Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 5, No. 1, p. 447-454, 2014
http://www.innspub.net

RESEARCH PAPER OPEN ACCESS

# Investigation the role of industry in polluting the groundwater aquifers (case study: Ardabil aquifer, Northwest of Iran)

**Ehsan Alizadeh[1], Ali Aryanfar[2], Vahid Rezaverdinejad[3*], Yosef Nabipoor[4]**

[1]*Environmental Geology, Urmia University, Urmia, Iran*

[2]*Young Researchers and Elite Club, Tehran Branch, Islamic Azad University, Tehran, Iran*

[3]*Department of Water Engineering, Urmia University, Urmia, Iran*

[4]*Watershed Engineering, Tarbiyat Modares University, Tehran, Iran*

Article published on July 14, 2014

**Key words:** Ardabil aquifer, GIS, Groundwater, Pollution.

**Abstract**

A large part of water consumption in the world, especially in drinking part, provided from the groundwater resources. In many cases, groundwater pollution, is diagnosed when the decontamination of the aquifer is almost impossible. So the protection of water quality is very important issue. One of the best ways to prevent contamination of groundwater is to identify the areas vulnerable to pollution and also operational management of water resources and land use. In this study, in order to assess contamination of Ardabil aquifer, one of the most important aquifers in northwest of Iran, several wells were sampled near the industrial centers. Changes in quality parameters of groundwater resources and identify areas that are vulnerable to contamination is the main objective of this research. Results indicate that water quality of studied wells for most parameters of heavy metals is much higher than standard limits, especially lead, iron and selenium that require specialized investigations.

***Corresponding Author:** Vahid Rezaverdinejad ✉ verdinejad@gmail.com

## Introduction

The water crisis is one of the biggest challenges of this century that can be the source of many positive and negative changes (Fakayode, 2005). Undoubtedly, all disasters that now threaten the Earth, Shortage and water pollution will become a great tragedy as an unrecognized crisis in this century and its loss is probably far greater than AIDS and war deaths that occur in the world, today (Buchholz, 1998). The United Nations has predicted that by 2050, more than four and half billion people all around the world will be subject to damages and losses caused by water shortages and pollution (Currie, 1998). Many experts have come to believe that in the twenty-first century, water will be raised as a political issue among Asian countries and the Middle East and economic value of water in coming years, will be more than today's valuable materials (Chester, 2000). The main causes of water shortages are population increases, improving the standard of living, climate changes and lack of proper management of water resources (Mariolakos, 2007). Iran is also predicted in the years after 2031, will be among the world's dry lands. A large part of the water consumption in the world, especially in the drinking, is supplied from groundwater sources. Iran is supplying the maximum amount of water from underground sources and it is so important to discuss water quality and pollution here.

When the groundwater contamination is detected, the aquifer decontamination is almost impossible. So the protection of water quality is very important. One of the best ways to prevent groundwater pollution is to identify areas vulnerable to groundwater pollution and exploitation of water resources and land use management. In the present study, Ardabil aquifer is selected. The main reasons for this choice are: located in the arid and semiarid climates, increasing demands for water in drinking, industry and agriculture, industrial wastewater discharged without treatment into the aquifer, water shortages in this region, increasing population and development of mining industry and the needs for sustainable development and regional balance between population and water.

Evaluation of groundwater level fluctuations indicates that more than ten meters drop in the average level of the groundwater of Ardabil aquifer has been occurred (Anonymous, 2012). Therefore, maintaining and returning groundwater quality as well as quantity, is an important issue. In this study, effects of industrial pollution on groundwater status in Ardabil aquifer were analyzed. For this purpose, using the results of tests on sampled wells in this area, infection statuses of heavy metal parameters are determined.

