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Evaluation of heavy metals (cadmium and lead) in groundwater of Razi Industrial Park, Isfahan

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Abstract

Groundwater is the most important resource to provide drinking water and the water used in agriculture in most parts of Iran and since industrial cities and particularly their sewage is significantly important in polluting these water resources, in this study we tried to recognize heavy metals' pollution like Cadmium and lead available in groundwater of Razi industrial park of Isfahan by sampling the downstream watershed areas under study and this city's share in the level and kind of heavy metals of water. The results of this study showed that the amount of these metals in the area's groundwater was so negligible and the city did not have a significant role in the content of these metals in these water resources.

Key terms: Cadmium, lead, sewage, industrial park, heavy metal

Introduction

In the 1970th, heavy metals were considered as the most serious threat for human health and in the middle of 1990th the impact of these metals on the pollution of groundwater attracted the attention of many researchers (Saghi, 2009). By the development of world's population and following that; the increasing water consumption, use of groundwater as the most important resource of providing water that humans required (AKbari Spili, 2005). Some researches were conducted to identify resource of these contaminants' entrance to groundwater. Researches done on the poisonous impacts of heavy metals verify that these heavy metals can directly impact behavior by impairing the mental and neurological factors. Target systems of poisonous metal elements include: blood and cardiovascular, detoxification directions of body (colon, leaver, kidney and skin), hormonal endocrines, energy production paths, Endocrine glands, hormones, energy production pathways, enzymes, digestive system, immune system, central and peripheral nervous system, reproductive and urinary tracts (Abdi Nejad, 2010).

Industrial sewage is the most important human resource of entering heavy and poisonous metals to groundwater because if industrial sewage is not transferred to certain and protected places through piping and their absorption to the ground, undoubtedly it penetrates to groundwater and contaminate it (Rofoiee, 2009). One of the significant points is the location of establishment of industrial park in groundwater area that leads to releasing large amounts of pollutants like sewage, Leachate and gases in the area and finally environmental and groundwater pollution. Important industries with industrial sewage which leads to water resources' pollution with heavy metals are metal industries, textile, and clothing and leather industry, chemistry and color making industries and power and electric industry (Abdi Nejad, 2010).

With regard to the importance of industrial cities in contaminating groundwater and the destructive effects of these sewages on groundwater which are the most important source of providing drinking and farm water in most areas of Iran and regarding the presence of various industrial cities in Isfahan province, we tried to identify pollution of heavy metals available in groundwater by sampling Razi industrial town of downstream catchment areas and these cities' share in the amount and type of heavy metal pollution in the water is determined.

Area under study

The area under study in this research is within a radius of 4 kms around the Razi industrial park located in Isfahan province, 25 kms north of Shahreza and is known as Rangsazan. This city with an area of 1000 hectares is the biggest industrial park of Isfahan. Its operational phase is 890 hectares and its industrial ground is 623 hectares. The total number of its units is 465 units and now 219 of them are under operation. This city has all fundamental facilities (water, electricity, gas, phone, railway station and service complex…) and the concentrated industries in this city generally include chemistry and color making industry.

Methodology

In order to study the impact of seasonal rainfall on the level of metals in groundwater of the area, sampling was done in two steps (March and August of 2011) from wells of the city and about four kms around the city). It should be noted that wells were selected with regard to the direction of Waterways, and the slope of the internal zone of 4 km buffer. As, in this area introductory detailed studies were already conducted, the files related to the Coordinates and profiles of the area's wells were available and in order to use textual data using ArcGIS 9.2 software, the location of wells turned into information layer to be able to draw maps of the well location.

Table 1: Sampling Stations and latitude and longitude points

Sample	Factory's name	X	Y
1	Daneshmand Chemistry	576777	3564307
2	Khod Rang	576740	3564397
3	Sarv paint production	576767	3564590
4	Esfahan Novin	577294	3564783
5	Sepahan Zinc	576834	3564114
6	Mobin Chemistry	577708	3564069
7	Yazdan Industry	577418	3564641
8	Sepahan Chemistry Flower	575481	3564272
9	Agriculture Well	578824	3564485
10	Behruz Valves	577388	3563699

Sampling water was done by the standard method of APHA. For sampling polyethylene dishes used, they were washed by detergents before sampling and was put in Acid nitric 10% and then was rinsed and dried with deionized water. From each station two samples were collected to one of the samples the direction of reading heavy metals, 2 cc acid nitric (0.1 normal) was added to fix the sample and the other sample was used to examine physiochemical parameters of water by applying multi-parameter assessment machines of ($HQ_{40(HATCH)}$) (HQ_D portable meter user manual). It should be noted that because of fast changes in parameters, their measuring was rapidly done in the area of sampling. After taking samples, they were transferred to the laboratory to digest and analyze heavy metals.

