RESEARCH PAPER:

Environmental geochemistry of lead and its impacts on groundwater pollution in East of Kurdistan, Iran

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SUMMARY

Lead pollution is an environmental priority and contamination of the environment by lead is recognized throughout the world as one of the major environmental problems. The main objective of this paper was to present systematic data on this problem in East of Kurdistan, Iran. Geological activity and natural factors are a possible contamination source of groundwater and sediments that increased trace-element (Pb) concentrations in East of Kurdistan. Geochemical analyses of groundwater and sediment samples indicated high levels in near alteration rocks.

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Key words :
Lead, Pollution, Environmental problems, Toxic elements

Heavy metals are natural components of the earth's crust. They cannot be degraded or destroyed. To a small extent, they enter our bodies via food, drinking water and air (Chi-Man and Jiao, 2006). As trace elements, some heavy metals (copper, selenium, zinc) are essential to maintain the metabolism of the human body. However, at higher concentrations, they can lead to poisoning. Heavy metal poisoning could result, for instance, from drinking water contamination (*e.g.* lead pipes), high ambient air concentrations near emission sources, or intake via the food chain. Heavy metals can enter a water supply by industrial and consumer waste, or even from acidic rain breaking down soils and releasing heavy metals into streams, lakes, rivers and groundwater. Lead is one of the most dangerous inorganic contaminants owing to its high toxicity to living organisms (Nriagu and Pacyna, 1988). In some regions mining activity represents or represented an important source of Pb to the environment. The occurrence of high concentration of lead (Pb), one of the most hazardous chemical elements in drinking water has been recognized, over the past two or three decades, as a great public health concern in several parts of the world (Franco *et al*. 2009, Guy Merciera *et al.,* 2002) Although surface water is still used as drinking water in some areas, groundwater from tube-wells, which is considered relatively free of pathogens, is one of the main sources of drinking water in east of Iran, especially in rural areas. Lead can enter the human body in several ways, including through air, food and water; of these water is generally the most common medium of entry. In this area groundwater and sediment pollution occurs naturally. The toxic metal lead, for instance, is commonly found in the sediments or rock of the eastern Kurdistan, and can be present in groundwater at concentrations that exceed safe levels for drinking water. (Harrison *et al.,* 1981; Fergusson, 1985).

MATERIALS AND METHODS

Study area:

The studied area is located in between Hamadan and Kurdistan province, Iran and is 35^0 00' to 35^0 30' N, and 47^0 20' to 48^0 10' E. This region is 400 square km^2, and is bordered of Bijar from North, on Qorveh town from South, on Hamadan from East. (Fig.1).

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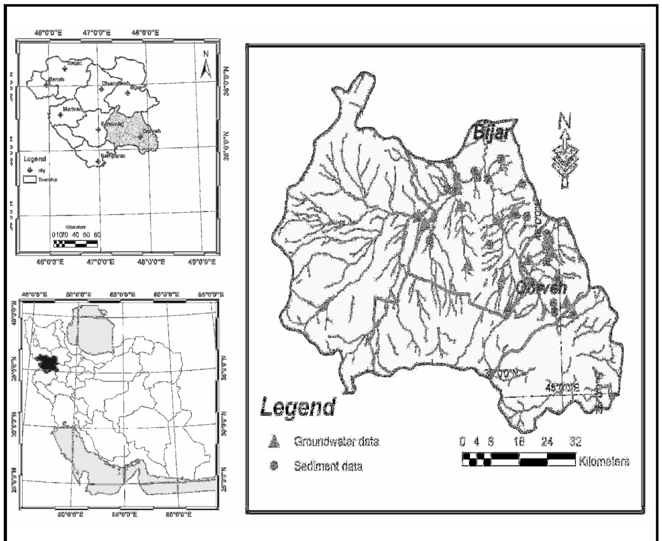
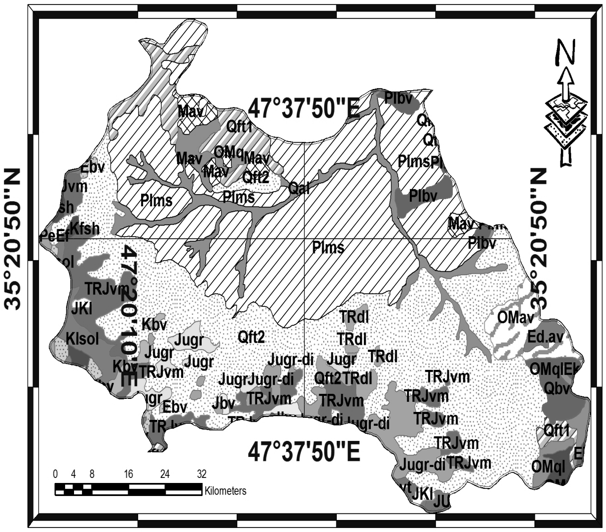