## Materials and methods

*Study area*

Ardabil province with 17953 km² in northwest of Iran, accounted for 1.09% of the total area of the country. Geographically located in 47° 30′ to 48° 55′ east longitude and 37°45′ to 39°42′ north latitude, has a common border with republic of Azerbaijan from north, Zanjan province from south, from the west by East Azerbaijan and with Gilan province from the east. Based on the meteorological data, long-term rainfall has been recorded 295mm in this region. In Fig. 1, location of the Ardabil aquifer is shown.

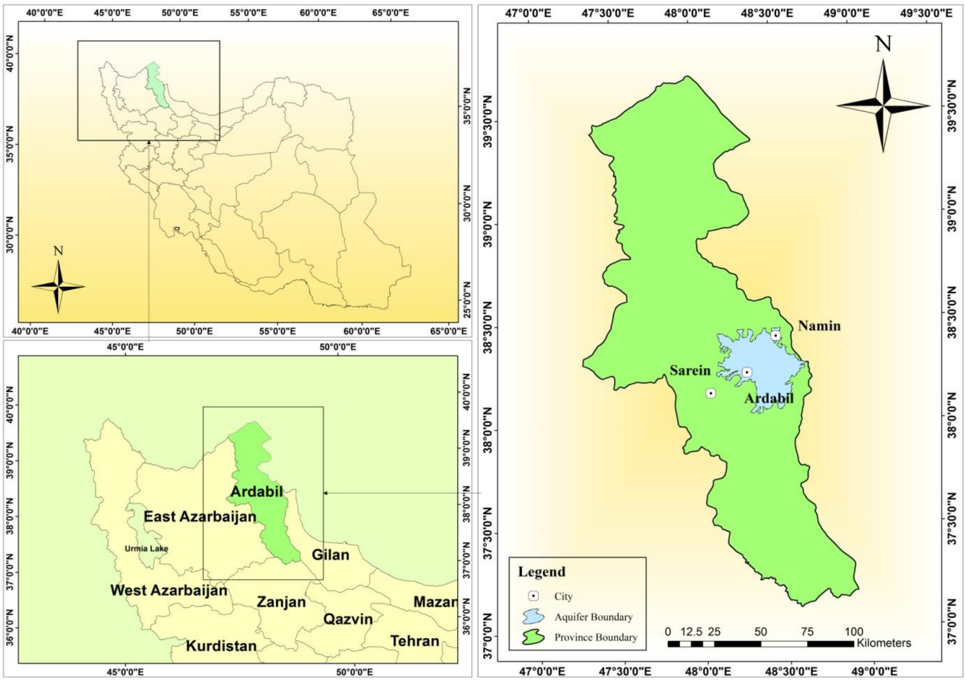


**Fig. 1.** Location of Ardabil aquifer in Ardabil province in Iran.

According to the observed wells that have been drilled by Ardabil's regional water authority to control the Fluctuations of groundwater level, fluctuations have been measured for 55 wells from 1971 up to 2012. The locations of these wells are shown in Fig. 2. According to studies, the sediments forming the aquifer layers are mostly clay, silt and fine to medium grained gravel. The maximum groundwater Level is in the south and the minimum level belongs to the northern part of the plain. Based on the analysis of the plain's hydrograph during the last 40 years, average groundwater level decreases from 1337 to 1325 that equals to 12 meters reduction in this period of time.

