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Assessment of heavy metal concentration in Irankuh Lead and Zinc mine

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ABSTRACT

Irankuh Lead and zinc mine is one of the largest reserves of lead and zinc in Iran. This reserve located in Isfahan province, along the mountain range of Irankuh and at a distance of 20 km southwest of Isfahan. In this study, concentrations of lead, zinc , iron , copper, manganese and chromium, were measured in water and soil samples by atomic absorption method. Among the elements of water samples contamination with copper , iron and manganese are important. The concentration of these elements in this research, compared to international standards (WHO) is concerned. The concentration of mentioned heavy metals in the soil compared to the international standards, apart from chromium is higher than anticipated. Increasing the concentration of these elements in the soil can be attribute to lead and zinc mineralization activity in the region, weathering of rocks that rich in studied elements , and the reaction of other elements in the soil.

Keywords: Heavy metals, Atomic absorption, Irankuh mine, Contamination, permissible limit

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INTRODUCTION

Expansion of mining activities is one of the most important and destructive industrial process, that in the absence of management, will have considerable impact on the environment. This effects and consequences of irreparable, all living and non- living components of the ecosystem, such as water, soil and air are overshadowed. Generally, damage to land and soil and water resources by mining, mainly depends on the conditions of topography and soil characteristics (Rodriguez *et al*, 2009). Soils exposed to mining operations are often chemically activated, and thus will be a source of water pollution. Mining be considered as one of the most important centers of pollution emissions, from the point of heavy metal compounds. In general, heavy metals because of unreliable data, and physiological effects on the ecosystem, in low concentrations as dangerous environmental pollutants are considered and high evaluated (Azarpour, 2012). Heavy metals have significant environmental pollutants, and their toxicity have environmental , evolutionary and nutrition reasons. Heavy metals " refers to any metallic element that has a relatively high density and is toxic even in low concentrations (Lenntech, 2004). Heavy metals in a comprehensive term, including a group of metals and semi- metals by atomic density greater than 4 or 5 or more, in grams per cubic centimeter (Hernandez, 1996). Soils , are the source of metals. Metals in the soil , are concentrated in the top soil, threaten plants and vegetation. Some of these heavy metals like copper and zinc as a cofactor and activator of enzymatic reactions, for example, Information enzyme or are applying a catalytic features such as prosthetic groups. in some soils , rare-earth metals are in some oxidation and reduction reactions, electron transport, and structural functions in nucleic acid metabolism. Some heavy metals such as cadmium and mercury, as highly sensitive enzyme, also react to the metal. Thereby, cause growth inhibition and death organisms (Mildvan, 1970).

Heavy metal pollution can come from both natural and human source. The composition and concentration of heavy metals depends on the type of rock and environmental conditions. The process of land erosion, face the plant material with a high concentration of chromium , manganese, nickel, copper , zinc, tin , mercury and lead (Shallari *et al*, 1999).

The human resources that lead to the production of heavy metal, can be noted to incineration of waste, transport (Cars, diesel vehicles and aircraft), as well as the burning of coal, and business waste removal, that imports primarily the chromium, copper , lead and zinc metals in the environment (Hawkes et al, 1988). Activities such as mining, metallurgical and agriculture, mainly lead to release heavy metals such as, cadmium, copper, zinc and lead. Like what is happening in northern Greece, or have been infected large areas of Japan, Indonesia and China.

The purpose of this study was to compare the concentrations of mentioned elements in soil and water within the specified range, with standard concentration, that done with sampling.

EXPERIMENTAL SECTION

Geographical area

Irankuh lead and zinc mine and factory, as the third largest lead and zinc mine in the Isfahan province, along the Irankuh mountain range, located at a distance of 20 km southwest of Isfahan, in the latitudes from 51 degrees and 31 minutes to 51 degrees 45 minutes, and latitudes from 32 degrees and 28 minutes to 32 degrees 37 minutes. The area in general, has the length of 25 km, and the width of 3 km. The highest point,is 2,750 meters above sea level. In both northern and southern flank of the mountains , Ore mineralization occurs. To achieve Irankuh mines, after over a distance of 12 km, Isfahan-Shahrekord highway, entering Pirbakran road. Then, after 8 kilometers ,and pass the Abnile, entering to Irankuh mining complex. The nearest village to the plant is Abnilat 2 km of it.

