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Evaluating the Trend of Changes in Groundwater Quality Parameters (Case Study: Jiroft Plain)

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Abstract
In recent decades, population growth and development of agriculture, indiscriminate increase and exacerbate the decline in the quality of groundwater resources in most parts of the country. Thus, given the importance of this research to study the spatial and temporal changes in parameters of calcium, magnesium, pH, chloride, sodium sulfate and water in Jiroft discussed. The data from 40 wells in the region of Kerman province in 2002 - 2012 water harvesting and qualitative analysis had been done on it was used. In this regard, after normalizing the data to evaluate the accuracy of different geostatistical methods including the kriging and inverse distance weighted, and then map the spatial zoning in the software quality parameters ArcGIS9.3 was prepared using the best method of interpolation. The results showed that the amount of calcium, pH and chlorine in the water and magnesium, and sodium sulfate also has declined. But the quality of groundwater resources Jiroft in general in 2012 compared to 2002, decreased and the process of change if they do go to the South and West Water quality is reduced.

Keyword: Modeling, Jiroft plains, groundwater, spatial changes, interpolation.

1. Introduction

Groundwater resources serve as the most important source of water for agriculture and drinking purposes in Iran and many other countries characterized with similar climates. On the other side as groundwater subjects to low risk of contamination, so even in areas with no water scarcity these resources are utilized frequently.Water pollution issue not only in industrialized countries but also in developing countries is controversial (Mahdavi, 2004). Thus, there are many actions to control and reduce groundwater pollutants and their impacts, awareness about the distribution and dispersion of pollutants.Such information is obtained only through air pollution monitoring stations distributed across the study area and interpolating sampled points and finally their analysis (Ale sheikh et al, 2008). In recent years, many researchers have attempted to generate water quality maps using geostatistical methods (Zamzam, 2009) as follow:

In a research entitled as statistical analysis of groundwater distribution in Alessandria state (a region in northwest of Italy), a sampling on 44 wells during the summer and spring (2001) was conducted to determine 29 water quality parameters.Results showed that water between small villages and remote areas of the countryside differed significantly (Nas, 2009).

In a research on groundwater quality in Kashan basin, physical properties such as PH, hardness, chloride, Electrical conductivity (EC) and total dissolved solids (TDS) were studied.Sodium percent indicated that only 53% of the samples are allowed to be

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irrigated (Jamshidzadeh, 2011).
Water samples were taken from ten wells around Negatin Kara efficient and parameters such as TDS, EC, PH, sulfate and carbon dioxide for four months from March 2012 to June 2012 were measured using standard methods.Parameters such as PH, EC and sulfate was within threshold recommended by WHO, but on some siestas was exceeded threshold (Nath, 2013).
In a seminal research, physical and chemical parameters of groundwater was measured in Kandahar in India. The parameters included pH, turbidity, total alkalify, total hardness, total dissolved solids, sulfate, nitrate, chloride and fluoride.The results showed that water quality index are within the permitted threshold during all seasons and groundwater is safe to drink and suitable for use in drinking purposes (Deepak, 2013).
Spatial and temporal changes in groundwater quality In Mumbai, India were assessed using underground water quality index.In this study number of 15 wells were sampled and the results show that it 74 percent of the samples were non-potable water and are not suitable for drinking as study area is located in an industrial area so that human activities have led to pollution of natural resources such as groundwater (Pawar, 2014).
While assessing underground water quality in Vanyar basin in India researcher concluded that according to Wilcox diagram downstream water quality is good for irrigation, but pollution was found in some upstream and this can be attributed to rocks weathering and geological interactions (Jamshidzadeh, 2011).
Given the aforementioned studies and urgent need to study groundwater quality on the one hand and high dependence of Jiroft people in groundwater resources, the present research deals withmapping tempo-spatial variations trends in groundwater quality in jiroft plain in times series 2002 and 2012.

