International Meeting on Soil Fertility Land Management and Agroclimatology. Turkey, 2008. p: 969-976

Evaluation of Nitrate Concentration in the Groundwater Resources of Gorgan

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ABSTRACT

Nitrogen is vital for plants and influences the amount as well as the quality of yield. However, in the absence of proper management, it's excessive in the water resources could have negative impact on water quality and may cause environmental as well as health complications. To evaluate the nitrate concentrations in groundwater resources in Gorgan area, north of Iran, 47 water samples were taken from different groundwater resources of shallow and deep wells as well as streams. The results showed that nitrate concentrations varied from 0.44 to more that 36 mgL^{-1}showing different pattern in different resources. In deep wells (wells with the depth of more than 50 meter), nitrate concentrations varied from 1.77 to 12.4 mgL^{-1} with an average of 5.8 while nitrate concentrations in shallow wells (wells with the depth of less than 50 meter) varied from 0.44 to 36.32 with an average of 13.37 mgL^{-1} . The corresponding data for streams was found to be varied from 3.54 to 27.9 mgL^{-1} with an average of 15.84. The results showed that nitrate concentrations was clearly greater in shallower groundwater resources compared to deeper ones showing increase of nitrate accumulation risks due to intensive agricultural activities in these area. The trends of nitrate accumulation showed that water resources is becoming more susceptible since they are the main drinking as well as agricultural source of water in the area. It seems that proper management in terms of fertilizers use and irrigation would be necessary to decrease the risk of nitrate accumulation in water with more emphasis to shallow water resources in the area.

Keywords: Nitrate concentration, Groundwater, Gorgan.

INTRODUCTION

Nitrate is an essential plant nutrient and a natural constituent of any soil. It is an important source of nitrogen for plant growth. However, if the soil contains more nitrate than plants can use, then the excess nitrate can be leached from the soil and contaminate groundwater. Most nitrate leaching occurs over the winter months, when plant growth is slow, soils are wet and rainfall is plentiful. As a result, nitrate concentrations in groundwater are highest in the winter and springtime. In the summer and autumn, plants are growing and taking nitrate and water from the soil, so nitrate leaching rates are lower. As a result, nitrate concentrations in groundwater generally decrease in summer and autumn. Mahvi et al (2005) found a few different between groundwater mean nitrate contents, during spring and summer 2004, in each subregions of Andimeshk and Susa plains of Iran, because the water table in these plains has very low fluctuations during the year.

Obviously the more nitrogen fertilizer a farmer uses the greater the chance of nitrate pollution of groundwater. Farmers still consider nitrogen fertilizer as s cheap insurance against crop failure (Looker, 1991; Mahvi et al, 2005). Even if farmers cut down on nitrogen fertilizer, there will still be some nitrate leaching. Although sustainable practices may not eliminate nitrates, it might lower them to a safe level. Obviously, if there is a chance of nitrogen pollution when no fertilizer is applied, the chance of pollution is greatly increased when a large amount of fertilizer is applied. However, some conditions such as riparian ecosystems, through their unique position in the agricultural landscape and ability to influence nutrient cycles, can potentially reduce NO_3 loading to surface and ground waters (Davis et al, 2006).

Some researchers have reported nitrate movement from waste application fields in shallow ground water, and soil, hydrologic, and biological factors influencing the amount of nitrate in the adjacent stream (Israel et al, 2004; Karr et al, 2001). The seasonal changes in the relative impact of nitrate sources on ground water contamination were also reported to be related to such factors as source distribution, the aquifer confining condition, precipitation rate, infiltration capacity, recharge rate, and the land use pattern (Jun et al, 2003). It has also reported that noncontrollable factors such as precipitation and mineralization of soil organic matter and manure have a tremendous effect on drainage losses, nitrate concentrations, and nitrate loadings in subsurface drainage water (Randall and Mulla, 2000; Dauden et al, 2004)**.** The elevated level of nitrate in groundwater is also a serious problem in Korean agricultural areas (Kaown et al, 2006).