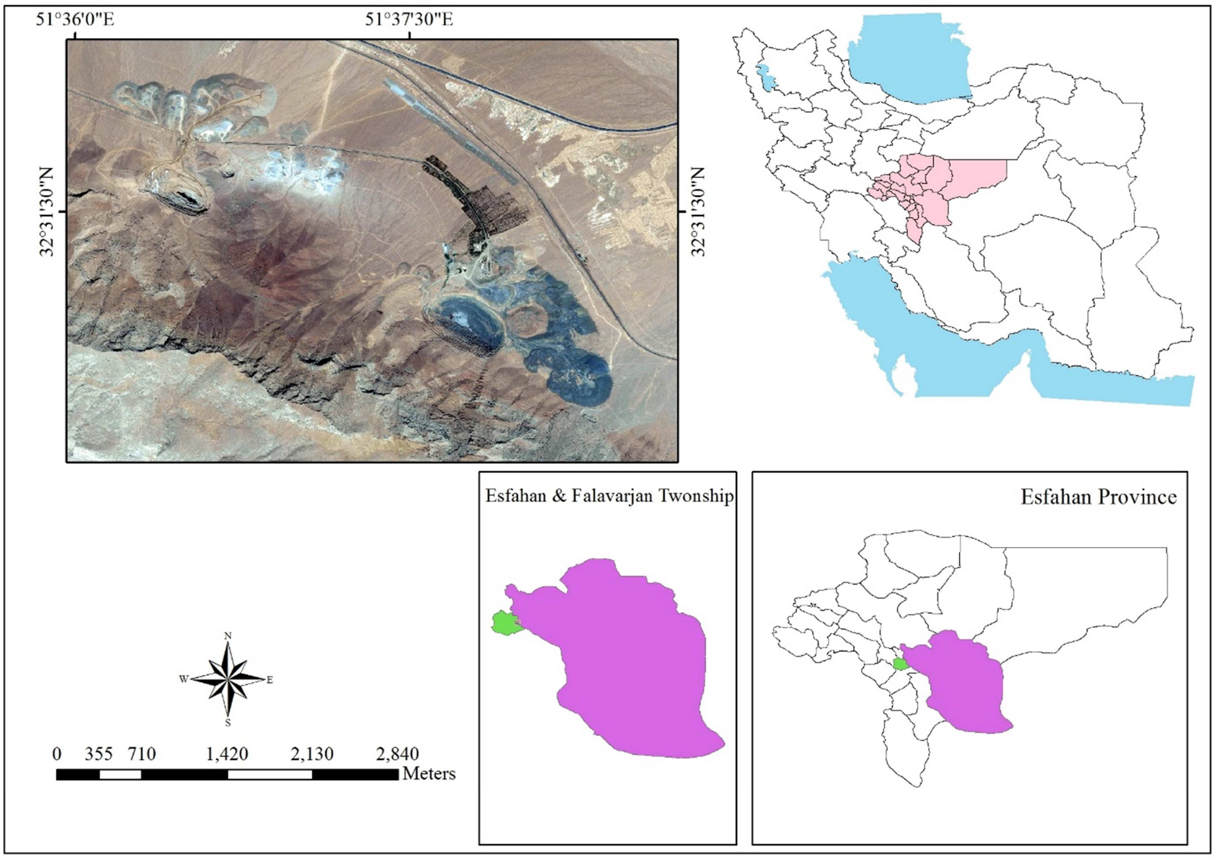


Fig.1. Study area position

Geology of the area

Based on data and knowledges that has been collected, in the mining range, 126 mineral deposits and signs have been identified. Now in this area, 3 mines include: Ahangaran, Irankuh complex and Ravanj, have extractive activities. And 2 mineral deposits include Emarat and Anjire of Tiran, is completed detailed exploration.

From stratigraphy view, Precambrian rocks, which includes: Soltanieh, Zagon and Lalon formations, are at the same slope on each other. Ordovician with Mila index formation has not been identified in this area. In this mining area, Silurian sediments only seen in the south of Kasha (Soh), in the red and gray sandstone body, dolomites and

volcanic rocks at the base.and in other parts of the region, there is a stratigraphical gap (Hiatus), in Silurian sediments.
After Caledonian Epirogeny, Devonian rocks seen in the south east of Ghamsar (Kashan), and around Soh village on the upper Silurian rocks. In this mining region, lower Carboniferous rocks, excluding the east of Shahreza, not found elsewhere and have a little expose. Upper Carboniferous rocks seen nowhere, because of Hercinian Epirogeny.

Permian period rocks begins with the base conglomerate, and then deposits of Jamal formation placed on it. Triassic Lithostratigraphic unit can be seen in the mining area, in the configuration of the two formations, Shotori Dolomite and Nayband formation. Jurassic rocks are in the form of Shemshak formation everywhere. After Jurassic Lithostratigraphic, there is a sedimentary gap that is representing lower Kimerian orogeny. On the Shemshak rocks, Lower Cretaceous deposit, are as unconformity. In this area, there is a gap in Paleocene, because Laramian orogeny is occurringat the end of the Cretaceous and the start of tertiary. After gap in Paleocene, Eocene rocks in most parts with an unconformity and basal conglomerate are onCretaceous rock. At the end of the Eocene and start of Oligocene, the effect of Pyrenee orogenic phase, makes clear angular unconformity. Oligocene start with lower red and Qom formations. Miocene and Oligocene rocks, have been continuously. Upper Red Formation rocks in the Pliocene followed. On the Pliocene, there are volcanic rocks , marl, porous limestone, pyroclastic and finally Bakhtiary formation. After deposition of the Pliocen, Pasadenian orogenic phase affected the mining area. In quaternary, continental clastic sediments and extensive alluvium emerge.

The mineralogy of the area indicates that smithsonite, serositis, sphalerite and galena minerals form the processing main minerals. In addition, mineralssuch as dolomite, barite, hemimorphit , malachite , markasyt, pyrite and calcite also viewed. The southern mines are carbonated composition, and North slope of mine are sulfide ores. The main mining operation of Irankuh plant, in southern flank, includes: KolahDarvaze, Govde Zendan and KhaneGorgi, and in north flank, Gooshfil and Tapesorkh. Type of reserve is karst (Geology report, Kavoshgaran engineers, 1996).