2. Materials and Methods

2.1 Study area

Jiroft Plain as a part of Jazmurianbasin nestled between 57 15 and 58 17 E and 28 12 and 29 13 N, in Kerman province southern Iran (Figure 1). Above sea elevation ranges 550 to 800 m. According to latest statistics in this area discharge is over 950 million cubic meters per year to Jiroft aquifer.Industry and agriculture consume this discharge water about 0.26 and 94% which accounting for lowest and highest utilization respectively (Faryabi, 2010).

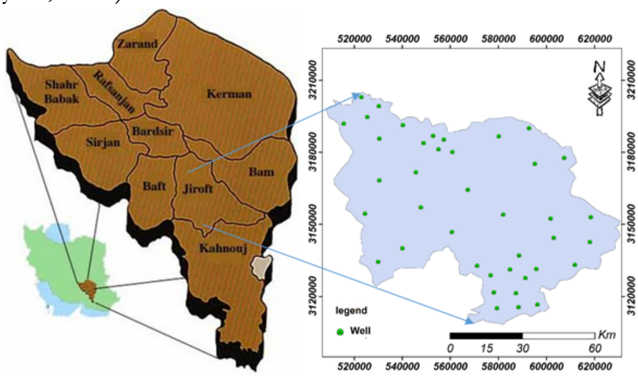


Figure 1: geographical position of Jiroft Plain

2.2 Methodology

In order to assess tempo-spatial variations trends in groundwater quality injiroft plain and to obtain forty years data in times series 2002 and 2012 were taken from regional Kerman water department.Oncedata were normalized, using RMSE criteria suitable interpolation method was considered and quality parameters map was plotted in ArcGIS 9.3. Finally, changes in parameters were assessed and critical and polluted sites were determined.

Kriging is an estimation method that is based on rationale of weighted moving average and this estimator is known as the best linear unbiased estimator (Nas, 2009).

If the variable z has the normal distribution, one can use Kriging method. Otherwise, linear Kriging should be used or variable Z should be normalized somehow (Baalousha, 2010). General relation of Kriging is as bellow:

$$Z^*(x_i) = \sum_{i=1}^{n} \lambda_i Z(x_i) \quad (1)$$

Where Z* (xi): estimated amount at position xi, λi: the weight related to its h sample, Z (xi): the amount of it h variable, and n: number of observations.

Other geo-statistical method is IDW which by weighting data around estimated point unknown quantity is obtain and interpolation is conducted. This method mostly is used to develop maps with many data and when maximum and minimum of a given variable in studied location are available this method is very useful. Indeed, it is supposed that points close to each other have more similarity than more remote points. Thus more close points have higher weight (Johnston et al. 2001). General relation of inverse distance weighting is:

$$Z = \frac{\sum_{i=1}^{n} \frac{Z_i}{d_i^m}}{\sum_{i=1}^{n} \frac{1}{d_i^m}} \quad (2)$$

Assessed measures in this study are defined based on parameters RMSE. The most important measure to assess estimation is amount of RMSE. Siska and Hang (2001) suggest that RMSE is an important parameter to show resolution precision in GIS and Geostatistical.

$$RMSE = \left(\sum (Z^*(xi) - Z(xi))^2 / n\right)^{1/2} \quad (3)$$

Where Z*(x): estimated amount of related variable, Z (xi): measured amount of related variable, and n: number of data.

3. Results

To data analysis data histogram and statistical parameters were evaluated in terms of classical statistics for each quality parameters.Given the histogram and the relevant parameters it was observed that all the variables research are skewed, so in order to normalize data from logarithmic transformation of data in the results for each variable was considered. Results are given in Table 1.

