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Investigation of Ground Water Nitrate Concentration in Ardestan, Iran*

Hamid Reza Rahmani and Mohmmad Koushafar
Islamic Azad University, Ardestan Branch, Ardestan, Iran

Abstract: Due to the harmful health effect of excessive nitrate concentration in human and animal food much research has been conducted on accumulation of nitrate in food plant and water resources. Nitrate concentration in well water of Ardestan region in central part of Iran was investigated during 2005. Ten agricultural districts were selected and in each district 3 to 4 well waters were seasonally sampled. The Nitrate, pH, Electrical Conductivity (EC) and Total Dissolved Solids (TDS) were measured. The results showed that pH is not a limiting factor for irrigation of agricultural land in the present study area. The EC and TDS in all districts were higher than permissible level according to USA EPA and Ayers and Westcot recommendation. Amiran district had the lowest and Charmil district had the highest EC and TDS values. The fall and winter had the highest seasonal TDS and EC values, which may be the results of pumping water in the previous season and deep percolation drainage water. Comparison of wells water nitrate concentrations with the permissible level by Ayers and Westcot for irrigation of agricultural land showed that in Amiran and Rigestan district in some seasons had low to medium and Zavareh-one and -two, Kachurastagh-one and -two, Telk-Abad, Charmil in all season had low to moderate and Hossein-Abad, Najaf-Abad do not have any restriction for land irrigation. Najaf-Abad and Kachurastagh-two had the lowest and highest mean nitrate content, respectively. The highest measured well-water nitrate content was observed during the summer and fall seasons. Also, nitrate concentration of Kachurastagh-one and Kachurastagh-two, Zavareh-one and Zavareh-two, Telk-Abad and Charmill were higher than drinking water standards.

Key words: Well water, Ardestan, permissible level, nitrate concentration, Iran

INTRODUCTION

In recent years many reports have identified agricultural non-point source pollution as the leading source of water quality impacts to rivers and lakes. The impact of agricultural practices on groundwater quality is of particular concern. This concern is heightened by the fact that a majority of the population of the state receives their drinking water supply from private wells. Most of these wells are shallow and are vulnerable to water pollution, especially from nitrate (Bhumbla, 2001). For example in west Virginia, contamination of surface and groundwater by non-point sources is of great concern. West Virginia is a water rich state and rivers originating in this state drain into the Chesapeake Bay and into the Gulf of Mexico (Bhumbla, 2001).

Nitrates and nitrites occur normally in nature from the breakdown of ammonia in the nitrogen life cycle. Nitrates in nature cause plant and algae growth that may affect the balance of water-based ecosystems. Nitrate is found in fertilizers and animal waste. Rain tends to wash fertilizers containing nitrates into nearby natural water systems and ground water. Groundwater used as drinking water that contains nitrogen represents a hazard to babies. Many die every year as a result from "Blue Baby Syndrome" (www.ScienceFairCenter.com). Nitrates cause sudden death when animals ingest large

Corresponding Author: Hamid Reza Rahmani, Islamic Azad University, Ardestan Branch, Ardestan, Iran

**Originally Published in Research Journal of Environmental Toxicology, 2007* amounts, as in fertilizer. Nitrates are not really very toxic, but are converted to nitrite. Nitrates are converted to ammonia and made into protein. If this conversion does not occur fast enough, nitrite is absorbed and converts hemoglobin to methemoglobin. The ferrous ion(+2) is converted to the ferric(+3) form. Methemoglobin can no longer carry oxygen, so the blood is a dark chocolate color and the animal suffers anoxia (Smith, 2006).

Excessive level of nitrate in drinking water and fresh vegetables when is converted to nitrate in the digestive system of human and animal interferes with the oxygen-carrying capacity of blood and caused a condition known as methamoglobinamia. Also continuous consumption of vegetable and drinking water with high level of nitrate content may react with nitrosamines to form N-Nitrose, which, are potent carcinogens in human and animals (Malakuti, 2000).