Sampling method
Sampling from soil surface using a shovel to a depth of 5 cm, and 50 g of each sample (the soil inside the mine andmine surrounding soil). Sampling of water using polyethylene containers done by buoyancy method and 20 cc from every three points. Coordinates were determined by using GPS.

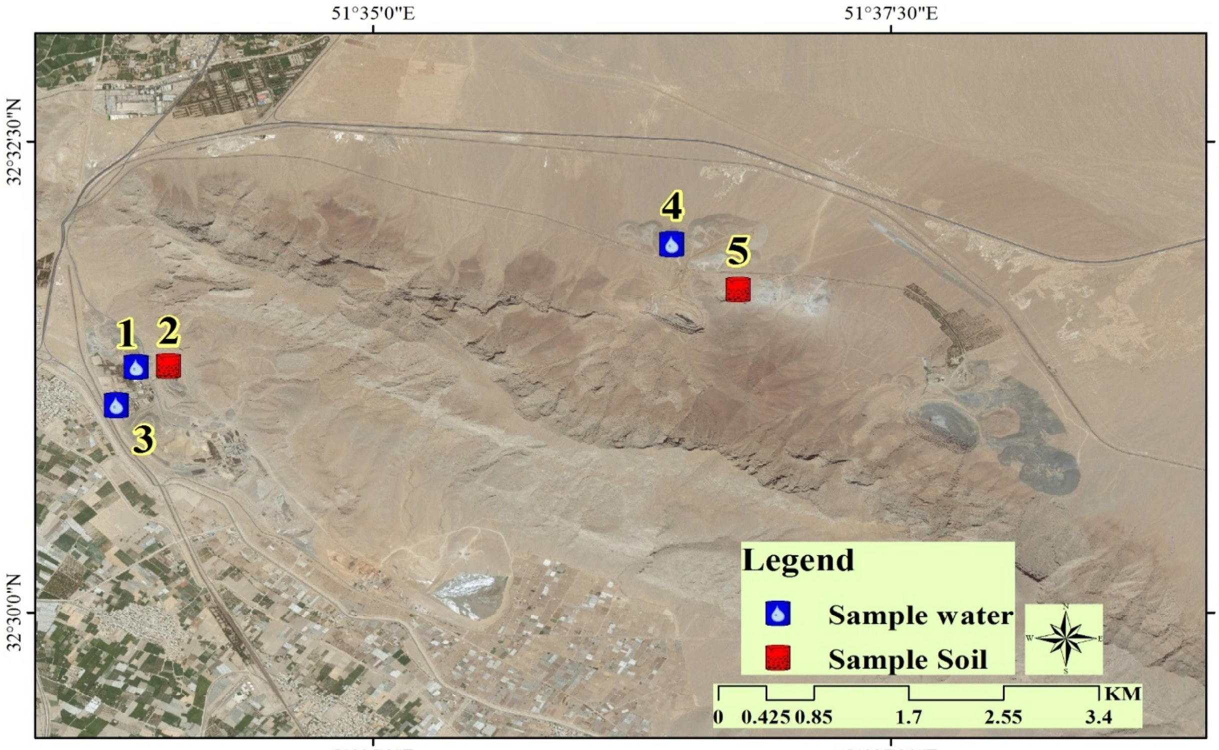


Fig.2. The map Sampling points

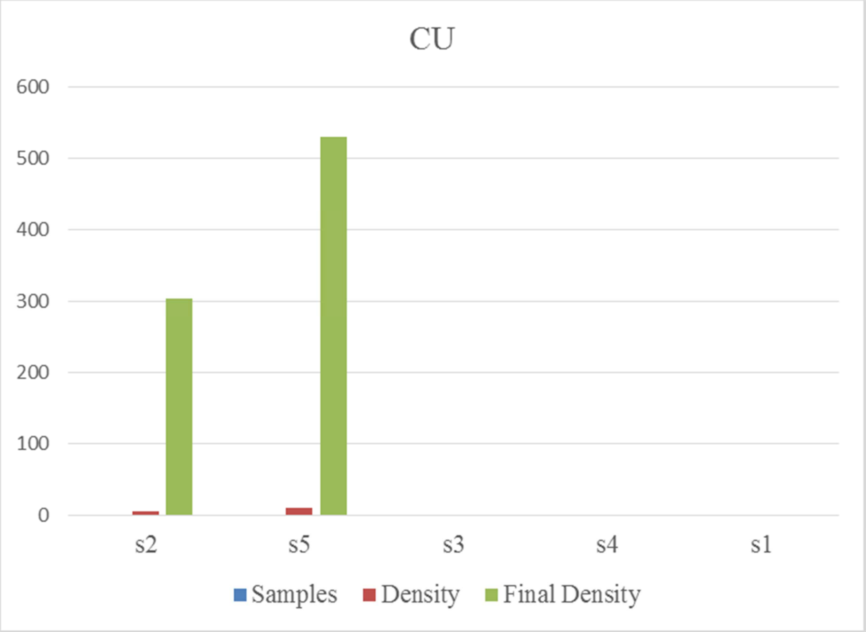
Preparation and analysis of sample

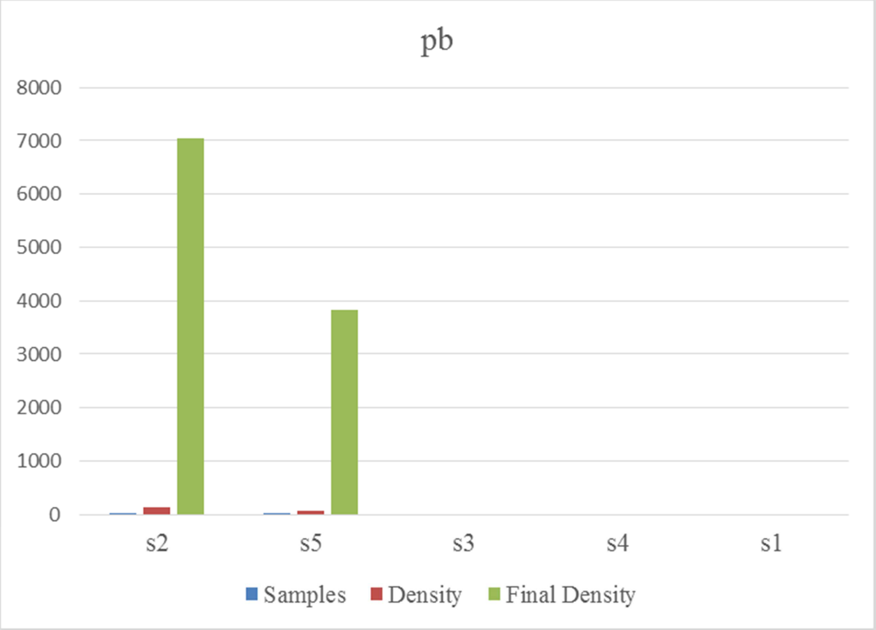
After collecting the samples, were transferred to the laboratory of Geology department, Isfahan university and there were analyzed. For the preparation of samples, 3 grams of dried sediment on a 230 mesh sieve throw into beakers, and about 15 ml of aqua regia (a mixture of one unit of nitric acid and three units of hydrochloric acid) added to it. The resulting solution bringon oven for 10 minutes to boil. After the desired time, we pass the solution