Table 1. Results of statistical analysis on groundwater data in study area

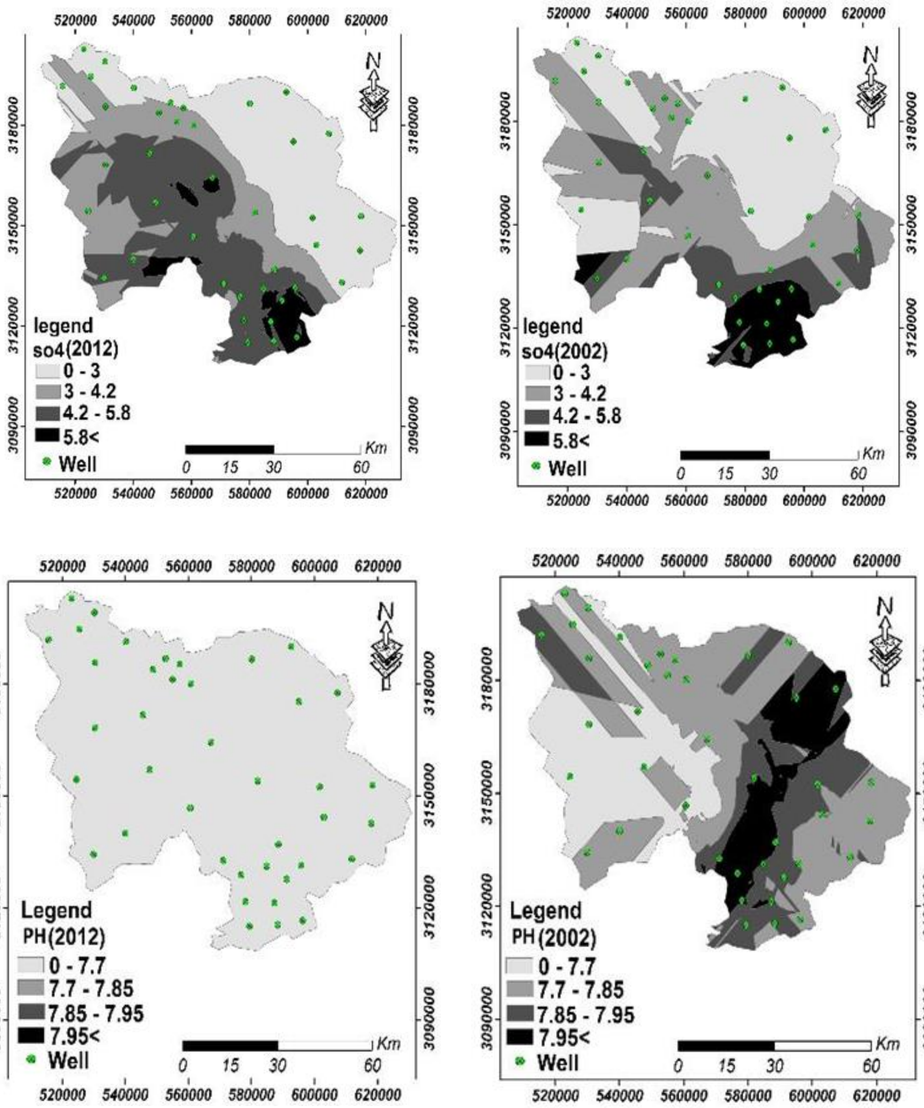
kurtosis	skewness	Max	Min	Std	Mean	Year	Parameter
14.61	3.26	15	0.4	2.43	2.30	2002	Mg(mg/Lit)
1.16	0.51	1.17	-0.39	0.38	0.36	2002	Mg*(mg/Lit)
3.05	3.61	48.5	0.1	3.61	5.37	2002	So_4(mg/Lit)
1.30	0.55	1.68	-1	0.88	0.73	2002	So4*(mg/Lit)
0.25	0.55	8.40	6.90	0.35	7.83	2002	PH
-	-	-	-	-	-	2002	PH*
11.87	2.71	67	0.2	11.23	9.37	2002	Na(mg/Lit)
1.07	0.43	1.82	-0.69	1.05	0.97	2002	Na*(mg/Lit)
22.98	4.04	17.60	0.7	2.58	2.78	2002	Ca(mg/Lit)
1.35	0.60	1.24	-0.15	0.41	0.44	2002	Ca*(mg/Lit)
15.50	3.14	44	0.20	7.20	5.08	2002	Cl(mg/Lit)
1.19	0.49	1.64	-0.69	0.85	0.70	2002	Cl*(mg/Lit)
20.69	3.98	13.60	0.20	1.82	1.67	2012	Mg(mg/Lit)
1.31	0.60	1.13	-0.69	0.26	0.22	2012	Mg*(mg/Lit)
5.12	2.07	13.90	0.10	2.61	2.67	2012	So4(mg/Lit)
0.70	0.31	1.14	-1	0.41	0.42	2012	So4*(mg/Lit)
0.75	0.19	8.8	7.4	0.29	8.09	2012	PH
-	-	-	-	-	-	2012	PH*
10.05	2.87	41.3	0.1	7.17	6.59	2012	Na(mg/Lit)
1	0.45	1.61	-1	0.85	0.82	2012	Na*(mg/Lit)
8.06	2.36	11	0.50	1.69	2.57	2012	Ca(mg/Lit)
0.90	0.37	1.04	-0.30	0.22	0.41	2012	Ca*(mg/Lit)
17.23	3.88	42.4	0.30	6.73	4.20	2012	Cl(mg/Lit)
0.90	0.37	1.04	-0.52	0.82	0.62	2012	Cl*(mg/Lit)