Sample preparation

Preparing samples immediately after taking them by the method proposed by Grift et al. (2008) was done which is a method confirmed by EPA to infer and digest heavy metals of the water samples. In this method, Perchloric acid and hydrogen peroxide was prepared by using acid nitric. In this study samples were collected by steam bath in polyethylene containers. After completing the

process of digestion, the samples were filtered through SS filter paper and then were brought to a volume of 25 ml with deionized water. For statistical analysis, SPSS 17 software was used.

Data Analysis

At first normality of data was determined by using Kolmogorov-Smirnov statistical test. The results showed that the data are not normal, therefore, a logarithmic conversion was performed on the data and because the data remained abnormal, for comparison between abnormal groups non-parametric test of Kruskal and Ellis was used whose results showed that with 95% confidency, the mean of metals in different sampling stations are different from each other. For more analysis of where this difference is derived from, post-hoc paired comparison tests was applied. Before this test, the test of variance Homogeneity was performed; for metals whose variance were the same, Duncan test was used and game havel test was used for metals that had unequal variance. These tests specifically for each metal showed that the difference of each metal is higher for both stations.

For descriptive statistical analysis of physical parameters, mean, maximum, minimum and standard deviation were calculated. The highest average values were about the EC and TDS variables.

Evaluation of linear correlation between elements took place using the Pearson correlation coefficient test statistics at the two significance level of 0.01 and 0.05.

Results and Discussion

The number of sampling stations in this industrial station consist of two series of data related to the amounts of metals like lead and cadmium and some physical parameters of water. The results are represented in the followings. Attention to charts represented below show that the amounts of the elements under study in different stations are highly different that verification of these differences are confirmed by statistical tests.

Among samples taken in first and second sampling in station 3, cadmium has the highest value, of course it should be noted that the amount of this metal in the first sampling station was undetectable. Also, no significant difference was observed between the levels of metals in various stations.

The highest average of Lead in the first sampling was observed in station 1. However, like cadmium, most stations in the first sampling have very little or undetectable amounts and in the second sampling, no significant difference was also observed between stations for this element.

Table 2: Levels of metals found in the two-stage sampling

Station	Cd		pb	
1	sampling		sampling	
2	first	second	first	second
3	nd	0.0008	0/3	0.00227
4	nd	0.001135	nd	0.00257
5	0.08	0.00114	nd	0.0027
6	nd	0.00085	nd	0.00231
7	nd	0.00038	nd	0.00115
8	nd	0.000452	nd	0.002
9	nd	0.0011	0.185	0.00203
10	nd	0.000945	nd	0.00158
11	nd	0.000925	0.08	0.00192
12	nd	0.00091	nd	0.00195

In general, the results showed that the sampling area around the Razi industrial park is negligible as most of the stations are not traceable. The second study of sampling data has shown that there is no statistically significant relationship between the elements, also there is no statistically significant relationship between physical parameters and elements due to the high variation range of the physical parameters and physical conditions of the water samples at the moment of taking is highly significant.