Fig. 1: Location map of the study area and sampling locations



Geology Unit	Description
E1f	Silty shale , sandstone , marl , sandy limestone
Ebv	Andesite and basalt mainly with vesicular texture
Ed.av	Dacitic and andesitic volcanics
JKl	Crystalized limestone and calc- schist
Jugr	Upper Jurassic granite
Jugr-di	Upper Jurassic granite to diorite intrusives
K1m	Limestone , argillaceous limestone
Mav	Massive andesitic to dacitic lavas
Plbv	Basaltic volcanics
Plms	Mudstone , locally gypsiferous and sandstone
Qal	Stream channel , braided channel
Qft1	High level piedmont fan and valley terrces deposits
Qft2	Low level piedmont fan and valley teraces deposite
TRdl	Crystaline limestone and dolomite
TRJvm	Meta - volcanics , phyllites , slate and meta- limestone

Fig. 2 : Geological map of the study area (Geological Survey of Iran after 2002 Sayareh)

Geological setting:

In the study area (Western Iran), two distinct volcanic cycles have been recognized. The first, of upper Miocene age, consists of high-K calc-alkaline volcanic rocks interpreted as final products the calc-alkaline Tertiary phase of central Iran. The second volcanic cycle, mostly of Pleistocene age consists of undersaturated, mainly potassic, alkaline products. As the lavas of this last phase are slightly fractionated, the chemical differences shown by these rocks have been interpreted as primitive features related to the physical conditions governing the partial melting in the mantle and/or the mantle heterogeneity (Berberian, 1977).

In a volcanic centre contemporaneous basic and acid magmas have been found, and interpreted as derived from two different and independent sources. The alkaline basic volcanism is considered as an expression of disjunctive processes that have affected the western margin of the Iranian plate after the Pliocene. Mio-Pliocene collection and Quaternary in East Province, Mio-Pliocene deposits and Quaternary layers almost horizontal surface is covered. North East Mehdikhan and South Qararhbolagh village, igneous magmatic activities that result is the beginnings of Quaternary of outcrops. Around the Delbaran and Maloojeh, Pliocene tuffs (Pt) are large-scale developments that have a high porosity (Fig.2) (Geological Survey of Iran, 1969).

Sampling and samples preparation:

The identification and sampling of the groundwater, as well as stream sediments and quaternary sediments were done. In addition, samples from the alterated rocks were collected. Sampling was performed after a rainy period, during normal flow conditions (infiltration period with enrichment by dissolution – spring season), and a dry period (no precipitation – summer season).Acidified aliquots were analyzed for heavy metals and trace elements by analyzed by inductively coupled plasma atomic emission spectrometry (ICPAES) (WHO, 1995; WHO, 2006).

Stream sediment samples:

Twenty threee samples of sediments were collected with plastic spatulas and stored in polypropylene boxes and transferred to pre-cleaned plastic bags, sealed and brought to the laboratory (Table 1). All soils and sediments were oven-dried at 70°C and powdered prior to analysis. In order to obtain representative aliquots for analyses, samples were homogenized, quartered and dry-sieved through a 165-mm nylon mesh (Fig.1) (WHO, 1995; WHO, 2006).