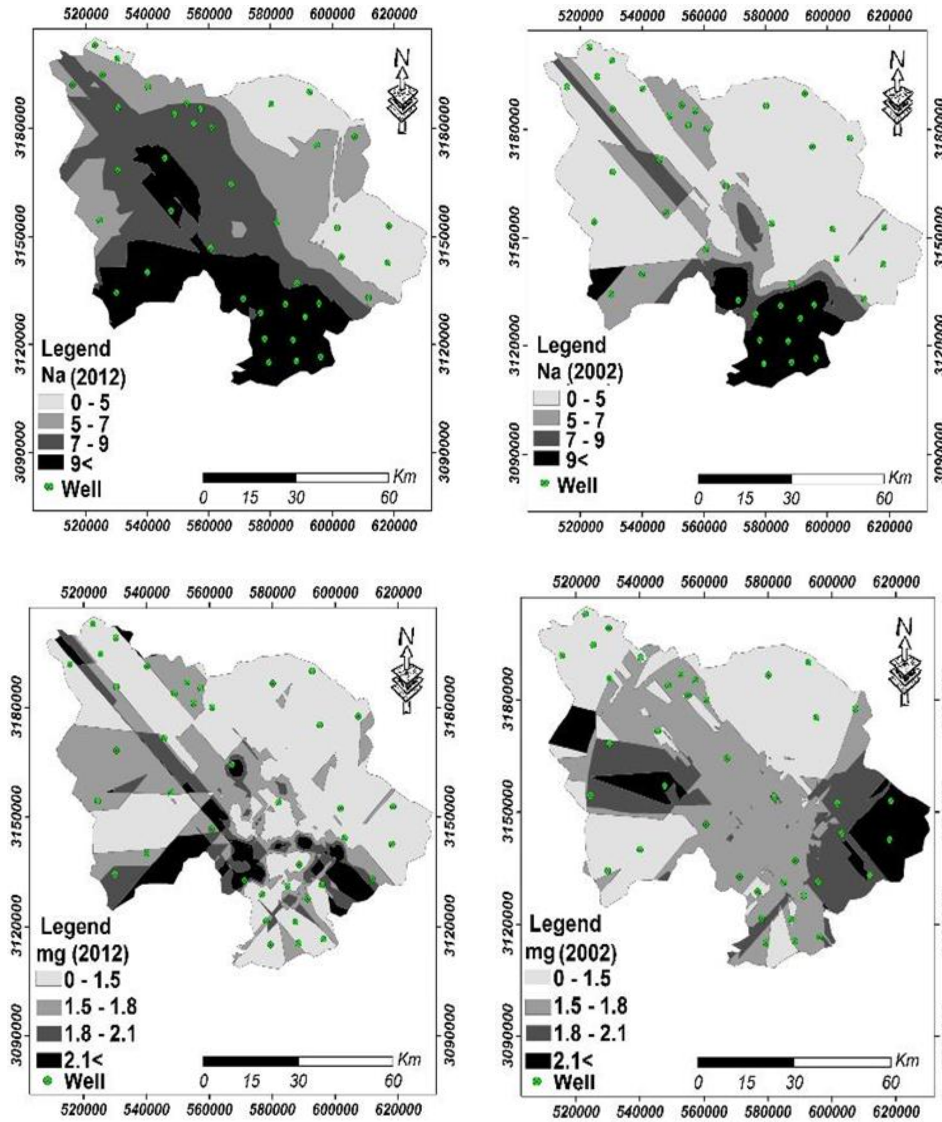
At this stage, to select the best interpolation method for mapping, between two interpolation methods IDW and kriging, ordinary kriging as the best method based on the criteria of RMSE less for zoning all quality parameters was selected that results are shown in Table 2.