The United States Environmental Protection Agency is currently establishing National Primary Drinking Water Regulations for over 80 contaminants under the Safe Drinking Water Act (Vogt and Cotruvo, 1987). The goal is to reduce the contaminant concentrations of all drinking water to levels near those prescribed in the Maximum Contaminant Level Goals (MCLGs) previously established by the EPA (Vogt and Cotruvo, 1987). MCLGs are "non enforceable health goals" at which "no known or anticipated adverse effects on health of persons occur and which allow an adequate margin of safety" (Vogt and Cotruvo, 1987). The Maximum Contaminant Levels (MCLs) are to be set as close to the MCLGs as possible (Vogt and Cotruvo, 1987). In the case of nitrate concentrations, the MCL has been set at 10 mgL-1 as nitrogen which is also the proposed MCLG (Vogt and Cotruvo, 1987). For many contaminants, carcinogenicity is the primary characteristic which determines the MCL; however, because there are no conclusive epidemiological studies which link nitrate to cancer in humans, carcinogenicity was not taken into account in the establishment of the MCL for nitrate (Kamrin, 1987). The determining factor in the EPA's decision to set the MCL at 10 mgL-1 was the occurrence of methemoglobinemia in infants under of six months. The MCL reflects the levels at which this condition may occur (Kamrin, 1987). Although the MCL for nitrogen was set at 10 mgL-1 nitrate - nitrogen, in 1976 the EPA suggested that water having concentrations above 1 mgL-1 should not be used for infant feeding (Rail, 1989). This guideline is very conservative and nitrate concentrations below 10 mgL-1 are probably harmless as well. However, because concentrations this low are common, the EPA hopes this guideline will induce people in rural areas to have their wells tested so that severe nitrate contamination is detected and serious health problems are avoided in the future.

However, there is substantial disagreement among scientists over the interpretation of evidence on the issue. There are two main health issues, the linkage between nitrate and infant methaemoglobinaemia, also known as blue baby syndrome (Comly, 1987), and finally cancers of the digestive tract. The evidence for nitrate as a cause of these serious diseases remains controversial. On one hand there is evidence that shows there is no clear association between nitrate in drinking water and the two main health issues with which it has been linked, and there is even evidence emerging of a possible benefit of nitrate in cardiovascular health. There is also evidence of nitrate intake giving protection against infections such as gastroenteritis. Some scientists suggest that there is sufficient evidence for increasing the permitted concentration of nitrate in drinking water without increasing risks to human health. However, subgroups within a population may be more susceptible than others to the adverse health effects of nitrate. Moreover, individuals with increased rates of endogenous formation of carcinogenic N-nitroso compounds are likely to be susceptible to the development of cancers in the digestive system. Given the lack of consensus, there is an urgent need for a comprehensive, independent study to determine whether the current nitrate limit for drinking water is scientifically justified or whether it could safely be raised (Powlson et al, 2007).

Gorgan is located in north of Iran where there have been extensive agricultural activities for a long time in the area. Since the main source of agriculture as well as drinking water of the area is mostly groundwater, the object of this study was to determine the nitrate concentrations in groundwater and some other different sources of water in the studied area.

MATERIALS and METHODS

The research was conducted in Gorgan a part of Golestan province located in the north of Iran. To evaluate the risk of nitrate concentration in water resources of Gorgan, 47 water samples were taken from different groundwater resource including shallow as well as deep wells. In general, 20, 18 and 9 water samples were taken from deep wells, shallow wells and streams, respectively. Shallow and deep wells were referred to the wells with less and more than 50 meter in depth, respectively. Few water samples were also taken from the streams at the surface. Well’s water samples were taken after an hour the water pump was turned on. All samples were taken using polyethylene plastic tubes which were already been truly washed and were kept in the fridge for nitrate analysis. Nitrate concentrations were measured in the water samples straightaway using spectrophotometer methods (Rowell, 1994). All data processing and graphs were prepared using Excel computer software.

RESULTS and DISCUSSIONS

The results are generally shown in Figures 1 to 4. In deep wells nitrate concentrations were ranged from 1.77 to 12.4 mgL-1 (Figure 1). The corresponding data for shallow wells and streams were from 0.44 to 36.32 mgL-1 (Figure 2) and from 3.54 to 27.9 mgL-1 (Figure 3), respectively. The results showed that there were relatively high variations between the points for nitrate concentrations which seem to be due to different crops and farms managements which were quite obvious in the studied area. Since the farmers would like to apply their own management to their private lands, nitrate concentrations in soil as well as in the water resources would be affected under different management strategies. Different rates of N fertilizers along with Soil as well as climate conditions are also reported to be important factors controlling nitrate leaching and concentrations in soil and water resources (Jun et al, 2003; Randall and Mulla, 2000; Dauden et al, 2004). Although, precipitation rate was relatively similar across the area, but different soil properties were found in different points. The results showed that higher nitrate concentrations in water sources were found in the areas with lighter soil textures with higher infiltration rates and vies versa.

