septic tanks.[1-5]

Nitrate inordinate levels in water

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resources can be unsafe to wellness, particularly for pregnant women and may lower the O_2 levels in the baby blood, famous as methemoglobinemia, with a possibility of mortality.[6,7] Ovarian and bladder cancer, stomach cancer, cardiovascular disease, miscarriage, high blood pressure, formation of nitrosamine and bad effect on the nervous system are the effect of high nitrate concentration, too.[1,8] So the U.S. EPA (1995) has appointed a maximum contaminant level of 10 mg/l nitrate.[9] Institute of Standards and Industrial Research of Iran has nominated 45 mg of nitrate per liter.[5,10,11]. Due to the simultaneous presence of nitrite and nitrate ions in drinking water, the sum of the measured values to proposed guideline values must necessarily be less than one.[1,12] The growing nitrate levels as the most important problems in water resources management that have been reported in many cities including Tehran, Mashhad, Isfahan, Arak, Rasht, Sari, and Babol indicate the presence of infection as microbial contamination.[13] The most effective way to prevent nitrate pollution is to determine contamination sources and reduction of these sources. Appropriate site selection for the water well's location and suitable well structure can prevent possibility of nitrate contamination. Nitrate level in wells is probably subjected to existence of sewage collection network, physical attributes of soil, kind of soil and substrate type, depth and manufacturing of wells, and its privacy.[14]

Because of the nitrate adverse health impact we choose Dehloran, Iran, as the study location since there are many major data available. The present study was carried out to understand the present status of groundwater quality about the nitrate and nitrite level, cause and source of contamination, mapping of their concentration with Geographical Information System (GIS) and also to assess the urban expansion and population density and its impact on the wells, in Dehloran, Iran.

Materials and Methods

To assess the effects of land use on groundwater quality, this descriptive-analytical study was carried out on 96 water samples from 8 wells (drinking water resources) of Dehloran, Iran, from spring 2015 to winter 2016. Spring and summer were considered dry seasons, and fall and winter were considered as wet seasons. Samples were taken in both high and low water periods on one liter polyethylene bottles, according to standard method. In order to measure the nitrate and nitrite concentration, we used spectrophotometer (DR-5000 model Manufacturing Hach Co.) for nitrate in applications of 355 in 500 nm and reagent of NitraVer 5, and for nitrite ions in applications of 371 in 507 nm and NitiVer3 reagents.[15] Normality of data assessing and one-way analysis of variance (ANOVA) was used to determine whether there are any statistically significant differences between the monthly average nitrate concentrations of 8 wells and average nitrate concentration of different wells per month and ArcGIS were used for database storage, after processing, plotting, and color zoning. Finally, the concentration distribution mapping was plotted in GIS environment and the affecting factors in nitrate and nitrite changes were analyzed.

Results and Discussion

Study location for current research has been shown in figure 1. The Average, maximum and minimum of nitrate level in 96 well water samples are shown in milligrams per liter as nitrogen in figure 2.

Highest and lowest nitrate concentration was associated to Dashte Akbar-3 with 12.6 mg/l and Bareh Bijeh 2 with 7.09 mg/l, respectively (Figure 3). Water quality monitoring depicted nitrate in Dehloran water sources existing at relatively low levels and was less than WHO guidelines (50 mg/l for drinking-water),[16] but in the region of severe agriculture the nitrate level may come near or exceed from EPA maximum contaminant level (MCL) of 10 mg/l measure