Table 2: parameters RMSE value for Geostatistical to determine the best method

3 IDW	2 IDW	1 IDW	Kriging	Year	Parameter
2.18	2.21	2.07	2.06	2002	Mg(mg/Lit)
7.26	6.52	5.86	5.66	2002	So4(mg/Lit)
0.33	0.31	0.30	0.28	2002	PH
9.63	8.76	8.03	7.83	2002	Na(mg/Lit)
5.40	5.62	6.04	2.09	2002	Ca(mg/Lit)
13.19	7.43	4.56	3.68	2002	Cl(mg/Lit)
1.38	1.42	1.50	1.09	2012	Mg(mg/Lit)
1.93	1.85	2.08	1.73	2012	So4(mg/Lit)
0.24	0.28	0.29	0.23	2012	PH
4.72	4.92	5.28	4.49	2012	Na(mg/Lit)
1.42	1.47	2.31	1.27	2012	Ca(mg/Lit)
4.71	4.91	5.20	4.54	2012	Cl(mg/Lit)

After selecting the best interpolation method for each parameter, zoning maps for each parameters related to each statistical years were plotted (Figure 2).




Legend
Na (2012)
0 - 5
5 - 7
7 - 9
9<
Well
Km
0 15 30 60
Legend
Na (2002)
0 - 5
5 - 7
7 - 9
9<
Well
Km
0 15 30 60
Legend
mg (2012)
0 - 1.5
1.5 - 1.8
1.8 - 2.1
2.1<
Well
Km
0 15 30 60
Legend
mg (2002)
0 - 1.5
1.5 - 1.8
1.8 - 2.1
2.1<
Well
Km
0 15 30 60
520000 540000 560000 580000 600000 620000
3180000 3150000 3120000 3090000
N