Agricultural activities in Slovenia are described and results of calculation of nitrogen and phosphorus balance in the catchment areas of the water bodies presented. The analyses show that hydro-morphological and chemical pressures from point pressures and diffused pollution from agriculture are the main reasons for the non-attainment of environmental objectives. Though consumption of mineral fertilizers and plant nutrients in Slovenia has reached more or less steady state in the last years, the quantities are still too high to reduce the risk to water environment (Globevnik *et al*., 2006).

Even thought the ratios between N, P and K uptake by plants is about 10: 1: 10, the fertilizer recommendation in Iran do not follow this ratio (Malakuti, 1999). Also, the application time is not synchronized with plant uptake. Consequently, the highly dissolved nitrate has been leached from the soil into ground water. In addition the accumulation of nitrate in vegetables such as Spinach, lettuce has causes in human and animals (Malakuti, 1999).

The denitrification and nitrate uptake by plants and microbes reduce the nitrate concentration in soil solution. In USA the permissible nitrate concentration for drinking water is 40 mg L^{-1} and higher concentrations may cause methamoglobinamia (Dabiri, 1996).

One month after nitrogen fertilizer application, the nitrate concentration in ground water increased, which shows nitrate leaching and transportations to ground water (Bhatt, 1997). Investigation of seasonal nitrate concentration shows that 97 kg ha^{-1} in spring and summer and 199 kg ha^{-1} in fall and winter have been leached and entered into ground water (Bruckler *et al*., 1997). Investigation of nitrate concentration (Edmunds and Gaye, 1997) in 8200 well-water in highly intensive agricultural showed that nitrate concentration is higher than permissible value 10 mg L^{-1}. Ninety percent of well-waters in Michigan State were contaminated with nitrate (Clift *et al*., 2001). In the paddy fields in northern Iran and southern of city of Tehran the high nitrate concentration is due to excessive application of nitrate fertilizer (Malakuti, 1999). In central Iran, in city of Yazd, in the vicinity of the Steel complex in Esfahan province the well water nitrate concentration were higher than permissible level (Rahmani, 2003).

In this study the nitrate concentration in water in Ardestan area in 2005 will be examine.

MATERIALS AND METHODS

This research did in 2005 in Ardestan area, located 100 km north of city of Esfahan in central part of Iran.

In the first phase from 86 agricultural districts in Ardestan county 10 agricultural districts was selected (Table 1). In each district 3 to 4 well waters were seasonally (times of sampling were in spring, summer, fall and winter in 2005) sampled. The water samples were immediately placed in an icebox and carried to the laboratory for standard analysis. The pH and EC were measured by a portable field EC and pH meters. The NO_3-N was determined with automated hydrazide reduction method (APHA, 1995) and Total Dissolved Solid (TDS) was measured in the laboratory (a well-mixed sample

Table 1: The selected studied districts

No. of well	Name of district	District No.
3	Kachurastagh 1	1
3	Kachurastagh 2	2
4	Amiran	3
3	Zavareh 1	4
3	Zavareh 2	5
3	Rigestan	6
3	Najaf-Abad	7
3	Telk-Abad	8
4	Charmil	9
3	Hosein-Abad	10

is filtered through a standard glass fiber filter and the filtrate is evaporated to dryness in a weighted dish and dried to constant weight at 180°C. The increase in dish weight represents the total dissolved solids (APHA, 1995). The results were compared with the permissible level for irrigation and drinking water.

