Assessment of Groundwater Pollution in Kerman Urban Areas

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Introduction

Perception of groundwater vulnerability level to pollutant is considerably essential in urban areas to facilitate groundwater planning and management. Because of the health and economic impacts associated with groundwater contamination, groundwater pollution assessment must be taken into consideration for sustainable groundwater protection. In this research, the concentrations of some heavy metals (Cd, Cr, Cu, Mn, Pb and Zn), major ions (Na^+, Ca^{2+}, Mg^{2+}, Cl^- , SO_4^{2-} and HCO_3^-, NO_3^{2-}), electrical conductivity, total dissolved solids, total hardness and pH were measured to evaluate the degree of groundwater pollution in Kerman urban area.

Materials and Methods

Kerman city is located in south east of Iran. The area has a semiarid to arid climate and its temperature mostly varies between -8° C in winter to 37° C in summer on average. The amount of precipitation is quite variable. The average of precipitation during the past 20 years is about 147 mm per year. Kerman lowland areas are composed of Cretaceous limestone covered by Quaternary deposits (alluvial, evaporative and Aeolian sediments). In order to assess ground water pollution, 43 groundwater samples were collected (Fig. 1). Three different measurement methods used include the application of Graphite Furnace atomic absorption spectrometry, titration and potentiometer to measure some elements. Concentrations of elements were compared with US environmental protection agency (EPA) standards. Using GIS analysis techniques, Isoconcentration geochemical maps for some trace elements and major ions were produced. Figure 1 shows the geological map of Kerman urban area, with sampling locations marked on it.

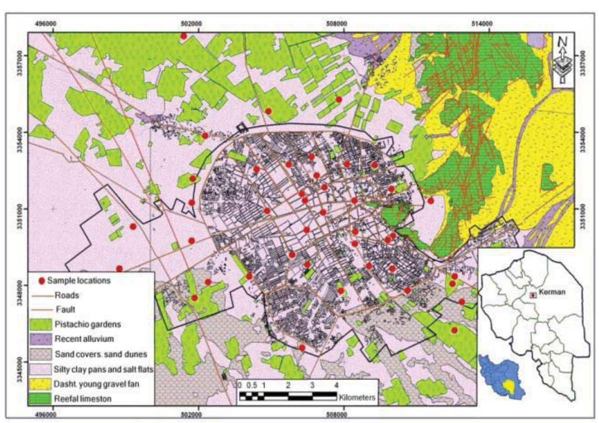

Fig.1: Geological map and sampling locations in Kerman urban area

Results and Discussion

The results demonstrated that the concentration of some heavy metals such as Cd, Cr, Mn, and Pb, some major ions including Na^+, Ca^{2+}, Mg^{2+}, K^+, Cl^- , SO_4^{2-} and NO_3^{2-}, electrical conductivity, total dissolved

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solids, total hardness and pH in groundwater in some parts of urban area exceeded the maximum permissible level for drinking water as established by the United States Environmental Protection Agency (Table 1). The concentration of ions in the evaporative mineral displayed a significant anomaly in some regions. For instance, Sulfate's concentration is more than three times the maximum permissible level for drinking water. Based on the correlation coefficients between the parameters, researchers can predict the similarities between the sources of the elements. It identified that there is no strong correlation between heavy metals such as Cr, Zn, Cu, and Pb and Major ions which shows that the source of heavy metals is anthropogenic. The strong correlation between Cd and major ions implies that the major source of Cd is geological formations such as evaporative sediments (magnesium and calcium sulfate). However, the role of the chemical fertilizers, applied to increase the productivity of the crops by farmers, as an anthropogenic source is not negligible. Moreover, Na^+ strongly correlated with Cl^- and Mg^{2+} significantly correlated with SO_4^{2-}, suggesting that dissolution of evaporative minerals is the main source of them. The correlation of K^+ and NO_3^{2-} with the other ions is weak. This shows that domestic sewages and chemical fertilizers are the potential source of these ions. The concentrations of most trace elements and major ions indicated enrichment beneath the city. A comparative study between 1994 to 2006 on 6 samples showed a dramatic increase in the concentration of Na^+, Mg^{2+}, Cl^- and SO_4^{2-}. This is due to the groundwater pollution by domestic waste water and dissolution of evaporative minerals (Halite and Gypsum), as a result of raised groundwater level. In Kerman a majority of houses have absorption wells which are the main sewage disposal method. Isoconcentration geochemical maps were depicted to interpret the distribution of elements in the area (Fig. 2). So the anomaly witnessed in Cd in the western part of the city is between 0.01- 0.12 ppm. It seems to be related to the natural sources and industrial wastes as a result of industrial activities in this region.