from Whatman filter paper No. 42. Two or three times, deposits remained on the filter paper is washed with distilled water. The solution has been rejected by the filter paper transferred to balloons and add with distilled water to bring the volume of 100 ml. The solution strongly to shake until is completely homogeneous. The solution obtained transferred to the polyethylene containers to analyze (atomic absorption). Sometimes the elements in the solution is more than the device is able to accurately report. In this case, a certain amount of solution is diluted with distilled water.

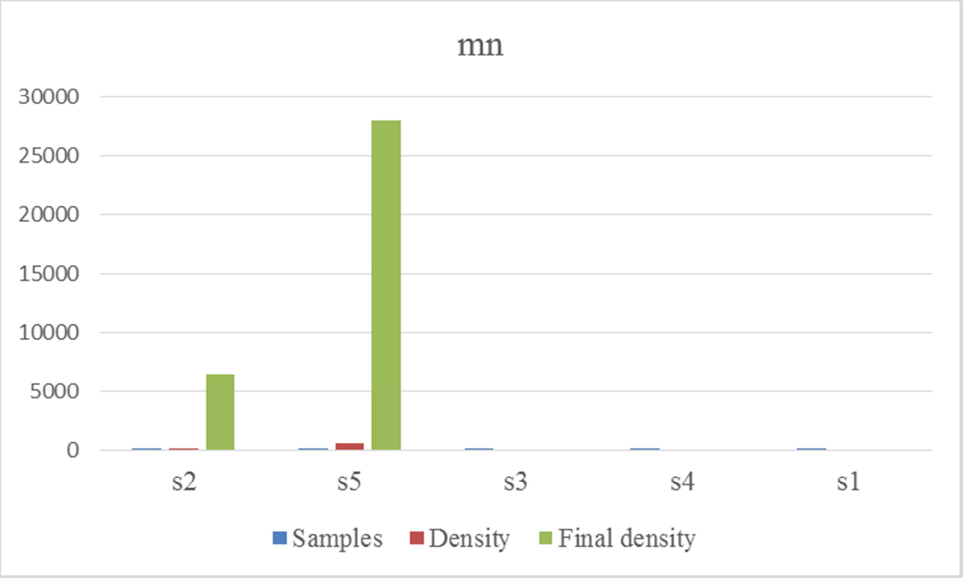
In the following table, analyzed and concentration of the samples are listed(Table 1).

Graphs of the distribution of the elements in the sampling points:

Blue, and red are the initial concentration, and green color is the final concentration of laboratory analysis, which should be compared with international standards.