RESULTS AND DISCUSSION

Table 2 shows the range and mean of pH, EC, TDS and NO_3-N in water samples of different districts and seasons. In water samples of different districts the highest pH was in spring (40% of districts) and summer (60% of districts) and lowest was in winter and fall. For EC and TDS the highest value was in fall (40% of districts) and winter (60% of districts) and lowest was in spring and summer. In other words the districts of 1, 4, 5, 6, 8 and 9 had the highest EC and TDS in winter and the districts of 2, 3, 7 and 10 had the highest EC and TDS in fall. In water samples of different districts the highest NO_3-N was, in districts of 2, 3, 4, 9 and 10 in fall, in districts of 6 and 7 in winter, in district of 8 in spring and in district of 1 in summer. In other words 50, 20, 10 and 10% of districts had the highest NO_3-N in fall, winter, spring and summer, respectively.

Table 3 shows the mean pH values in the various selected districts. The pH ranges from 6.73 to 7.01. The permissible pH values are from 6.5 to 8.4 or 6.0 to 8.5 (IEPA, 1994; EPA/ROC, 1989). Therefore, the pH value is not a limiting factor in the well-water.

Table 3 shows the mean Electrical Conductivity (EC). The lowest and the highest EC was recorded from Amiran (4.4 dS m^{-1}) and Charmill (7.7 dS m^{-1}), respectively. The EC's of all of the well water are higher than the recommended non-limiting values (EPA/ROC, 1989; Ayers and Westcot, 1985) for irrigation. The salt tolerance crop and cultivars should be planting and irrigation management such as leaching fraction be applied to minimize the crop yield reduction due to salinity. It is suggest that the Agricultural management office recommend planting suitable salt resistance crop and genotypes, to minimize the effect of saline irrigation water on crop yield.

In addition recommend irrigation practices to minimize salt load to ground water, while controlling root zone salinity. The total dissolved solid is ranging from 2900 to 4990 mg L^{-1}. Table 3 shows the total dissolved solid is higher than permissible values (EPA/ROC, 1989; Ayers and Westcot, 1985) for irrigation utilization. The permissible level is 2000 mg L^{-1} and is 450 mg L^{-1} for long-term irrigation application without any limitations.

The TDS Value in the Decreasing Order Are:

Charmil>Telk-Abad>Kachurastagh2>Zavareh2 and Zavareh1>Hosien-Abad and Kachurastagh1>Najaf-Abad>Rigestan>Amiran

Table 3 shows the mean concentration of NO_3-N in the well water. The mean NO_3-N and considering the permissible concentration level (Ayers and Westcot, 1985) the mean concentration of well water in Kachurastagh 1 and 2, Zavareh 1 and 2, Telk-Abad and Charmil is higher than 5 mg L^{-1} and has low to medium limitation for agricultural land irrigations.

Table 2: The range and mean of some characteristics of water samples in the selected districts with time of sampling