Table 1: Concentration of trace elements, major ions and other water quality parameters in the study area

Element	***Cd* (μg/l)**	***Cr* (μg/l)**	***Cu* (μg/l)**	***Mn* (μg/l)**	***Pb* (μg/l)**	***Zn* (μg/l)**
Average	6	28	13	26	45	35
Maximum	12	280	150	132	120	172
Minimum	1	1	1	1	10	0.5
Median	5	20	5	15	40	11
Maximum permissible level for drinking	5	50	1000	50	50	5000
Maximum permissible level for agriculture	10	100	200	200	5000	2000
Element	Ca^{2+} (mg/l)	Mg^{2+} (mg/l)	Na^+ (mg/l)	K^+ (mg/l)	SO_4^{2-} (mg/l)	Cl^- (mg/l)
Average	132	147	455	22.7	877	435
Maximum	240	388	1715	97	2696	1732
Minimum	20.45	28	92	10	148	103
Median	126.7	112	370	21.5	703	383
Maximum permissible level for drinking	200	150	175	12	250	250
Maximum permissible level for agriculture	400	60	900	75	950	500
Parameter	HCO_3^- (mg/l)	NO_3^- (mg/l)	***TDS* (mg/l)**	***EC* (μm/cm)**	***TH*** (mg/l_{CaCO3})	***pH***
Average	490	119	2233	3485	822	7.28
Maximum	1008	395	5801	9050	2167	8.4
Minimum	165	23	686	1070	166	6.74
Median	488	61	2147	3350	819	7.2
Maximum permissible level for drinking	–	45	1500	2000	500	6.5-8.5
Maximum permissible level for agriculture	600	600	2000	2700	–	6.5-8.5

The concentration of Pb in the city center groundwater is as a result of municipal waste disposal which includes Pb produced by fossil fuel combustion in cars engines and emitted into the atmosphere in the form of fine particles.

The concentration of Pb in the city center is mostly due to municipal waste disposal. The waste is a combination of Pb produced by fossil fuel combustion in cars engines emitted into the atmosphere in the form of fine particles. A previous study by Hamzeh (2006) has shown that the concentrations of Pb in the soil of Shahid Rajaie gas station and Kerman transportation terminal are 0.5 and 5 g/kg, respectively. The concentration of Mn in the southern part of the city where many industrial units are located is high, but it is still under the permissible limit. Generally there exists a quite low concentration of Cr (<0.05), except for one sample from the industrial region. The concentrations of Cu and Zn are within the permissible limit. Only in a few samples a slight increase can be seen. Nitrate ion concentrations show meaningful increases in the city center which is an indicator of low groundwater quality due to domestic waste water. Significant increases are seen in the concentrations of Ca and HCO_3^- in the eastern part of Kerman where limestone facieses are dominant. These increases pervade toward the western part where the majority of facieses are evaporative minerals. In the city center the concentration of HCO_3^- enlarges as a result of organic substance degradation in domestic waste water.

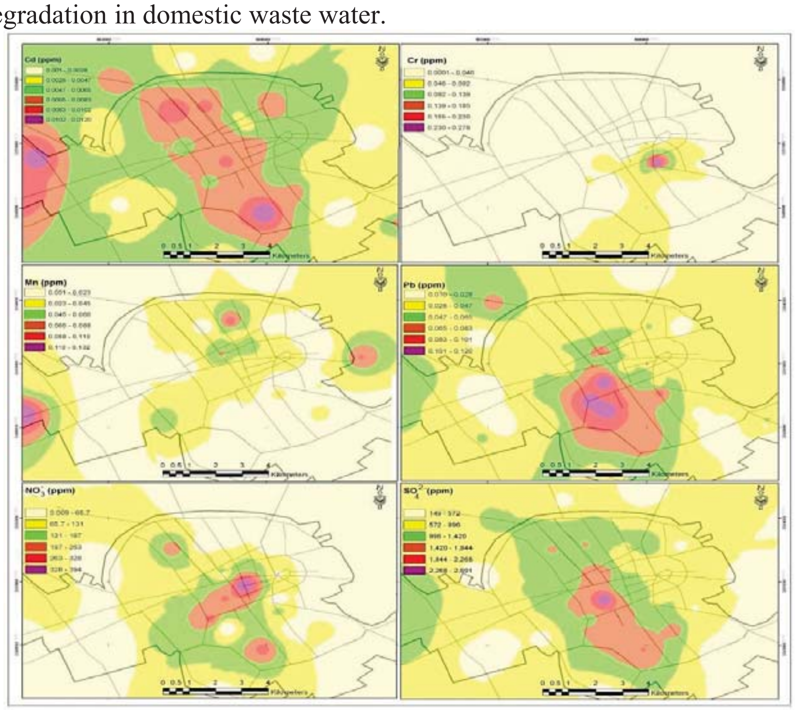

Fig. 2: Geochemical maps of Cd, Cr, Mn, Pb along with nitrate and sulfate ions in Kerman groundwater

Conclusion

Alkaline clay soils reduce the heavy metal movement. There is a large amount of clay minerals in Kerman soils as a consequence of increase in cation exchange capacity, and existence of Sodium, Potassium, and Magnesium in soils which accelerates this process. Thus they operate as a natural purifier in the environment and preserve groundwater from pollutants, by absorbing them. As Hamzeh (2006) stated, the concentration of Pb, Cu, and Zn in the surface soil is three times more than that of soil in the depth of 20-25cm. This means that the ions are absorbed in the surface. In conclusion, geological formations play an important role in increasing the concentration of major ions. Also municipal and domestic waste water can be the major reason for increasing concentrations of groundwater heavy metals (Pb, Mn, and Cr) in Kerman.

Key words

Heavy metals, Groundwater, Kerman, Major ions, Pollution