The variations in nitrate concentrations were also found to be higher in shallow wells and streams compared to deep wells (Figures 1-3) showing greater effects of soil properties in shallow wells and streams compared to deep wells suggesting safer water in deep wells especially in the heavier soil textures. However, the general data showed that the risk of nitrate concentration would be greater in shallower water sources as mean values of nitrate concentrations were increased by 2.3 and 2.7 times in shallow wells and streams compared to deep wells, respectively (Figure 4).

The results showed that although most of deep waters contained low nitrate concentrations with only few samples higher than 10 mgL-1 nitrate, but more than 55% of the samples in shallow wells and more than 66% of the samples in streams were found to contain more than 10 mgL-1 nitrate concentrations with the maximum of as high as 36.32 mgL-1 in shallow wells (Figure 5).

The data are generally suggest that the risk of nitrate concentration would increased in shallower water resources and it would enhanced by light texture soils as well as higher N fertilizer applications by farmers in the studied area. In these situations nitrate would easily leached and enter to groundwater and would increased the health risk (Kamrin, 1987; Mahvi et al, 2005). The findings are in agreement with others who are also reported higher risk of nitrate contamination in the similar conditions (Israel et al, 2004; Karr et al, 2001; Jun et al, 2003). Although the data did not showed high risk of nitrate concentration in most of water resources in the studied area, fair considerations should be taken into account to prevent future risk especially in shallower resources across the areas with high N fertilizer application.

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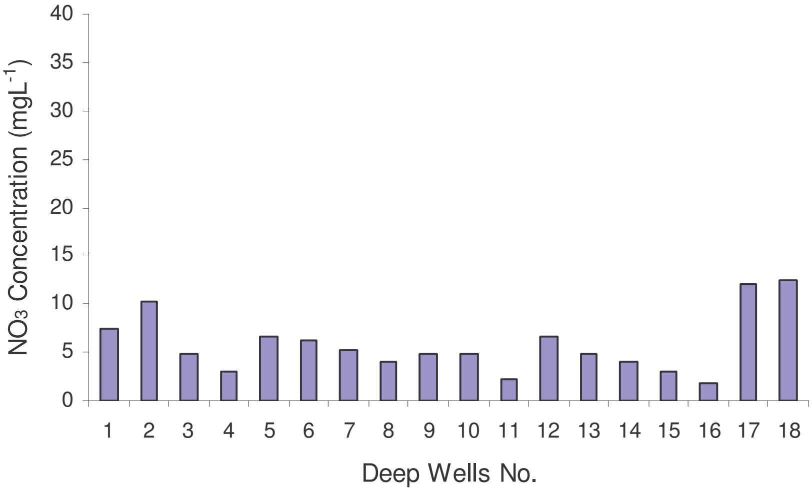