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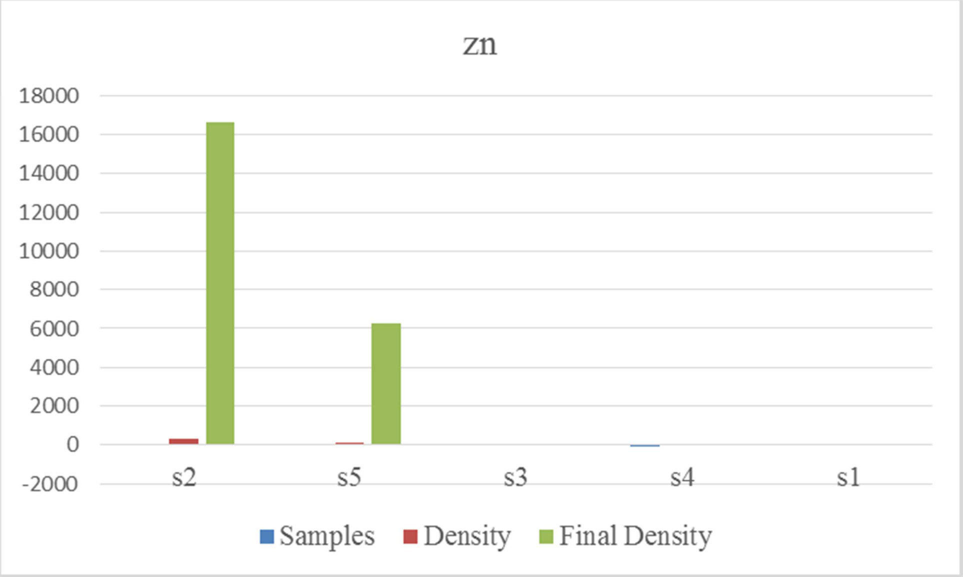
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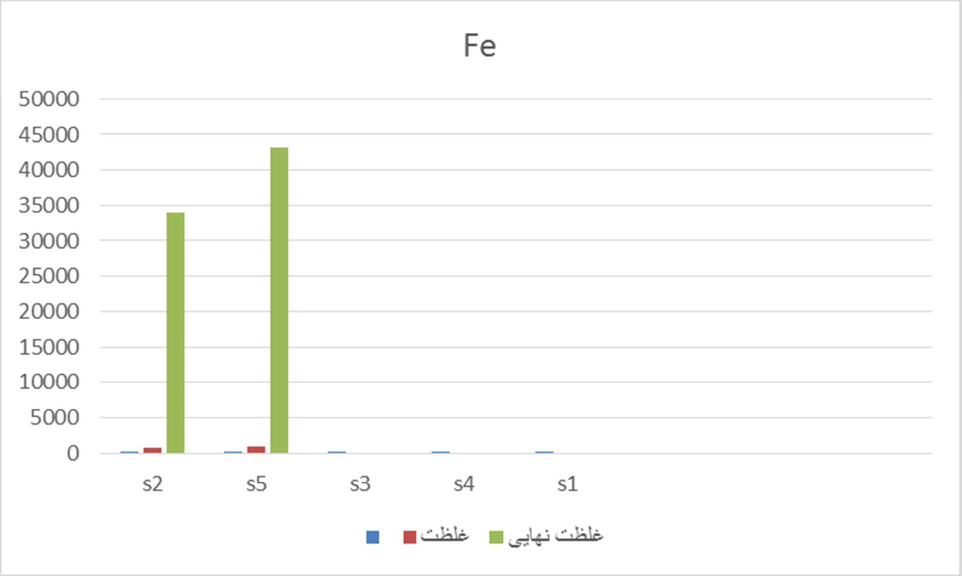
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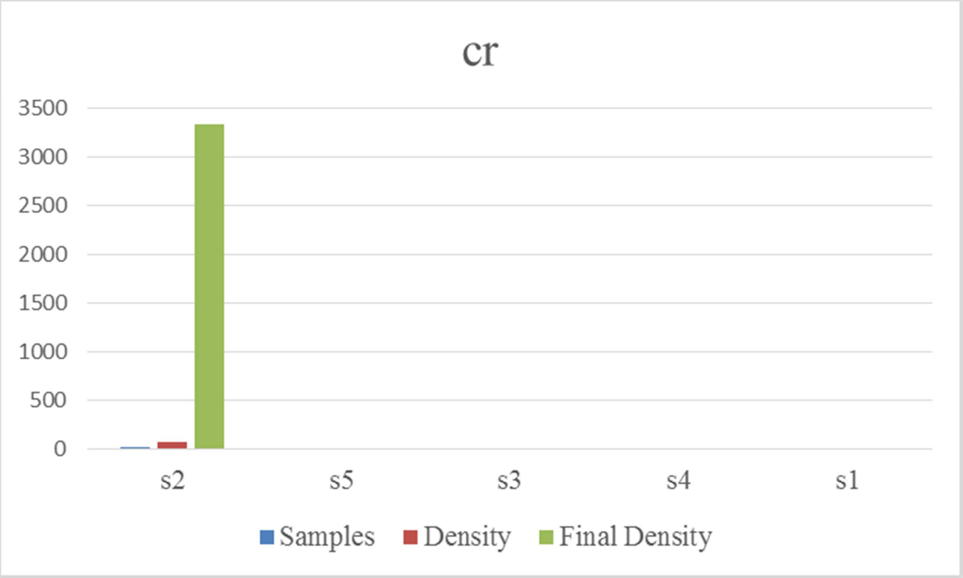

Fig.3. Elements concentration in the sampling stations in separated

RESULTS AND DISCUSSION

T- test for comparison, the concentration of water elements in this area with international standards

Based on the average of elements concentration in the water studied (2 table), and comparison with international standards (3 table), how that the amount of copper , zinc and iron is higher than the standard. In the following, to examine the hypothesis of whether the sample mean with an average population (μ) is identical, we used the one-sample t-test. The results of t-test shows, because sig is less than 0.05, so about lead, manganese , iron and chromium elements, H0 assume that based on to equal elements concentration with world standard is rejected, and H1 the assumption of inequality confirmed (concept of sig is to gauge the significance level of error in each test). Lead and manganese and chromium are lower than standard (because the mean of lead and chromium is zero,and negative at the top and bottom of manganese).