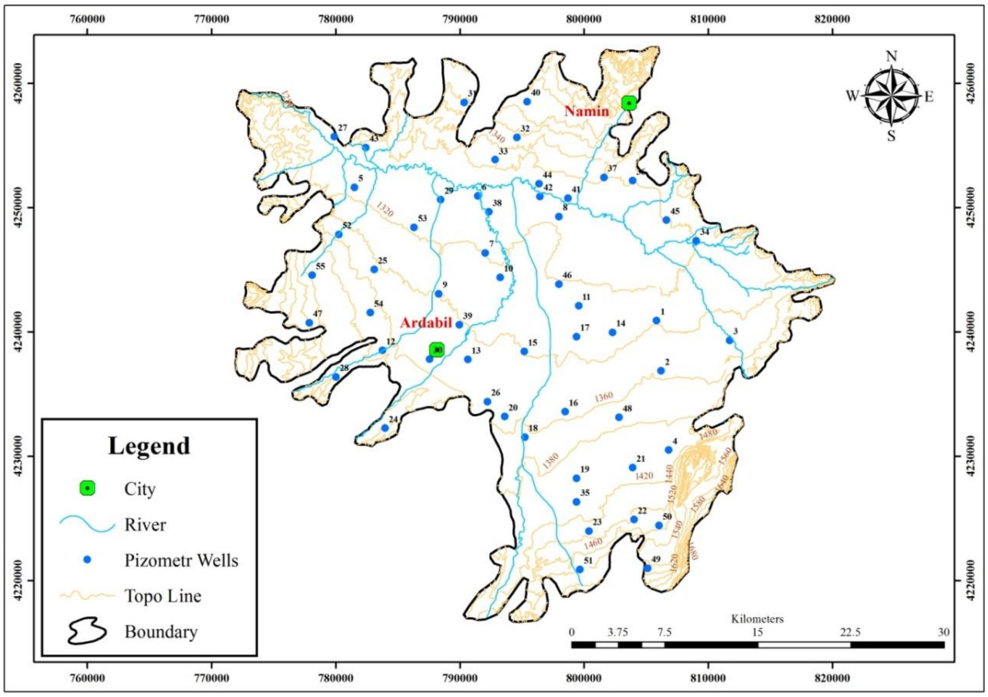


**Fig. 2.** Piezometric wells located within the boundary of Ardabil aquifer.

In this study, in order to evaluate the quality of groundwater in this region, samples were taken from wells near urban and industrial centers according to the Fig.3. Sampling, conducted at both wet and dry seasons in 2012 and finally experimental results were determined. It should be noted that the parameters of heavy metals, were also considered. Using statistical indicators and EPA, WHO and EU standards, all data were analyzed. Then, zoning maps were produced by using GIS package and critical zones were determined.

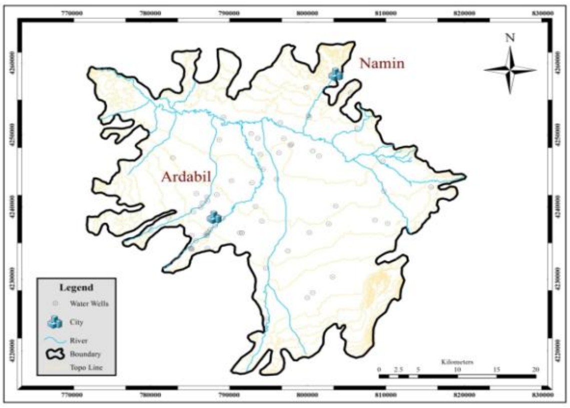


**Fig.3.** Location of sampled wells within the boundary of Ardabil aquifer

## Results and discussion

Parameters at different stations in both wet and dry seasons were evaluated and compared to standards according to Table 1.

