Effect of Nitrate Fertilizer on Agriculture and its Influence on Groundwater Pollution

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ABSTRACT: In the last few decades, the use of nitrogen fertilizer has increased substantially, without taking into consideration their effects on soil properties, agricultural products and especially on environmental pollution. Nitrate as the main form of nitrogen, causes groundwater pollution as it has negative charge. Due to its good and somehow constant quality and easy exploitation, groundwater is the most important water resource, especially in arid and semi-arid areas. Excessive amounts of nitrate in the drinking water are harmful for humans, livestock and plants. This study aims to investigate the nitrate pollution and its variations in the groundwater of the agricultural, industrial and urban areas of Shahryar area. Shahryar area is located in the arid and semi-arid area of Iran and in dealing with drought in the last few years, using its groundwater has become every increasingly important. To conduct this research, the area under study was divided into three districts: Shahryar, Ghods and Malared and with regards to land use, it was divided into three areas: agricultural, industrial and urban. Totally, 30 wells were chosen for sampling. Sampling the water of these wells was done in five stages (from May to September, 2008) with the time intervals of one month. And the amounts of nitrate, nitrite, pH, electrical conductance and total dissolved solids in the samples were measured. Approximately, in 60 percent of the wells, the concentration of nitrate was more than the standard level (45 mg/L) and during the study period, the mean concentration of nitrate in the water of the wells was varied between 2.9 and 66.2 mg/L. The mean concentration of nitrate in the groundwater of Shahryar, Ghods and Malared districts was 29.8, 35.7 and 54.1 mg/L, respectively. The nitrate concentration was more than the standard level in 53.3, 50 and 85.7 percent of wells in Shahryar, Ghods and Malared, respectively. However, the abundance of nitrate concentration in different districts was not the same. Most of nitrate pollution in the groundwater was observed in the agricultural areas; with the urban and industrial areas placed in the next ranks. Agricultural activities are the most important factor of nitrate pollution in the groundwater and pollution distribution has a very close relationship with these activities. In most of the study areas, the nitrate concentration in the groundwater increased over time and the highest amount of nitrate concentration was related to July 2008. There was no high correlation between nitrate concentration and any of the chemical parameters measured in the groundwater samples.

Key words: Nitrate Fertilizer, Agriculture, Influence, Groundwater Pollution

INTRODUCTION

Nowadays groundwater resources contamination to nitrate is one of the most important issues in the contexts of environment and sustainable agriculture. Nitrate as the most important form of nitrogen is added, directly or indirectly, to organic compounds. Groundwater is among the important water supplies in the nature which is exploited through digging deep and semi-deep wells, springs and subterranean canals (Ghanats). About 97 percent of total freshwater of the earth is stored in the form of groundwater; and surface waters make up only 3 percent of it (Jamayee, 1989). Today, about 60% of the drinking water, 15% of household water use and 20% of water used for irrigation is supplied through groundwater. In Iran, near 75% of urban water and more than 50% of agricultural water is supplied through this source. During the last 20 years, the volume of the water exploited from this source has increased by 3 times (Yarnia, Mirabzadehand Keshavarz., 1994). Shahryar area (county) which includes a notable part of the southwest of Tehran province, is located in the arid and semi-arid area and due to the occurrence of drought in the last few years, consumption of its groundwater for agriculture and for supplying the drinking water of cities and villages has become very important. Because of the large area of the agricultural regions, usage of chemical fertilizers especially nitrogen ones, existence of other pollution sources in the area and high consumption of groundwater for general and agricultural uses,
investigation of pollution in this area is very important. Briefly, goals of this research include the following ones (Jafari Malak Abadi, 2002):

- Recognizing the nitrate pollution distribution in groundwater of Shahryar area;
- Investigating the role of agriculture and other sources in nitrate pollution of groundwater; and
- Comparing the nitrate amounts in the groundwater against the international standards.