But in the case of copper and zinc, because standard limit is one trail (2 table), and in SPSS only two trail test can be calculated ($\mu = \mu 0$), to calculate one trail tests, must sig amount of two trail test divided in two, to achieved a significant amount of a trail. So the sig obtained for copper and zinc, 0.065 and 0.212 respectively. However, assuming H0 is rejected for copper and for zinc is confirmed.

And finally, in the case of water , the amount of copper and iron is higher than the standard level, zinc equal to standard, and Pb , Mn and Cr is lower than the international standard.

T- test for comparison, the concentration of soil elements in this area with international standard

As can be seen in Table 5, the average of each of the elements listed in the studied territory and comparison with international standards indicate that the amount of copper , lead , manganese , zinc, and iron is higher than the standard, And chromium is below international standard. In the following, to examine the hypothesis of whether the sample mean o is equal with to the population mean (μ), one-sample t-test is used. Here H0 and H1 hypothesis is as follows:

$H0:\mu=$ Standard mean

$H1:\mu\neq$Standard mean

The results of t-test shows, because sig is less than 0.05, so about lead, H0 assume that based on to equal elements concentration with world standard is rejected, and H1 the assumption of inequality confirmed. Lead and manganese and chromium are lower than standard(because the mean of lead and chromium is zero, and negative at the top and bottom of manganese).

But in the case of copper and zinc, because standard limit is one trail (2 table), and in SPSS only two trail test can be calculated ($\mu = \mu 0$), to calculate one trail tests, must sig amount of two trail test divided in two, to achieved a significant amount of a trail. So the sig obtained for copper, zinc, manganese, iron and chromium 0.089, 0.373, 0.007, 0.038, and 0.005 respectively. However, assuming H0 is rejected for copper, manganese, iron and chromium and for zinc is confirmed.

Table 1. Concentration of elements in the sampling stations

Chromium	Iron	Manganeze	Zinc	Lead	Copper	
333.3 mg/kg	340.3 mg/kg	644.6 mg/kg	166.3 mg/kg	704.3 mg/kg	303.3 mg/kg	Soil in the mine
0	431.3 mg/kg	279.7 mg/kg	628.3 mg/kg	382.3 mg/kg	530 mg/kg	Min surrounding soil
0	143 ppb	1.77 ppb	0	0	22 ppb	Blank water
0	143 ppb	1.24 ppb	<139 ppb	0	14 ppb	Mine water
0	143 ppb	12.62 ppb	0	0	14 ppb	Drink water

Table.2. Elements mean concentration in the study waters

	Copper	Lead	Manganeze	Zinc	Iron	Chromium
Mean	16.6667	.0000	5.2333	-.0463	143.0000	.0000
Std. Deviation	4.61880	.00000	6.46310	.08025	.00000	.00000

Table.3. Standard limit for elements in the water (WHO)

Chromium	Iron	Manganeze	Zinc	Lead	Copper	
50 ppb	66 ppb	400 ppb	>0.0002 ppb	15 ppb	4.2-10 ppb	Water

Table.4. T- test for comparison water elements concentration with standard

	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Copper	2.500	2	.130	6.66667	-4.8071	18.1404
Manganeze	-105.794	2	.000	-394.76667	-410.8219	-378.7114
Zinc	-.996	2	.424	-.04613	-.2455	.1532
Lead	-	3	.000	.00000	.0000	.0000
Iron	-	3	.000	.000000	.0000	.0000
Chromium	-	3	.000	.000000	.0000	.0000

Table.5. Element mean concentration in the soil study

	Copper	Lead	Manganese	Zinc	Iron	Chromium
Mean	416.6500	543.3000	462.1500	397.3000	385.8000	166.6500
N	2	2	2	2	2	2
Std. Deviation	160.30111	227.68838	258.02326	326.68333	64.34672	235.67869

Table.6. Standard limit for elements in soil

Chromium	Iron	Manganese	Zinc	Lead	Copper	
50-10000 ppm	0.1-10 ppm	10-9000 ppm	10-300 ppm	25 ppm	13-25 ppm	Soil

Table.7. T- test for comparison soil elements concentration with standard

	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Copper	3.455	1	.179	391.65000	-1048.5983	1831.8983
Lead	3.281	1	.188	528.30000	-1517.3990	2573.9990
Manganese	-46.796	1	.014	-8537.85000	-10856.0971	-6219.6029
Lead	.421	1	.746	97.30000	-2837.8333	3032.4333
Iron	8.259	1	.077	375.80000	-202.3323	953.9323
Chromium	-59.006	1	.011	-9833.35000	-11950.8390	-7715.8610