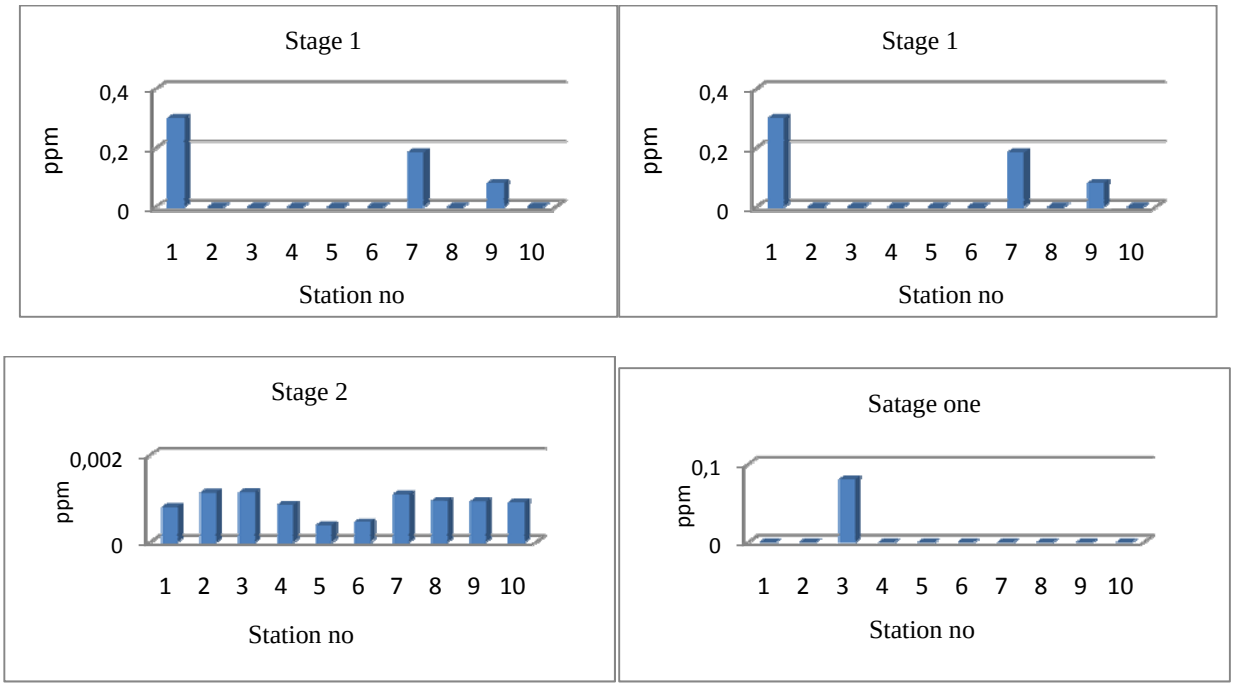

Figure 2. The level of cadmium measured in two samples

Elements of Zonation map

After determining the amount of each element in different stations, due to the dispersion of sampling stations around industrial park, close scrutiny and judgment and decision-making about the amount and the way of affecting different parts of park makes problems for the quantity and quality of each element's pollution. For this reason, in this study, after determining the amount of each element in stations of 4 km buffer zone around the park, we tried to provide the zonation plan for each element separately in the park. The zonation plan is a plan in which, with regard to the concentration range of each element in the area under study, a specific ranking classification regarding concentration was done on data and then the element's dispersion map was provided regarding different concentrations as areas located within a colored limit in this map have the same concentration of that element.

Study of zonation maps to judge about the quality and quantity of pollutant elements' dispersion is so important and necessary. Paying attention to zoning maps (pollutant dispersion maps) in short time shows a complete objective and real image of the amount and distribution of pollutants in the area. It should be noted that for the presence of indefectible elements in most stations, the zonation planning for the first sampling of the path is not possible, it is only admitted at the time of second sampling.

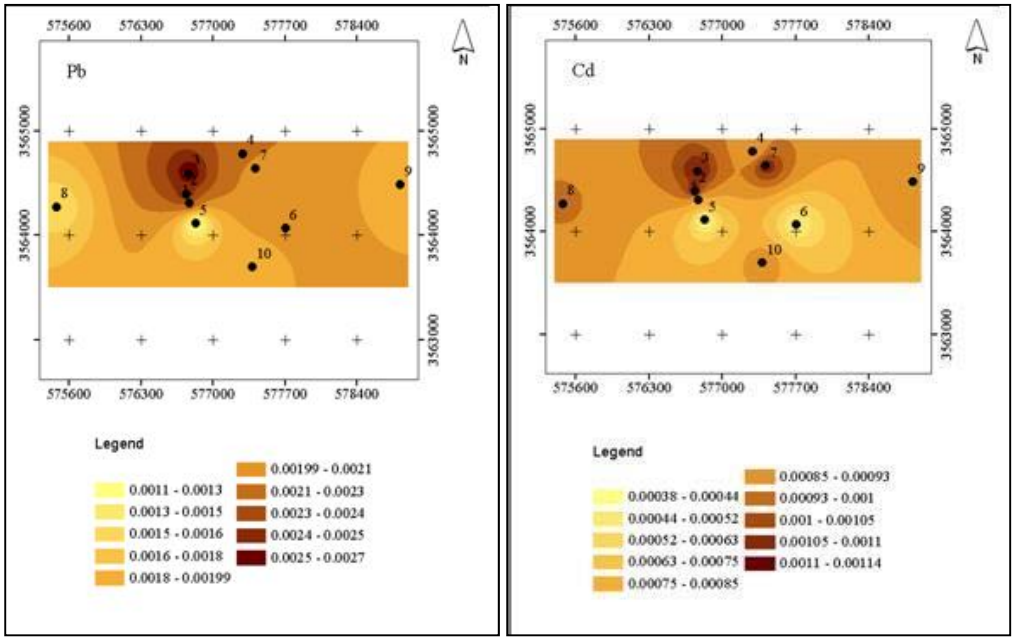

Figure 3. The zonation map of elements under study

In general, the results show that in both stages of sampling the amounts of heavy elements like Cadmium and lead is so negligible as in most stations are indictable. Also, lack of significant relationship among the elements shows the application and specific impact of industrial park's activities on the availability of these elements in the groundwater. Also, the investigation of the elements' zonation maps show that distribution of different elements in stations outside and within the industrial park does not follow a fixed law which is a reason for lack of impact of the different activities of industrial park on the content of elements in groundwater.