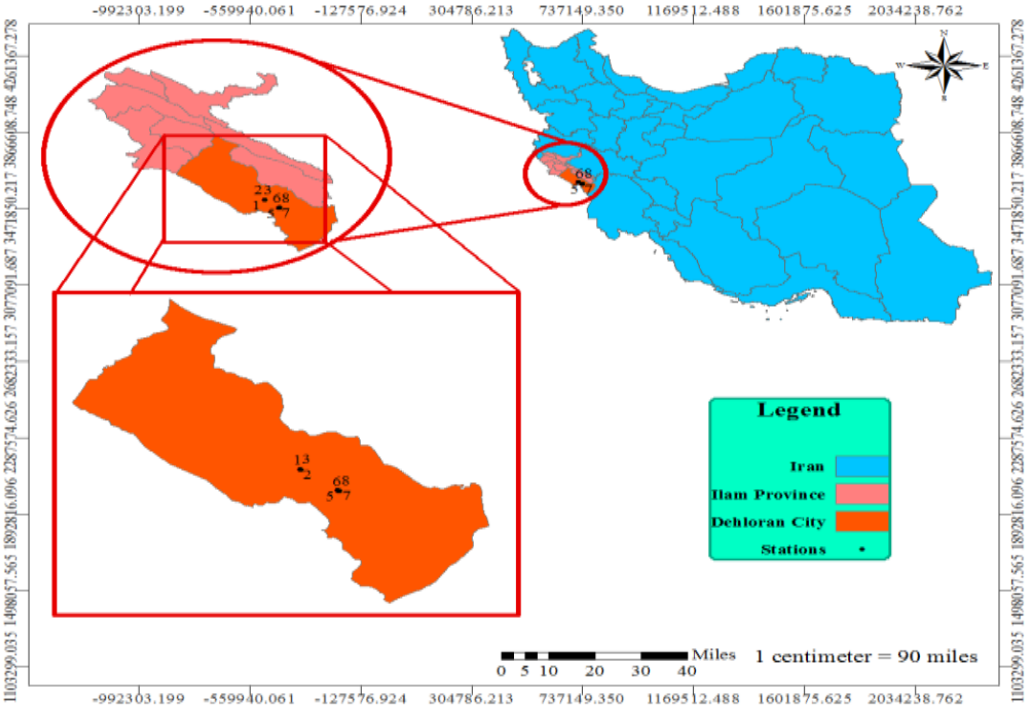

Figure 1. study locations
Dashte Akbar 1 named well No. 1; Dashte Akbar 2, Dashte Akbar 3, Bare Bije 1, Bare Bije 2, Bare Bije 3, Bare Bije 4, and Bare Bije 5 were called well No. 2, 3, 4, 5, 6, 7, and 8, respectively.

as nitrogen.[17] However, The nitrate level of water supply had no problem and was suitable for drinking. Figure 3 shows the monthly average, maximum and minimum nitrate concentration in the variety of wells and in variety of months in 2015.

The nitrite concentration in all tests of our research was zero, so it was not discussed. Regarding to this result, there was not a serious problem about nitrate and nitrite concentrations in ground water of Dehloran and pollutant levels were less from standards. It was found in Miranzade et al.[18] study that average nitrate concentration in most samples taken from water wells and distribution network in Kashan was lower from the EPA and WHO standard. Amarloei et al.[12] also, reported nitrate and nitrite concentrations in Ilam, Iran, groundwater were according to the drinking water standards. Based on similar studies in other parts of the country in recent years, it was recognized that nitrite had an increasing trend, like in study of temporal and spatial variations of drinking water sources of Gachsaran, Iran, using GIS.[19] Mozafarizadeh and Sajadi[20] investigated the chemical pollution of Borazjan's, Iran, groundwater and presented high nitrate pollution up to 160 ppm, especially in the southern Borazjan plains which was occurred by farming activity and absorbing wells. Our results ruled out health risk of nitrite and nitrate contamination in water supplies of Dehloran, but due to high consumption of nitrogen fertilizers in the scope of wells, we suggest a continuous assessment in future. Lee et al.[21] declared landscaping and farming has the greatest impact on the amount of nitrate in the summertime, similar to our finding. Residential and commercial land-use have also increased the concentration of nitrate.[21] So this confirms land use affects the water nature in aquifers and characterizes the types and amounts of chemicals introduced to the land surface that is penetrated into the water. The soils in Dehloran are well-drained, so have a low capacity to hold water; hence, these soils require some of the highest utilization of fertilizer and irrigation.[9]