Table.8. Mean rank

	Mean rank
Copper	5.00
Lead	2.17
Manganese	4.00
Zinc	1.67
Iron	6.00
Chromium	2.17

Table.9. Conclusion of Friedman test for region water

N	3
Chi-Square	14.688
df	5
Asymp. Sig.	.012

Table.10. Mean rank

	Mean Rank
Copper	3.50
Lead	4.50
Mangenese	3.50
Zinc	3.50
Iron	4.00
Chromium	2.00

Table.11. Conclusion of Friedman test for region soil

N	2
Chi-Square	2.000
df	5
Asymp. Sig.	.849

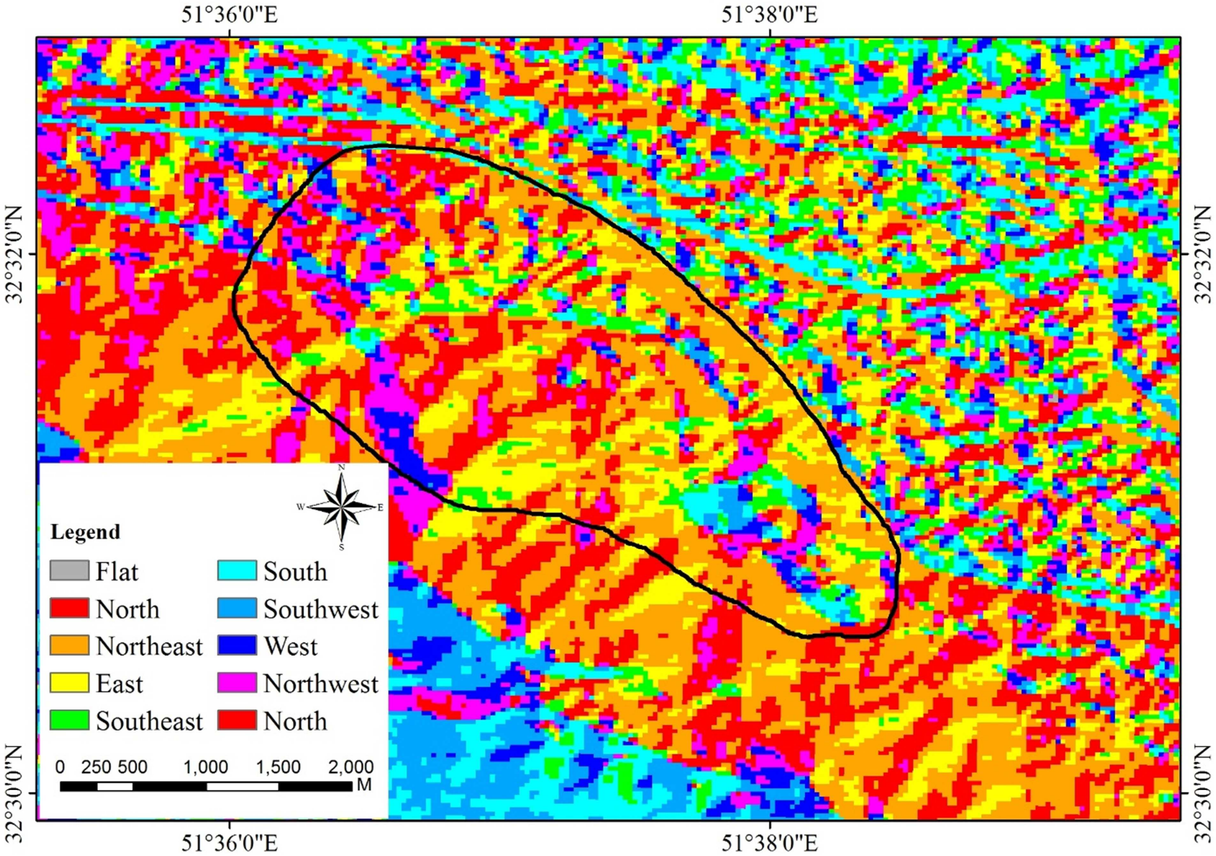

Fig.4. Slope direction in the study region by GIS

And finally, considering the high and low limit of test , the amount of copper, lead, zinc and iron is higher than the standard level, and Mn and Cr is lower than the international standard.

Measurement the elements concentration in the sampling stations

Because the standard of each elements in the soil and the water is different, therefore, water and soil stations studied separated.

Measurement the elements concentration in blank , mine water and drinking water stations

In this research to check, if the concentration of each element in the studied station is equal, or not, was used from Friedman test.

From provisions that can be used Friedman test, can be noted to sample groups.
H0: Average ranks between groups is the same.

H1: n: At least two groups have no significant difference.

In table 7 average ranks of each element is mentioned:

According to Table 7, because the value of sig is less than 0.05, therefore the zero hypotheses is rejected. Based on these results, the concentration of each elements in various waters is different. Accordingly, iron, the highest, and lead and chromium have the lowest amount in the water to be studied.