Table 1: Lead analysis of sediments (ppm) in study area

Name of the village	X(UTM)	Y(UTM)	Pb (ppm)	Standard limit WHO
Shoorabhezareh	752825	3927030	24	12
Around lak	749026	3928869	12	12
Ghaslan	753341	3911921	22	12
Niazbolag	756427	3931659	15	12
Abdol abad	762466	3925999	12	12
Sarayehjoog	766000	3927230	44	12
Mehraban sofla	771861	3924452	23	12
Qarnieh	769358	3914423	30	12
Qarnieh	770404	3912914	36	12
Ghezeljeknad	769508	3911467	56	12
Maloojeh	769252	3907970	53	12
Alahyari	763804	3918351	26	12
Shadi abad	749855	3927418	17	12
Haji abad	742083	3930556	16	12
Ghoojag	744001	3927580	29	12
Toghan	767401	3902051	27	12
Gilko	771327	3898384	29	12
Jidaghayeh	771658	3896367	42	12
Seid jal	765389	3903114	9	12
Delbaran	771983	3902190	44	12
Khosro abad	736554	3931126	30	12
Hasan khan	741404	3924653	11	12
Yalquz Aghaj	736323	3912922	9	12

Groundwater samples:

Natural water samples were taken from the wells that supply the rural area of east of Kurdistan from different reservoirs. About 15 groundwater representative samples were collected from 45 sampling points of east of Kurdistan with the help of global positioning system (GPS). The samples were collected from wells and springs. The collection of samples was performed by using plastic bottles and was kept in well stoppered polyethylene plastic bottles previously soaked in 10% nitric acid for 24 h and rinsed with ultra pure water. All water samples are filtered in the field (0.45 Am). Samples for cation analysis were acidified (concentrated HNO_3 to pH was 2), whereas non-acidified samples were collected for anion and stable isotope analysis as shown in Fig. 1 (WHO, 1995; WHO, 2006).

Results and Discussion

The main study of lead contamination was measured from both highly contaminated and non-contaminated regions of East of Kurdistan, Iran. In humans exposure to lead can result in a wide range of natural, industrial and biological effects depending on the level and duration of exposure. Various effects occur over a broad range of doses, with the developing foetus and infant being more sensitive than the adult. High levels of exposure may result in toxic biochemical effects in humans which in turn cause problems in the synthesis of hemoglobin, effects on the kidneys, gastrointestinal tract, joints and reproductive system, and acute or chronic damage to the nervous system (Riley and Kirk, 1990, WHO, 1995). Average lead was estimated at 1.6µg from air, 10µg from drinking water and 12µg from sediments. Such as water in areas with lead piping and plumb solvent water, air near point of source emissions, soil, dust, paint flakes in old houses or contaminated land. For the majority of rural people in the east of Kurdistan is used of groundwater with wells and spring.

Lead in the environment arises from both natural and anthropogenic sources. Exposure can occur through drinking water, air, soil and dust from old paint containing lead (WHO, 2006). In the study area, the major exposure pathway was from geological affects and was used through sediment, soil and water. Chemical industries are one of them that effect in the environment contamination, but we could not see any manufacture and industrial activities in this area. An analysis of the respective materials indicated that the main source of lead contamination in all parts of the environment in Kurdistan. The metals existed naturally in the bedrock and released through weathering. In water, metals exist in different forms, both solved and suspended, depending on a number of different parameters. The solubility, transportation and toxicity differ between different metal species (Chi-Man Leung and Jiao, 2006, Pearce and Gal, 1977).

Lead contamination of the groundwaters:

The Safe Drinking Water Act was amended to cover the national problem of lead in drinking water. It is important to recognize that lead rarely if ever contaminates drinking water at the source reservoirs or groundwater but it can enter our drinking water through the entire distribution system including mains, service lines, in-house plumbing, water coolers, and plumbing fixtures within our houses, schools, and other buildings (Darrell, 1989). The main objective of the study of hydrogeologic features that have been contaminated by lead from geological formation. The result of this investigation is the application of an efficient tool for handling their sources and evaluating the environmental impact from the transport of contaminants in groundwater (Bryan *et al.,* 1999).