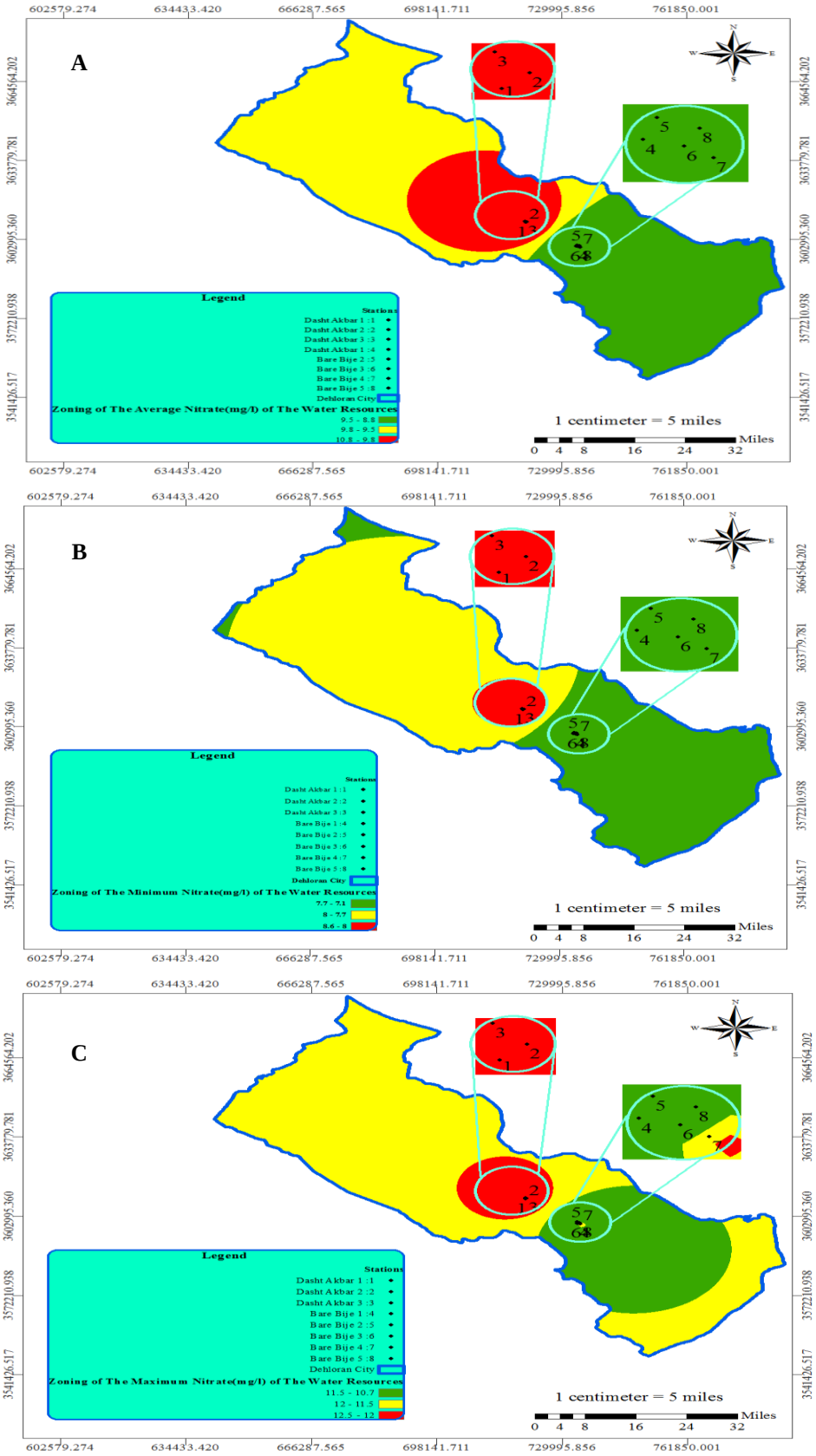

Figure 2. (A) Average (B) minimum and (C) maximum nitrate concentrations during different season of 2015