**Table 1.** Statistical analysis of heavy metals in both wet and dry seasons (Microgram per liter)

| Parameter | Wet seasons | | | | Dry season | | | | Standard values | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Min | Max | Mean | SD | Min | Max | Mean | SD | EPA | WHO | EU |
| Mercury | 0 | 0.116 | 0.027 | 0.029 | 0 | 0.312 | 0.038 | 0.063 | 0.002 | 0.006 | 0.001 |
| Chromium | 0 | 0.167 | 0.042 | 0.054 | 0 | 1.28 | 0.074 | 0.171 | 0.1 | 0.05 | 0.05 |
| Selenium | 0 | 0.141 | 0.024 | 0.029 | 0 | 0.157 | 0.033 | 0.038 | 0.05 | 0.01 | 0.01 |
| Zinc | 0 | 6.270 | 0.278 | 0.737 | 0 | 15.52 | 2.069 | 3.593 | 5 | - | - |
| Iron | 0.156 | 18.19 | 3.511 | 3.286 | 0 | 28.52 | 2.327 | 4.642 | 0.3 | - | 0.2 |
| Manganese | 0 | 2.357 | 0.646 | 0.469 | 0 | 20.143 | 0.645 | 2.519 | 0.05 | 0.4 | 0.05 |
| Arsenic | 0 | 0.942 | 0.042 | 0.111 | 0 | 1.559 | 0.048 | 0.196 | 0.01 | 0.01 | 0.01 |
| Lead | 0 | 1.381 | 0.058 | 0.200 | 0 | 0.088 | 0.0066 | 0.016 | 0.015 | 0.01 | 0.01 |
| Nickel | 0 | 0.284 | 0.046 | 0.065 | 0 | 1.559 | 0.102 | 0.207 | - | 0.07 | 0.02 |
| Copper | 0 | 1.140 | 0.252 | 0.242 | 0 | 3.89 | 0.382 | 0.692 | 1.3 | 2 | 2 |
| Antimony | 0 | 0.332 | 0.025 | 0.046 | 0 | 0.332 | 0.04 | 0.066 | 0.006 | 0.02 | 0.005 |

*Methods of statistical analysis*

In this study, statistical analysis of measured heavy metals to evaluate pollution of Ardabil aquifer, Excel software is used. Arranging all parameters of stations in this software, maximum, minimum, average and standard deviations of all data were calculated in both wet and dry seasons. Then by using heavy metal parameters of sampled wells, zoning maps were prepared with GIS package and ground statistics techniques. These maps are shown in Fig.s 4 and 5.