In the study area, the concentration maximum migrates at centre of area to NW and SE. All sites were carefully screened to eliminate obvious data bias. Specific sites excluded from the study included those with restricted access and rural properties with extremely high concentrations of a lead metal. The sites were screened groundwater occurring this research that sites were therefore to be in a naturally contaminated with geologic formation (American Society for Testing and Materials, 1992, APHA ,1995).

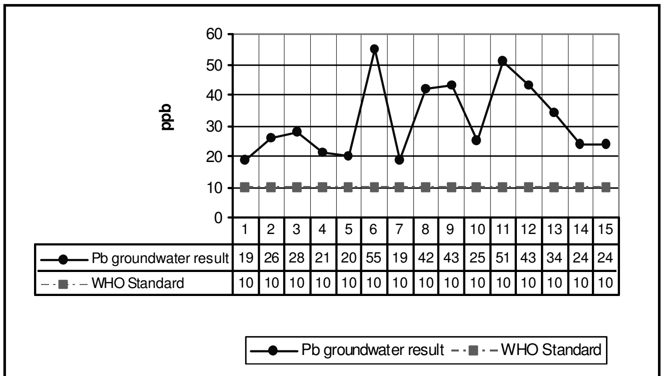


Fig.3: Comparison of groundwater pollution with international standards

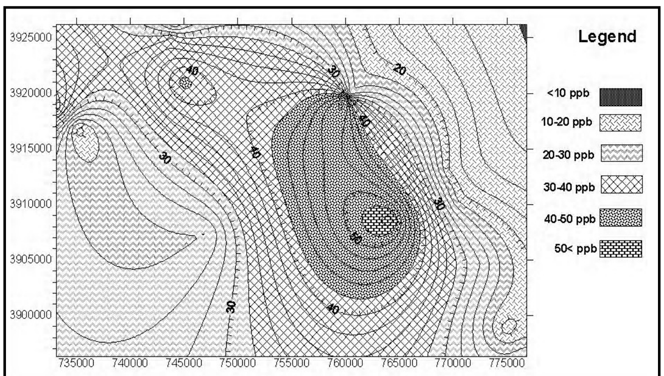


Fig. 4: Groundwater pollution map of lead of study area

This screening resulted in a final dataset of 15 representative groundwater samples collected from the selected sites included new residential developments as well as older residences, rural region and wells and springs that used for drinking water. The metals evaluated for this study included Pb and Fig. 3 and 4 show the site locations and Table 2 represents the number and amount of distribution of the samples obtained within each well and spring.

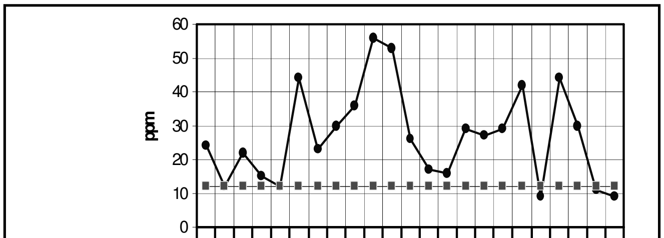
Lead contamination of the sediments:

Metal mobility was assessed by computing the ratio between the mean concentrations of metals in

Table 2: Lead analysis of groundwater (ppb) in study area

Name of the village	X(UTM)	Y(UTM)	Pb (ppb)	Standard Limit WHO
Ghoochagh village	774951	3898707	19	10
Jodaghayeh village	776858	3896307	26	10
Delbaran village	772508	3904741	28	10
Malujeh village	770666	3910460	21	10
ghezeljekand	769558	3913188	20	10
Baba Gorgor spring	764218	3908625	55	10
Zobahan factory well	735082	3916875	19	10
Baytomer	733174	3918552	42	10
Mehdi khan village around1	755570	3917857	43	10
Nadershah village	760354	3919879	25	10
Mehdi khan village around	760001	3919428	51	10
Seylab village	744984	3921053	43	10
Hasan khan village	743790	3925018	34	10
Hasan khan village around	744053	3926215	24	10
Serish abad around	747191	3907442	24	10