Figure 1. Range of nitrate concentrations in deep wells

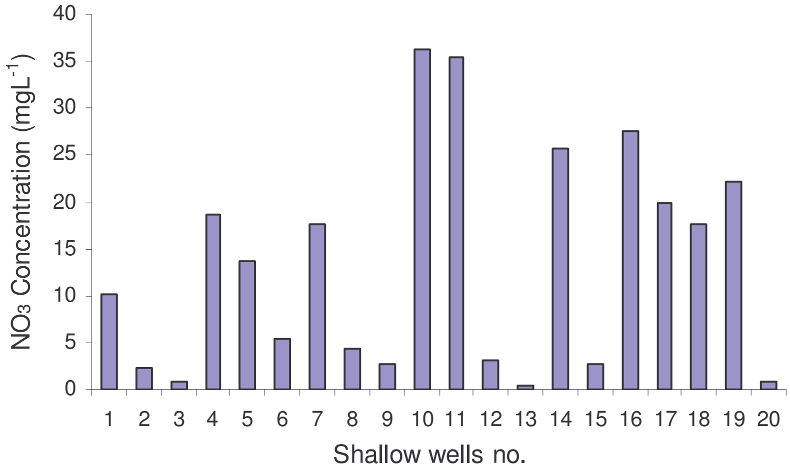

Figure 2. Range of nitrate concentrations in shallow wells

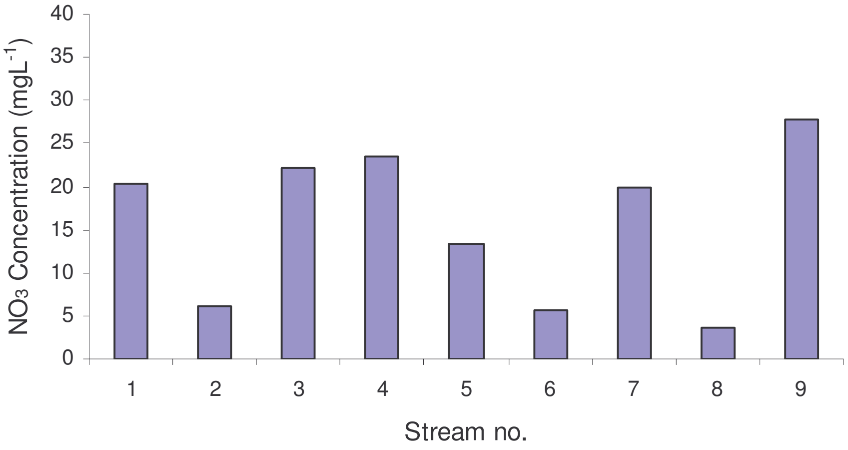

Figure 3. Range of nitrate concentrations in streams

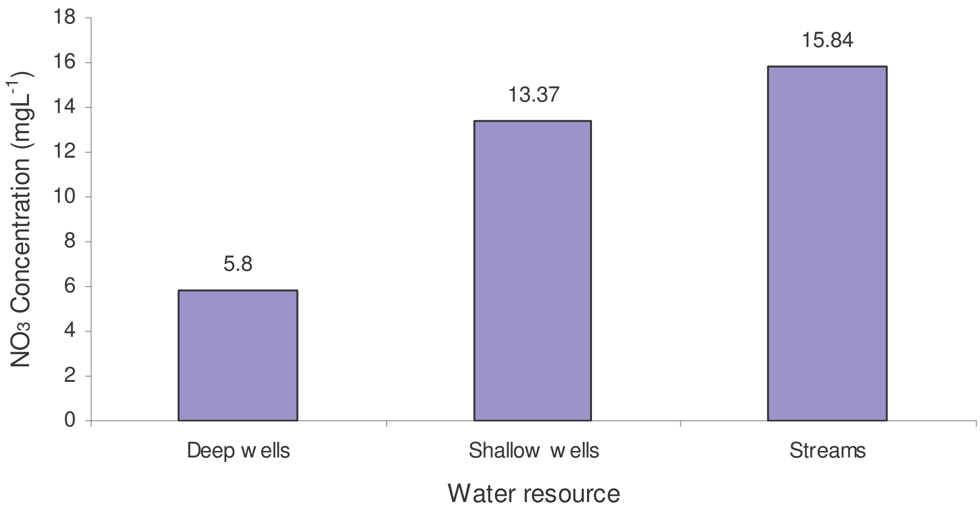

Figure 4. Mean values of nitrate concentrations in different water resources of Gorgan

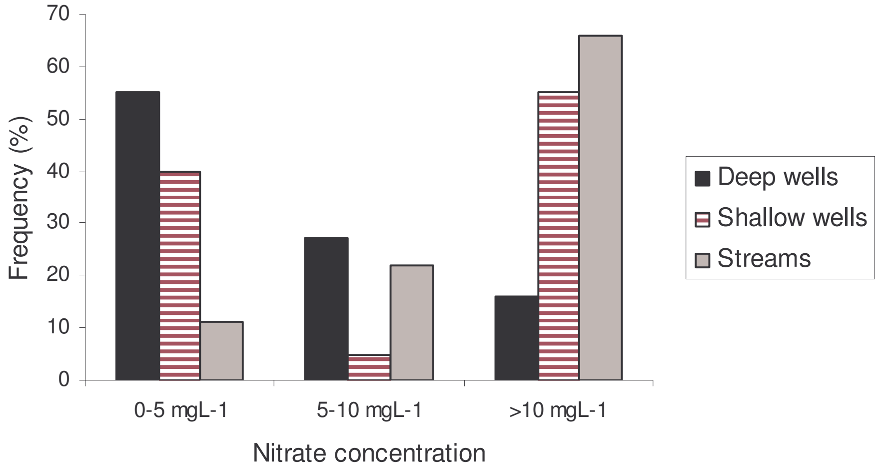

Figure 5. Nitrate frequencies in different water resourses