District No.	Time of sampling	pH Range	pH Mean	EC (ds m^{-1}) Range	EC (ds m^{-1}) Mean	TDS (mg L^{-1}) Range	TDS (mg L^{-1}) Mean	NO_3-N (mg L^{-1}) Range	NO_3-N (mg L^{-1}) Mean
1	Spring	6.0-7.0	6.8	5.2-5.7	5.4	3228-3648	3456	3.9-7.5	5.8
1	summer	6.7-7.1	6.8	4.4-5.8	5.1	2790-3665	3264	8.4-10..5	9.7
1	Fall	6.0-7.0	6.7	5.2-5.4	5.3	3322-3450	3328	6.1-8.6	7.1
1	winter	6.0-7.0	6.6	5.1-5.6	5.5	3264-3584	3520	2.2-6.4	4.8
2	Spring	6.6-7.1	6.8	5.5-6.8	6.1	3520-4353	3904	8.5-11.0	9.5
2	Summer	6.7-7.1	7.0	3.7-6.5	5.3	2374-4186	3392	5.5-14..3	10.2
2	Fall	6.0-7.0	6.7	6.0-7.7	6.8	3840-4941	4378	10.9-15.5	12.4
2	Winter	6.0-7.0	6.8	6.2-7.0	6.5	3962-4461	4147	6.2-9.7	8.5
3	Spring	6.8-7.2	7.0	3.9-4.9	4.1	2496-3136	2624	4.6-5.8	5.2
3	Summer	6.8-7.3	7.1	3.1-3.7	3.5	1997-2381	2214	1.7-4.2	3.2
3	Fall	6.5-7.0	6.8	3.9-7.2	5.6	2464-2621	3565	3.6-7.3	5.8
3	Winter	6.6-7.1	6.9	4.0-5.1	4.4	2266-3251	2816	4.0-4.9	4.7
4	Spring	7.0-7.3	7.1	4.2-5.7	5.1	2656-3667	3245	6.7-7.0	6.9
4	Summer	6.9-7.4	7.2	4.1-5.2	4.5	2611-3302	2854	6.3-7.2	6.7
4	Fall	6.5-7.0	6.8	4.7-6.4	5.6	3014-4102	3558	5.0-9.1	7.2
4	Winter	6.5-7.0	6.8	5.4-9.6	6.8	3450-6157	4358	2.9-7.5	4.8
5	Sring	6.9-7.1	7.0	4.4-7.6	5.5	2784-4864	3520	5.0-7.3	6.3
5	Smmer	6.6-7.0	6.7	4.6-5.9	5.4	2950-3757	3443	6.9-10.5	8.7
5	Fall	6.5-7.0	6.8	3.4-5.8	4.7	2387-3699	3034	0.9-4.1	2.9
5	Winter	6.5-6.9	6.8	4.5-9.5	6.3	2874-6080	4032	3.7-6.2	5.3
6	Spring	6.9-7.1	7.0	3.4-5.3	4.6	2202-3398	2938	0.7-1.3	0.9
6	Summer	7.1-7.4	7.2	4.5-4.8	4.6	2874-3053	2938	2.9-8.4	5.2
6	Fall	6.5-7.0	6.7	3.3-5.0	4.4	2099-3187	2816	1.4-8.6	4.9
6	Winter	6.7-6.9	6.8	4.5-5.1	4.7	2874-3258	3002	5.1-6.2	5.7
7	Spring	6.9-7.4	7.1	4.5-5.4	5.1	2906-3430	3232	0.4-2.7	1.6
7	Summer	6.7-7.6	7.4	3.2-4.1	3.7	2048-2624	2394	2.7-3.4	3.1
7	Fall	6.5-6.8	6.8	3.9-6.5	5.3	2490-4160	3366	2.7-3.2	3.0
7	Winter	6.5-6.8	6.7	6.1-5.3	4.9	2611-3418	3136	3.4-4.3	3.9
8	Spring	6.9-7.2	7.1	5.9-12.8	8.9	3776-8192	5696	7.3-13.0	10.5
8	Summer	7.1-7.5	7.3	5.7-7.4	6.6	3661-4736	4224	7.2-10.1	8.6
8	Fall	6.5-6.8	6.7	3.3-7.2	5.3	2099-4589	3411	4.3-11.4	8.3
8	Winter	6.5-6.9	6.8	5.2-18.4	9.7	3328-1776	6189	2.3-5.9	4.1
9	Spring	6.8-7.0	6.9	5.5-9.5	8.0	3520-6080	5120	8.5-13.4	11.8
9	Summer	7.0-7.1	7.0	5.8-10.2	7.7	3706-6515	4947	7.2-11.4	8.5
9	Fall	6.6-6.9	6.8	5.6-10.3	7.1	3597-6592	4525	10.5-14.1	12.3
9	Winter	6.5-6.7	6.6	5.7-10.5	8.1	3674-6746	5184	7.0-8.7	8.0
10	Spring	7.1-8.4	7.2	4.5-6.0	5.4	2880-3840	3456	2.8-4.2	3.8
10	Summer	7.3-7.4	7.3	4.2-5.5	5.1	2656-3526	3226	2.0-3.4	2.7
10	Fall	6.6-6.9	6.7	4.9-5.7	5.4	3155-3629	3443	3.2-5.5	4.4
10	Winter	6.8-7.0	6.9	4.8-5.9	5.3	3085-3757	3482	3.5-5.4	4.3