In studies conducted by Leung et al. (2006) investigating groundwater pollution in different geology slops show that the impact of slop, the direction of runoff and the levels of runoff will not have a significant impact on the levels of available elements and the most important reason for this issue is mentioned to be the delay in runoff penetration in the surface of groundwater aquifers, the complex nature of rainfall and different layers of geology in removing or increasing some elements. Other researchers also in examining short time periods show that analysis of short time periods of drought and wet year and the role of runoff resulted from polluted areas to heavy metals does not show a significant judgment and only by long term analysis of raining pattern in different seasons and exact analysis of the penetration time of runoffs in watery seasons, the role of rainfall in the spatial distribution pattern of heavy metals in groundwater can be studied (Grift et al. 2006; Kamra et al. 2002).

According the findings of this study we can state that the presence of industrial park in this area and different activities does not significantly impact on the increase in heavy metal content in the groundwater of the area and the study of the area under study in two seasons of sampling in an area with 4 Km radius around the Razi industrial city confirms this issue, of course we should note that certainty of this issue require more study in a long term period.

Conclusion

Nowadays with regard to the lack of water resource, the importance of groundwater and the necessity to pay attention to the quality and quantity of it for different uses is highly specific and

important. With the expansion of population and increasing urbanization and industrialization of human society, the more use of water resources and following that releasing different types of chemical and synthetic materials to the environment increased. Typically, water and groundwater resources are the last recipient of different pollutants in the environment and the quality and quantity of groundwater resource pollution depends on different factors such as natural and geology features of the area, application around it and the level of releasing different pollutants.

Over all, the release resources of heavy metals in the environment include natural and human resources. Attention to this duality of resources of heavy metal distribution in the environment is an important point in evaluation of environmental pollution derived from human activities. In the analysis of share determination, a certain application and or certain activity in the pollution of an area, attention to human resources, distribution of pollutant and differentiating it from natural amounts is a necessary task. The common method in differentiating these two source of distribution is possible through the chemical isolation of samples with Speciation and or Fractionation. In this study different amounts of heavy metals and other elements in areas around Razi industrial park were studied, however in this study, the presence of these elements in areas around the industrial park was completely attributed to the activities of the park. The level of different heavy metals traced in groundwater around the industrial parks is not just derived from releasing resources within parks. The presence of farmlands and dry depot of atmosphere also lead to release of elements such as Cadmium, Chrome, Nickle, manganese, lead and zinc. On the other and, different marginal activities, the presence of small industries in the area, closeness to the main road and the movement of vehicles also led to release of certain elements, especially lead, in dirt of this area. As it was mentioned the maps of zonation of different elements showed that for some elements a high concentration of that element at center and areas close to the industrial park is not much higher than areas around the park, which is a valid reason for the fact that the overall release resources of these elements are not within the industrial park. As a result, it can be concluded the impact of this industrial park in releasing different elements and entrance of these elements to waters is negligible. High distribution of different elements in farther areas of Razi industrial park in areas with long distance from the industrial park can also have different sources including agriculture, transformation, road traffic etc.

With regard to what was mentioned, from this study we can state that the impact of this park's activities in the nearby groundwater is negligible regarding Cadmium and lead because analysis of zonation map show that distribution of most elements within the park is not more than outside Razi industrial park. However, analysis and environmental monitoring of activities of different industrial parks and different wastewater discharge units is necessary to continually control pollutant entrance into surface water and groundwater resource so that no problem arose over the time.

This study ,by determining the buffer limit influencing the park and sampling the groundwater resources within this constraint, getting help from geographical information system, analysis of new laboratory methods to determine the element's concentration in samples and reading elements with ICP system with high sensibility in identification, joint study of amounts of metals with qualitative parameters of water at the moment of taking groundwater samples, providing zonation maps about the elements in the park separately, complete statistical analysis of data and comparison of its results represented some of these metals in groundwater of the area whose results are represented in details. A detailed analysis of this issue for valid judgment in this field requires further and more comprehensive studies. Correct and scientific judgment about the impact of this industrial city on the traced and determined amounts of different elements in groundwater of the area needs to consider all points explained above some of which are:

- Considering geological nature of the area to prove naturalness of some elements in the area's dirt
- Detailed attention to other release resources of heavy metals in the area and determining the share of this resource in the water pollution to heavy metals
- Analysis of comprehensive studies by speciation of samples to differentiate human resources of heavy metal release
- Conducting comprehensive study on heavy metals available in dirt of the area to evaluate the amount of these elements in dirt

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