**Background**

In natural conditions, soil nitrogen reaches the balance at a constant level. Magnitude of this level depends on factors like weather, kind of lands, physical properties of soil and activities of microflora and microfauna (Salar Dini, 1995). During 1928 to 1940, he published some articles about the relationship between soil nitrogen amount and factors constituting the soil; i.e. weather, plant coverage, topography of the land, kind of the source rock and time (Jenny, 1941). Climate is one of the most important factors determining the existence of certain species of plants, extent of the produced plant materials and severity of microbial activities in soil; hence it is an effective factor in accumulation of nitrogen in soil. Effect of moisture on accumulation of nitrogen in soil is mainly due to its impact on plant growth and on production of most of the raw plant materials which can be effective in generating homos in the soil. Dini's classic studies about the accumulation of nitrogen and its relationship with climate are very interesting and show that the percentage of soil nitrogen is a function of temperature. Soils located under plant coverage including plenty of roots usually have more organic matter and nitrogen, because plant coverage is a function of climatic conditions. Therefore, the effect of these factors on accumulation of soil nitrogen is not exactly clear (Salar Dini, 1995). The amount of nitrogen in clay soils is more than that in the loamy soils and that of the loamy soils is more than that in the sandy ones. The reason is that clay has a higher strength to hold mineral nitrogen. Organic matters of soils, in their own turn, produce organic-mineral complexes with clay particles which show a great resistance against oxidation by microorganisms (Malakooti, 1994).

Type of clay minerals also affects nitrogen content of the soil. Soils having clay of Montmorillonite group, can maintain mineral nitrogen in the exchanged or stabilized form; hence it can not be consumed by soil microorganisms easily. However, by mineral nitrogen, we mean compounds having positive charge like ammonium. Scientifically, other factors including activities of microorganisms, forms of nitrogen in the soil, soil mineral nitrogen, soil organic nitrogen and distribution and dispersion of nitrate in the soil control the nitrogen content usable by a growing plant, with respect to its active root extent(Gardner and Broknns. 1975). Losses of nitrate-nitrogen from light and sandy soils are more than that of the heavy soil (Black. 1968). (Smica. 1977) investigated the nitrate-nitrogen loss from sandy soils and stated that its average amount is 9-14 kg/ha per year. Walters, D.T. and Malgner, G.L.(1990) also concluded from their investigations that 18 to 30% of each 90 to 180 kg/ha nitrogen added to the medium-textured soil(loamy sand) under maize cultivation is lost from the root zone through leaching. Studies performed by Sharma, U.C.(1990) on soils of different textures in India show that the extent of nitrate leaching depends mainly on soil texture, amount of rainfall and irrigation water. (Malakooti Jafari,1992) by measuring nitrate in maize fields of south Tehran , having light or heavy texture, concluded that the extent of nitrate leaching, even in the control land parcels and after the first irrigation was very notable. And for calcareous soils of south Tehran, this loss(movement of nitrate to a depth of more than 60 cm) in medium-textured (loamy) soil was more than that of the clay soil. Even the amount of 94.1% of nitrate-nitrogen lost has been reported for calcareous soils of Greece. (Ritter and Manger. 1985) in their study on effect of irrigation efficiency on losses and leaching of nitrate reported that the leaching of nitrate has a direct relationship with the volume of the drained water and reduces when the irrigation efficiency, volume of the drainage and amount of the leached nitrate increase. (Lucey and Goolsby, 1993) and (Owens. 2000) having studied the nitrate leaching from corn –soybean rotation using a lysimeter reported that the corn rotation with plants like soybean which need less nitrogen fertilizer, reduces the nitrate leaching and prevent groundwater pollution. (Lucey and Goolsby. 1993) in their study on the influence of climatic variation over 11 years on nitrate concentration in Iowa State in U.S.A. concluded that during drought or lack of precipitation , nitrate accumulation in the soil takes place as a result of
nitrate transport reduction, lack of nitrate uptake by plants and increase of the thickness of the unsaturated zone beyond the stability level.

**RESEARCH METHOD**

**Selecting the Sampling Points**

To perform this research and to investigate the nitrate pollution of groundwater, after specifying the study area, the balanced map of the groundwater and the wells existing in the area was provided by Power Ministry and combining the information existing on the maps, the finder map of the sampling area was prepared. After preparing the finder map, the study area (Shahryar) was divided into three parts according to the geographical and political divisions: Shahryar, Ghods and Malared; and into three areas according to land use: agricultural, urban and industrial. In the divided districts, wells were selected which as much as possible could fully represent all of the wells in the area and were as far as possible always active. On the other hand, due to the criminality of the groundwater situation in Shahryar plain and increase of stability level depth in the area, wells were chosen which more than 220 m in depth were. The positions of the wells were fully noted and their geographical length and width was determined and recorded using GPS device and then by Arc GIS, version 9/3 and Franson, version 2/3 were again investigated on finder maps and the satellite image produced by Landset Satellite. 30 wells were selected in this area.