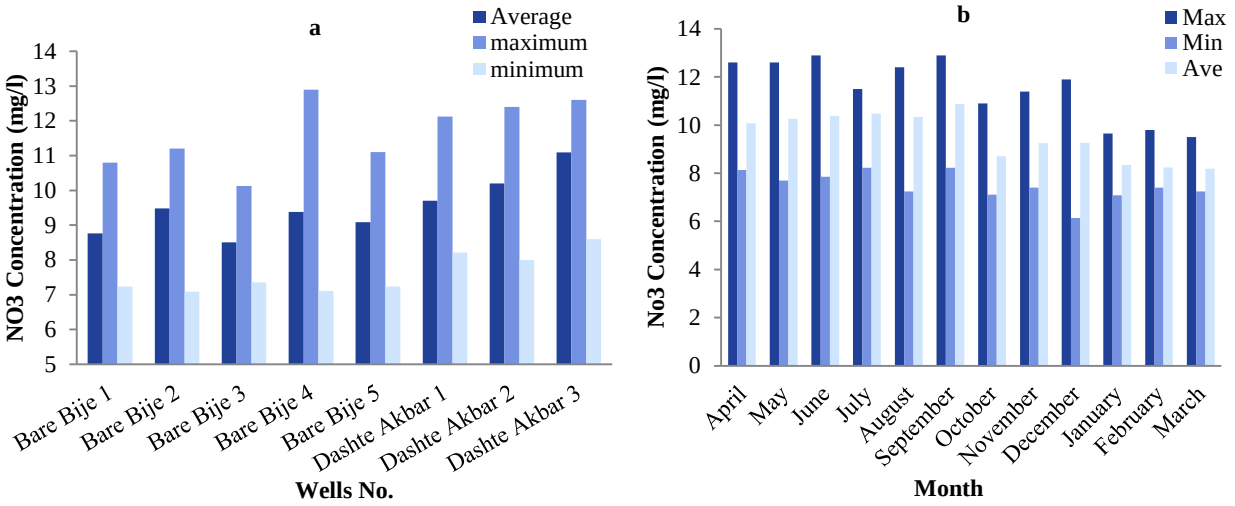

Figure 3. Average, maximum and minimum nitrate concentration in Dehloran drinking water sources in (mg/l- NO3-N) in variety of wells No. (a) and in variety of months in 2015

Regarding to the wells that are away from residential areas and existing wastewater collection network in Dehloran and high density agricultural activity, this amount of nitrite was attributed to the popular use of chemical fertilizers. Nassery and Nadafian[22] observed low concentrations in the western part of the region that was due to the proper distance from residential areas which is consistent with the our findings. There was significant difference among the average nitrate concentrations in different months ($P < 0.0001$), Tukey's test showed that such differences were between the following months: July with February ($P = 0.0250$) and March ($P = 0.0280$), August with February ($P = 0.0480$), and September with October ($P = 0.0450$), January ($P = 0.0130$), February ($P = 0.0050$), and March ($P = 0.0060$). Also, results of this study showed that nitrate concentrations in both wet and dry seasons without any significant difference has been affected by human activity, and similar results were reported by Badeenezhad et al.[14] One previous study announced nitrate in low rain season is more than wet season. A study in Jordan, reported that reduction of the nitrate concentration in the rainy season was attributed to dilution and feeding the plain by rain and nitrate concentrations dropped sharply with the construction of wastewater collection network.[23] Statistical analysis shows that there were significant associations among the yearly average nitrate concentration in different wells ($P = 0.01$). Dashte Akbar 3 had a significant relationship with Bare Bije 1 and 3 ($P = 0.0020$ and $P = 0.0010$, respectively).

Due to the same depth wells, approximately 100 meters, it was not possible to evaluate the statistical significance between the depth of wells and nitrate concentration. Badeenezhad et al.[14] have demonstrated reduction in the nitrate concentration with increasing the depth of well that indicates that the source of nitrate was mainly on the surface and subsurface layers. They also reported high nitrate concentrations in the central city of Shiraz attributed to lack of sewage collection network and expressed a not specified quality and privacy of wells, nearby wells and residential areas, density residential, and unimproved site selection of wells were reasons for raising of nitrate concentration.[14]

Conclusion

The nitrate concentration found to be less than 20 mg/l in all water well samples in Dehloran drinking water resources. Given that Dehloran had an incomplete sewage collection network, but because of long distances between the wells and residential

areas (the wells were farther away from urban areas), and due to agricultural use and soil type, this amount of nitrate was because of the extensive farming activities along with the use of manure and organic fertilizers. So the proper management of fertilizer application and privacy of wells are necessary.

Conflict of Interests

Authors have no conflict of interests.

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None.