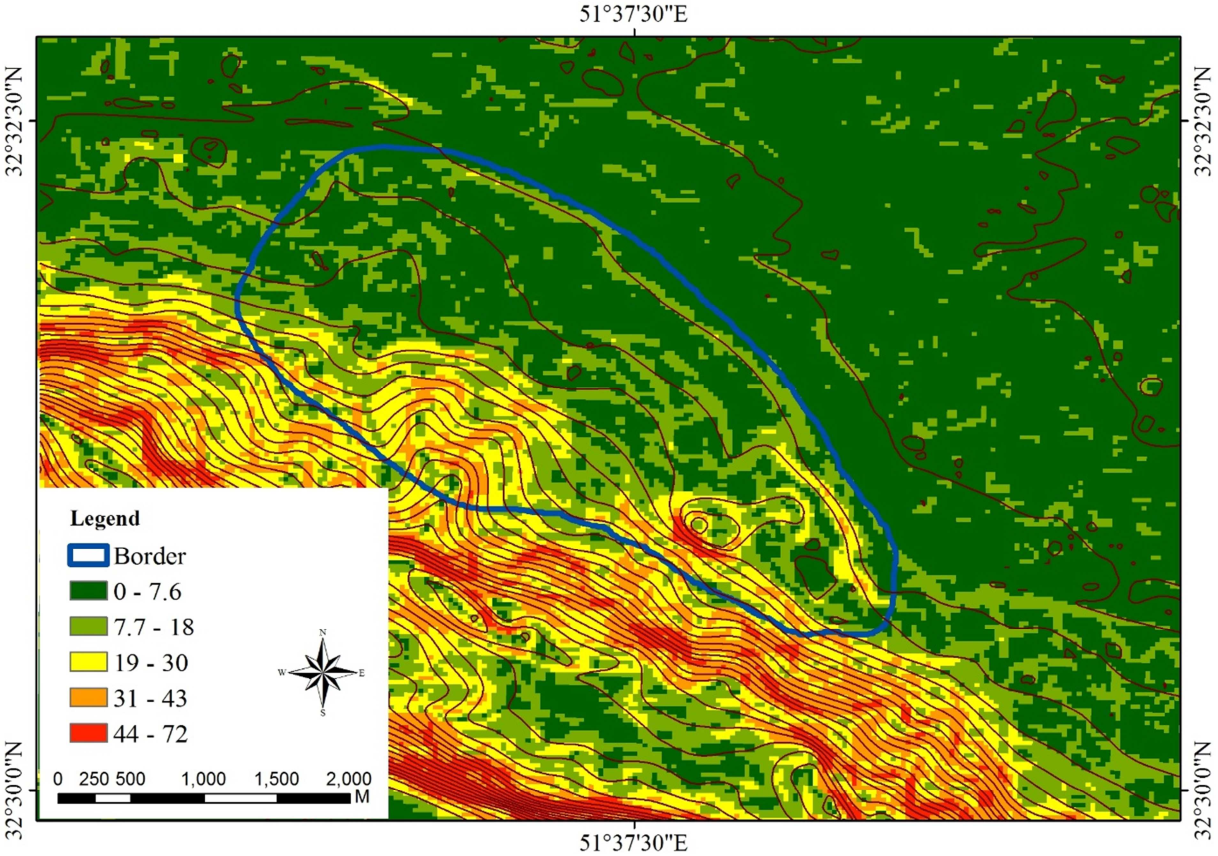

Fig.5. Dip degree in the study region by GIS

Measurement the elements concentration in the soils

In this research to check, if the concentration of each element in the studied station is equal, or not, was used from Friedman test.

Results of Friedman test show(7 table), sig is more than 0.05 (sig= 0.849), therefore, the zero hypothesis that the mean scores between groups is the same, is confirmed. this means that mine soil and soil surrounding the mine , almost are the same in terms of their elements.

But according to Table 3 , the concentration of each element in the soil of the region is different. Accordingly, lead has the maximum and chromium minimum amount, in the soils of studied area.

CONCLUSION

According to the analysis of elements in different parts of the mine and standards of Table 3 concluded, in the Iran kuh mine , in soil samples , Pb and Zn more risk than others. In water samples also elements have the standard range. Due to the slope of mine from southwest to northeast and mine dip from 7to 30 degrees, and with regard to the underlying geological units which are limestone and alluvial, in most cases, a combination of elements due to the weathering, or mineralization, there is possibility of increased concentrations of heavy metals in the soil even higher than the danger zone. From environmentally is extremely dangerous. However, because Abnil village, Baharan, Sepahanshahr and Baghabrisham cities is near to the Iran kuh mountain and lead- zinc processing mine, and occur the treatment of Sepahanshahr waste water near Goushfil and Tape sorkh mines, the existence of these elements in the soil of the area, can appear adverse environmental effects on agriculture, health and even the animals of the region.

Also, due to geographical location and unintended and unpredictable winds in the region, dust from mining activity , with dispersed elements in the city, cause pollution of surface water, especially drinking water and agricultural lands around of the region.

In general, can be said, water from drainage pits, even with lower concentrations, can be in a long time, cause to the accumulation of these metals in the soil and plants. Due to waters of Iran kuh mine, and penetration of output waters to the ground waters and soil in the adjacent lands, this pollution can will have a secondary source.

Vapor forms of heavy metals such as copper , lead, and zinc, in combination with water in the atmosphere , in the form of aerosols , or with the wind (dry sediment), dispersion form, or deposited in the rain (wet sediment), cause pollution (Verkleji, 1993).

Suggestion
1- Prevent indiscriminate agricultural in soils and the land surrounding the mine.
2- Prevent livestock grazing and not using animals from waters and plants in the region.
3- Create a better and accurately place for to build a waste depot.
4- Avoid of indiscriminate construction And the settlements in the region, especially in Sepahanshah.
5- The exact and suitable localization for the construction of municipal facilities such as water treatment plants and food plants.
6- Quality control of the health of miners, on a weekly basis and report on the physical condition of the miners.

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