**Nitrate Measurements**

Nitrate ion was measured by Spectrophotometer, Genoy Model 6305 (American Public Health Association 2003). This device is able to measure very rapidly the nitrate ion of the sample at the wave length of 220 Nanometer.

To measure nitrite, Kajel device, model 400 D, was used which measures nitrite amount according to Nanocalorimetry method (American Public Health Association 2003).

**Electrical Conductance Measurement**

The electrical conductance of the water samples gathered from the wells was measured by Electrical Conductance Device, model 644 meter-ohm. (Chapman, H.D. and Pratt, P.F., 1961).

**Total Dissolved Solids Measurement**

To measure the total dissolved solids in the water of the wells, the Oven Method was used. However, by using the empirical formulas of the relationship existing between electrical conductance and total dissolved solids existing in the water, this relationship was investigated (Chapman, H.D. and Pratt, P.F., 1961). To perform the statistical operations, SPSS, to plot the curves, the Excel Software, to plot the maps of nitrite pollution extents, Arc GIS, Version 9/3 and to verify the maps, FRANSON Software, version 2/3 was used.

**RESULTS**

**Investigation of nitrate pollution of groundwater in shahryar district (central district).**

To investigate the nitrate pollution of groundwater in this district a number of wells were sampled. The nitrate ion concentration in the whole area's groundwater was measured in different time stages from May to September, 2008 (sampling stages 1 to 5). About 53.4 percent of wells selected in this district were located in agricultural areas, 26.6 percent in urban areas and 20 percent in the industrial ones. In the current study, to investigate the extent of nitrate pollution and to compare it against international standards, the standard of U.S. Environmental Protection Agency (EPA) and World Health Organization (WHO) for nitrate in drinking water was used; i.e.45mg/L. In Iran also these standards are used to compare the nitrate concentrations in water sources. Another task performed in this research was measuring nitrate amount by using the very exact method of Nanocalorimetry. The mean nitrate concentration in the groundwater of this district was 30 mg/L and the amount of nitrate concentration in different wells ranged from 2.9 to 57.1 mg/L. Regarding the abundance of nitrate in this district, it can be said that the nitrate concentration was below 10 mg/L in 40% of wells, between 40 and 50 mg/L in 26.7% of the wells and between 50 and 60 mg/L in 26.7% of them. Totally, 53.3% of wells in this district had nitrate concentration above the standard level accepted for drinking water. Concerning the time variations in different time stages, the nitrate concentration of the district varied at different stages. The mean nitrate concentration in the groundwater of this district at stages 1 to 5 (from May to September, 2008) was 28.2, 30.2, 31.1, 30.5 and 29.5 mg/L. The maximum nitrate concentration was observed at July.

**Investigation of Nitrate Pollution of Groundwater in Ghods District**

Concerning the human activity and economical importance, Ghods district is placed in the second rank after Shahryar; in such a way that it is changed to be a separate county but occupies less area than Shahryar district. 8 wells were studied in this district (from No.16 to No.23). Total mean nitrate concentration of Ghods district was 35.7 mg/L and the mean amount of nitrate concentration of different wells of this district was varied between 15.4 and 49.5 mg/L. Concerning the abundance of different ranges of nitrate concentration, it can be said that the concentration was between 10 and 20 mg/L in 12.5% of the wells, between 20 and 30 mg/L in 25% of wells, between 30 and 40mg/L in 12.5% of them and more than 40 mg/L in the remaining 50 percent. Totally,
5.0% of wells in this district suffered from nitrate contamination and the nitrate concentration of them was more than the standard level acceptable for drinking water.