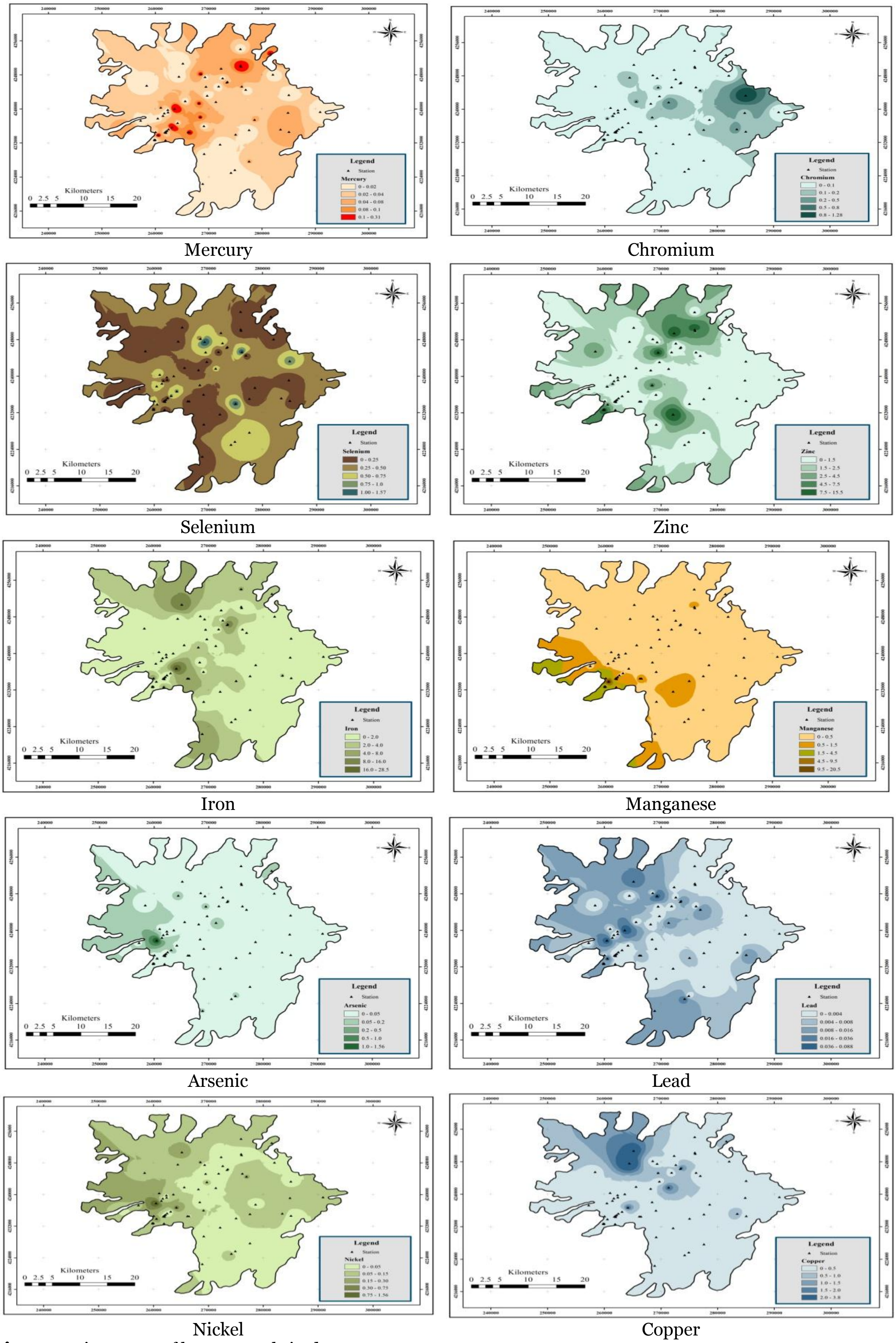


**Fig. 4**. Zoning maps of heavy metals in dry season.

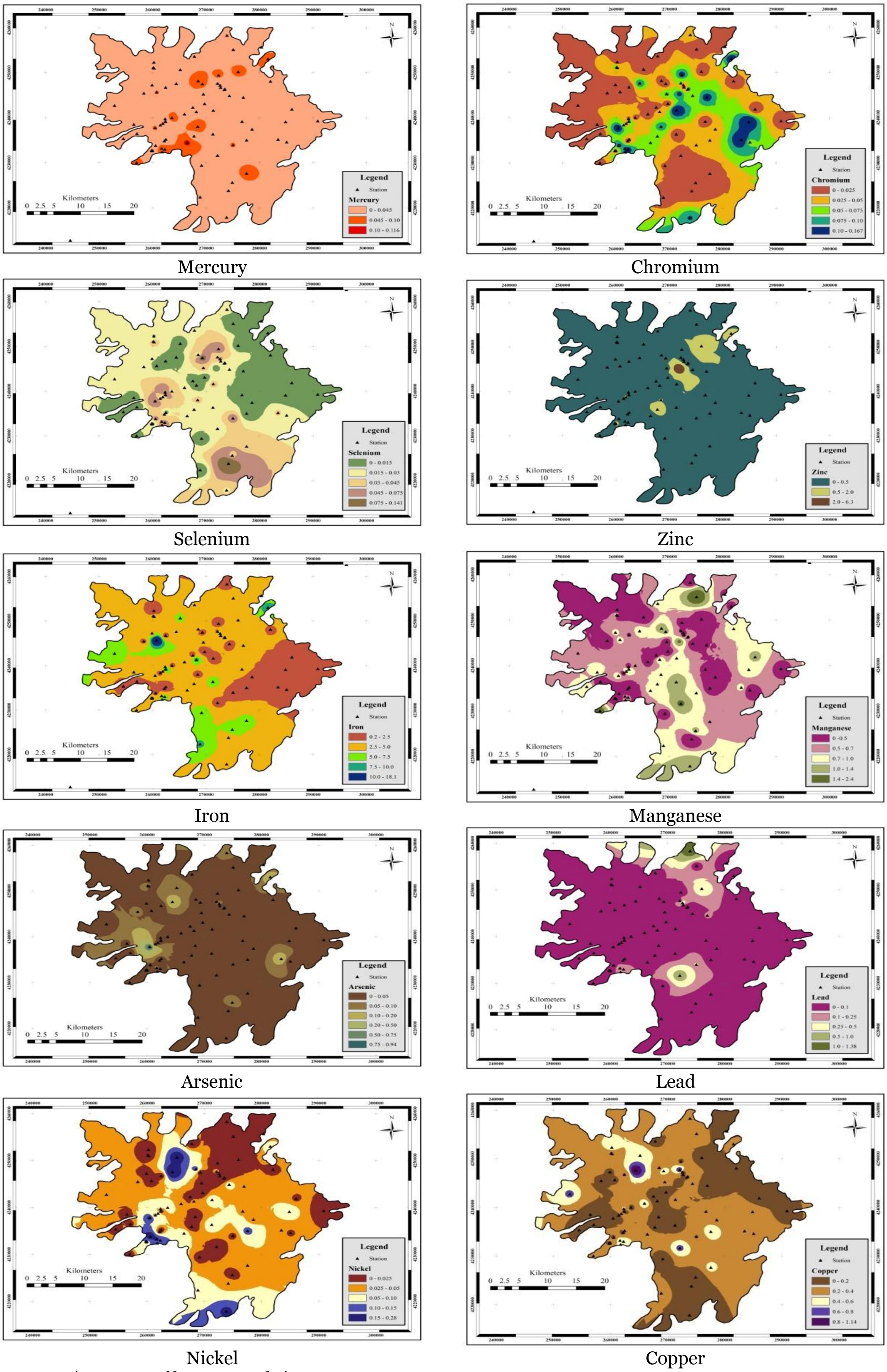


**Fig. 5.** Zoning maps of heavy metals in wet season.

**Table 2.** Amount of city wastes (ton per day).

| City | Amount of waste |
|---|---|
| Ardabil | 400 |
| Namin | 22 |

**Table 3.** Volume of wastewater produced by Health centers.

| Hospital | Volume of wastewater produced |
|---|---|
| Isar | 3.5 cubic meters per day |
| Boali | 700 cubic meters per day |
| Alavi | 108 cubic meters per day |
| Fatemi | Information not available |
| Sabalan | 15 cubic meters per day |
| Arta | 100 cubic meters per day |

**Table 4.** The amounts of wastewater produced by industrial plants.

| Name | Amount of waste ($m^3$/hr) |
|---|---|
| Parkan | 15 |
| Samian | 6.25 |
| Ardabil Meat industry factory | 8.3 |

## Conclusion

Results indicate that water quality of studied wells for most parameters of heavy metals is much higher than standard limits, especially lead, iron and selenium that require specialized investigations. Research also showed that heavy metal concentrations will change over time and it was found that existing wells in one place can have different concentrations of these metals (Geen *et al.,* 2003). In fact, the concentrations of heavy metals are associated with the location and depth of the wells. Robina and Zulfiqar also evaluated heavy metal pollution in groundwater of Kahvta industry in Islamabad, Pakistan that showed with the exception of selenium, there is not a serious problem about the concentrations of other heavy metals (Rubina and Zulfiqar, 2009).

In short, some cases that have led to increased pollution and increased in the values of the parameters are:

- Human activities caused by three broad categories of residential, industrial and agriculture.
- Waste production includes construction and demolition wastes, sludge of discharge wells tankers, household and healthcare centers wastes.
- Industrial estates and factories that, in turn, have a great influence on the groundwater contamination.

Wastes from urban communities and health centers located within the Ardabil aquifer are shown in tables 2 and 3. The amounts of wastewater produced by industrial plants are shown in table 4.

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