groundwater and at the sediments. Pb is also mobile within units consisting of larger-grained soil particles that have higher hydraulic conductivities (sand, gravel). Some trace elements also exhibited high ratios within the sand, gravel and alteration rocks in geologic units (Nurdan and Aydin, 2007). Compounding the contamination problem within the sand unit are the physical characteristics of its aquifer and surface drainage. The relatively high hydraulic conductivity of the sand unit, coupled with hydraulic conductivity of the sand unit, coupled with short residence time for contamination. Groundwater recharges streams through base flow. Thus, any contaminant entering groundwater within the sand and gravel unit will flow in the general direction of the surface drainage and would enter a surface stream within a relatively short time due to the high drainage density. Another significant finding was the presence of elevated concentrations of Pb within the ground water of the clay and silty clay geologic units, as mobility of metals in clay is generally believed to be very low. Several factors could account for this result, including very high concentrations of Pb within the clay soil units; cracks within the clay unit that allow for some downward migration of contamination and the long duration and continuous deposition of Pb within these areas due to the development alteration rocks of the watershed



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Pb Sediment result	24	12	22	15	12	44	23	30	36	56	53	26	17	16	29	27	29	42	9	44	30	11	9
WHO Standard	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12

Fig. 5: Comparison of sediment pollution with international standards

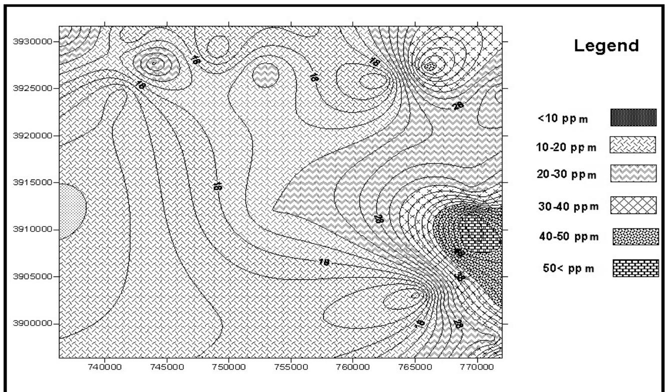


Fig. 6 : Sediments pollution map of lead of study area

(Nakamura, 1974).

This screening resulted in a final dataset of 23 representative sediments samples collected from the selected sites included residential place, rural region and sediments in main and subsidiary steams. The metals evaluated for this study included Pb and Fig. 5 and 6 show the site locations and Table 1 shows the number and amount of distribution of the samples obtained of sediments. Alteration of rocks is a common phenomenon in a wide variety of geologic environments, including fault zones and explosive volcanic features. Weathering of the alteration rocks can help to this process that more stable material from their exposure to the agents of sediments and groundwater. In the study area was seen the processes affecting the sediments and groundwater pollution.

Conclusion:

This study showed that the heavy metal Pb concentrations in groundwater samples and sediments in the natural slopes .Although it is believed that seepage from stream drains would be common in the study area and groundwater samples in study area did not contain elevated levels of Pb found in sediments in surface water. This shows that the vadose zone could effectively remove many of the heavy metals, like Pb and thus protect the underlying groundwater from contaminations. On the other hand, groundwater samples were found to contain elevated levels of minor that sediments have heavy metals including Pb with high elevated levels. Pb may also be derived from remobilization from alteration rocks and natural soils due to the changes in geologic formation that it's different in the study area. More attention should therefore be paid to investigate this process that could possibly affect the groundwater contamination in the study area. These results demonstrated that alteration rocks and volcanic rocks were commonly in the rural area and they affected the heavy metal like, Pb distributions in groundwater to different extents. Trace elements with elevated levels were considered to be mainly the result of natural processes such as the weathering of minerals and alteration rocks that are affective in sediments and groundwater pollution. Although limited in number, groundwater samples collected from wells and springs showed similar heavy metal and trace element levels as that of the samples in the natural. This study suggested that the vadose zone could filter many of the heavy metals and source of contamination was SE toward NW.

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