Investigation of Nitrate Pollution of Groundwater in Malared District

Concerning the human activity and economical importance, of the three divided areas, Malared occupies the third place. 7 wells were studied in this district (from No.24 to No.30). Total mean nitrate concentration of Malared district was 54.1 mg/L and the mean amount of nitrate concentration in different wells of this district ranges between 20.8 and 66.2 mg/L. Concerning the abundance of different ranges of nitrate concentration, it can be said that the nitrate concentration was between 20 and 30 mg/L in 14.3% of the wells, between 40 and 50 mg/L in 14.3% of wells, between 50 and 60mg/L in 28.8% and more than 60 mg/L in 42.8% of them. Totally, nitrate concentration in 85.7% of Malared district wells was more than the standard level acceptable for drinking water (45 mg/L). Comparing the mean nitrate concentration in Malared district groundwater (54.1) with those of Ghods district(35.7) and Shahryar district(30) , it was noted that there is a significant difference between the mean amount of the two pervious districts and that of the Malared district, which may have been caused by different factors, of which one of the most important ones is the continuance of traditional methods of irrigation and fertilization used in Malared district. The area of regions at the risk of pollution (pollution margin) has had the highest decrease compared to those of the contaminated and uncontaminated regions and has had decreased about 7.3% compared to Fig. 2.3 to reach 21.65% which is equivalent to 281.3Km².

DISCUSSION AND CONCLUSION

Generally, Shahryar region which was our target area is one of the affiliated areas of Tehran province which as a result of proximity to Tehran metropolis, enjoys a great potential for human and economical development. According to the latest statistics of the State Management and Planning Organization, the population of this county is increasing by 167 persons per day; i.e. 6.7 person per hour. The rate of population growth in Shahryar county is 7.8% which is 3 times more than that of the Tehran province (2.6%)(Wetselaar. 1961). Now, if we desire to compare the population amount of urban and rural residential zones, it must be said that the indicator of urban population proportion of this county was 86.6% and that of the rural one was 12.4%. From the economical point of view, it must be said that Shahryar County's economy is, to a large extent, dependant on agricultural activities which due to proximity to the capital, is well flourished. Now, by investigating the above contents and having in mind the lack of suitable infrastructure in the economical and human development section, it must be said that in the future, this county would be at the risk of numerous environmental pollutions, one of which is the contamination of groundwater of this county to nitrate ion. As mentioned above, on one hand, 60% of wells studied in Shahryar county suffered nitrate pollution and on the other hand, 17% of the rest wells would be at the risk of nitrate pollution in the near future. This indicates the non-observance of environmental measures and standards and excessive pressure on these natural resources. The impacts originated from agricultural, urban and industrial activities were different; the percentage of them is shown in Fig.6-3. Concerning the extent of the contamination of each of the above said activities, it must be said that contribution of the agricultural activities is about 72.2%, that of the urban activities was 16.5% and that of the industrial ones was 11.3%. This means that 72.2% of all of the points with groundwater contaminated to nitrate were located in the agricultural lands, 16.5% in the residential zones and 11.3% in the industrial areas. As noted, the importance of the role that agricultural activities play in the groundwater pollution is much more than that of the urban and industrial ones and the main reason of this is that the agricultural activities have a direct impact on groundwater sources pollution, both in the field of nitrogenous pollutants and increase of leaching extent. In the agricultural activities section which is divided into three subsections of gardening, cultivation and husbandry, factors like excessive use of chemical nitrogen fertilizers, lack of appropriate management of irrigation and traditional irrigation methods, use of pesticides including nitrogenous compounds, inappropriate collection and drainage to remove excessive runoff from agricultural and other secondary factors have increased nitrate concentration of groundwater. Nitrate pollution of Shahryar groundwater was notable, and with regard to this fact that in the last years, Shahryar plain and southwest area of Tehran province, have been among the critical regions concerning the groundwater sources; hence it must be accounted as one of the newest issues of sustainable agriculture and exploitation of water resources. Concerning the spatial distribution of nitrate pollution, it can be said that Malared district groundwater suffers from the highest extent of pollution (85.7%), while Shahryar (53.3%) and Ghods (50%) occupy the second and third places, respectively. Pollution distribution of the studied areas has a very close relationship with the spread and severity of the agricultural activities and with level of farmers’ knowledge and welfare; in such a way that the highest nitrate concentration was relevant to agricultural lands of Malared and Shahryar districts and the lowest extent was observed in Ghods district. In Ghods district, the severity of traditional agricultural activities is lower and the agricultural activities are more scientific, so most of the agricultural activities are in the form of greenhouse and a large extent of lands of this area are under other land uses. The highest nitrate concentration of groundwater was relevant to agricultural lands of west part of
Malared district. Sometimes, the concentration of this ion in some of the wells of this district has exceeded beyond the limit of 66mg/L.

REFERENCES