References

1. World Health Organization. Guidelines for drinking-water quality. 2nd ed. Geneva, Switzerland: WHO; 1996.
2. Thorburn PT, Biggs JS, Weier KL, Keating BA. Nitrate in groundwaters of intensive agricultural areas in coastal Northeastern Australia. Agr Ecosyst Environ J 2003; 94(1): 49-58.
3. Kalvif S, Khan IU, Siddiqui. Nitrate/Nitrite contamination in groundwater of karachi and its correlation with other physicochemical parameters. Sci Environ Manage 2005; 13(2): 121-5.
4. Zawaideh LL, Zhang TC. The effects of pH and addition of an organic buffer (HEPES) on nitrate transformation in Fe0-water systems. Water Sci Technol 1998; 38(7): 107-15.
5. Environmental Protection Agency. Drinking water standards and health advisory tables [Online]. [cited 2012]; Available from: URL: https://www.epa.gov/sites/production/files/2015-09/documents/dwstandards2012.pdf
6. Kapoor A, Viraraghavan T. Nitrate removal from drinking water-review. J Environ Eng 1997; 123(4): 371-80.
7. Setareh P, Rezaei M, Hassani AH, Zinatyzadeh AA. Distribution of groundwater nitrate contamination in GIS environment: A case study, Sonqor plain. J Kermanshah Univ Med Sci 2014; 18(3): 157-64. [In Persian].
8. Salvato JA. Environmental engineering and sanitation. New York, NY: Wiley; 1992.
9. Gardner KK, Vogel RM. Predicting ground water nitrate concentration from land use. Ground Water 2005; 43(3): 343-52.
10. Gheysari MM, Houdaji M, Najafi P, Abd Elahi A. Assessment of nitrate pollution of groundwater in south -east of Isfahan region. Journal of Environmental Studies 2007; 33(2): 43-50. [In Persian].
11. World Health Organization. Guidelines for drinking-water quality. Geneva, Switzerland; 1997.
12. Amarloei A, Nazeri M, Sayeh Miri K, Nourmoradi H, Khodarahmi F. Investigation on the Concentration of Nitrate and Nitrite in Ilam ground waters. J Ilam Univ Med Sci 2014; 22(4): 34-41. [In Persian].
13. Torabian A, Amin Zadeh B. Nitrate removal from drinking waterusing ion exchange and nitification method. Proceeding of the Congress of Chemical Engineering 2008 Feb 18-20; Tehran, Iran. [In Persian].
14. Badeenezhad A, Gholami M, Jonidi Jafari A, Ameri A. Factors affecting nitrate concentrations in Shiraz groundwater using geographical information system (GIS). Toloo e Behdasht 2012; 11(2): 47-56. [In Persian].
15. Clesceri LS, Eaton AD, Greenberg AE. Standard methods for the examination of water and wastewater. Washington, DC: American Public Health Association; 1998.
16. World Health Organization. Water sanitation hygiene [Online]. [cited 2016]; Available from: URL: http://www.who.int/water_sanitation_health/en
17. United States Environmental Protection Agency. Table of regulated drinking water contaminants [Online]. [cited 2016]; Available from: URL: https://www.epa.gov/ground-water-and-drinking-water/table-regulated-drinking-water-contaminants
18. Miranzadeh MB, Mostafaii GR, Jalali A. An study to determin the nitrate of water wells and distribution network in Kashan during 2005-2004. Feyz 2006; 10(2): 39-45. [In Persian].
19. Yousefi Z, Barafrashteh Pour M, Taghavi M, MashayekhSalehi A, Sedaghat F. Survey on Temporal and spatial variation of nitrate and nitrite in drinking water of Gachsaran by using Geographic Information System (GIS). J Mazandaran Univ Med Sci 2013; 22(2): 158-62. [In Persian].
20. Mozafarizadeh J, Sajadi Z. Survey of groundwater chemical pollution in the Borazjan plain. Iran South Med J 2014; 17(5): 927-37. [In Persian].
21. Lee SM, Min KD, Woo NC, Ahn CH. Statistical models for the assessment of nitrate contamination in urban groundwater using GIS. Env Geol 2003; 44(2): 210-21.
22. Nassery HR, Nadafian H. Transport modeling of ground water nitrate contaminant in Hamadan drinking water wells area. Iranian Journal of Geology 2008; 2(6): 87-98. [In Persian].
23. Obeidat MM, Ahmad FY, Hamouri NA, Massadeh AN, Athamneh F. Assessment of nitrate contamination of karst springs, Bani Kanana, northern Jordan. Rev Mex Cienc Geol 2008; 25(3): 426-37.