Table 3: The range and mean of some characteristics of water samples in the selected districts in 2005

District No.	pH Range	pH Mean	EC (ds m^{-1}) Range	EC (ds m^{-1}) Mean	TDS (mg L^{-1}) Range	TDS (mg L^{-1}) Mean	NO_3-N (mg L^{-1}) Range	NO_3-N (mg L^{-1}) Mean
1	6.5-7.1	6.7	4.4-5.7	5.3	2790-3665	3392	2.2-10.5	6.8
2	6.5-7.1	6.8	3.7-7.7	6.2	2374-4941	3955	5.5-15.5	10.2
3	6.5-7.3	6.9	3.1-7.2	4.4	1997-3251	2805	1.7-7.3	4.7
4	6.5-7.4	7.0	4.1-9.6	5.5	2611-6157	3504	2.9-9.1	6.4
5	6.5-7.1	6.8	3.7-9.5	5.5	2387-6080	3507	0.9-10.5	5.8
6	6.5-7.4	6.9	3.3-5.3	4.6	2099-3398	2924	0.7-8.6	4.2
7	6.5-7.6	7.0	3.2-6.5	4.7	2048-4160	3032	0.4-4.4	2.9
8	6.5-7.5	7.0	3.3-18.4	7.6	2099-1776	4880	2.3-11.4	7.9
9	6.5-7.1	6.8	5.5-10.5	7.7	3520-6746	4944	6.7-14.1	10.2
10	6.6-7.4	7.0	4.2-6.0	5.3	2656-3840	3402	2.0-5.5	3.8

The NO_3-N values in the decreasing order are:

Kachurastagh 2, Charmil>Telk-abad>Kachurastagh1>Zavareh1>Zavareh2>Amiran>Rigestan> Hosien-Abad>Najaf-Abad

According to the results Najaf-Abad and Kachurastagh 2 have the lowest and highest value NO_3-N concentration in well-water, respectively. For irrigation, wells water in Najaf-Abad and Hosein-Abad areas do not have and in other areas have low to moderate limitation, respectively.

CONCLUSION

The results of pH analysis indicate that pH of wells water is in the normal and permissible range and has no limitation for irrigation of agricultural land.

The comparisons of the well-water EC values with the maximum permissible values for irrigation water (Ayers and Westcot, 1985) shows that EC of all well-water are higher than maximum permissible values for irrigation. From the 10 studied districts the well-water in the Amiran and Charmil had the highest and lowest EC value, respectively.

Application of best management practices for reducing soil salinity and cultivation of salt tolerance plants is necessary.

The TDS of wells water in every district are higher than maximum permissible level (2000 mg L^{-1}) and according to Ayers and Westcot (1985) have limitation for land irrigation.

The highest nitrate concentrations were measured in summer and fall seasons, which may be the results of soil nitrogen fertilizer application and leaching from the upper soil profile in the previous seasons and transportation into ground water.

For irrigation, wells water in Najaf-Abad and Hosein-Abad areas do not have and in other areas have low to moderate limitation.

RECOMMENDATIONS

Due to negative balance of ground water resource due to excessive pumping, water resource planning and implementation is recommended. Uncontrolled and excessive ground water pumping put more pressure on local water resources and brings about water crisis especially in dry years.

The establishment and expansion of industries with high water demand is not feasible. Assessment of water demand for establishment of new and expansion of current industries should be considered.

Ground water pollution especially in arid regions is a serious treat. The ground water in many of the studied areas is the sources of drinking water. It is recommended to study the prevention and reduction methods for chemical loads into ground water by reducing and timing of fertilizer application and sound irrigation managements.

The high Nitrate concentration in ground water in some studied districts is due the over application of chemical nitrogen fertilizer in agricultural lands.

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