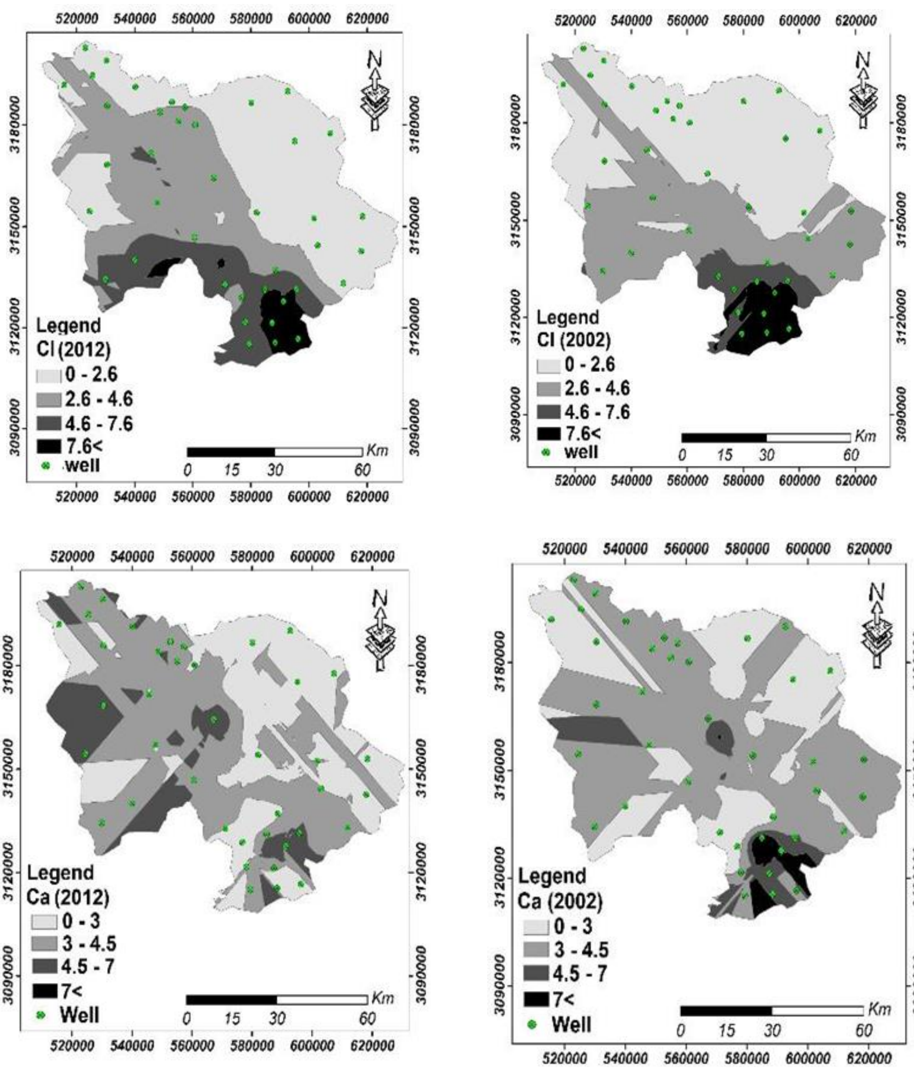


Figure 2. Zoning maps of groundwater quality parameters

4. Discussion and Concluding Remarks

As results of statistical analysis showed most of water quality parameters are characterized with high skewness so were normalized using the logarithmic transformation. This is in line with research conducted in Delhi, India [1] and northwestern Italy [15]. Also it confirms [8], who states that a logarithmic distribution is appropriate for most field studies.This can be attributed to inadequate sample size, or improper distribution. The high variability and environmental factors may affect this index, in turn leads to most environmental parameters do not follow a normal distribution. Between two interpolation methods IDW and kriging, ordinary kriging as the best method based on the criteria of RMSE less for zoning all quality parameters was selected which it is consistent with results obtained by (3-9).

Next maps were prepared so that for various parameters trend was obtained. Water calcium during period 2002-2012 was declined and highest concentration of pollutants were found in southern and western parts.Chlorine in the southern part in 2002 was exceeded the threshold and fall into inappropriate class and had ascending trend over time. Sulfate also has increased over time so that such increases is much obvious from south to west. PH was greatly increased during this period and exacerbated pollution outbreak in entire region.

As for magnesium results showed that this element in the southeastern part exceeded threshold and then it reduced and contaminated western part in 2012. Sodium concentration was risen in this time and pollution trend was much more from west to east.Finally water quality results in the study area suggested that regional water pollution is rising which is much more outstanding in southern part of the region mostly due to geological formations in the area while in northern parts many formations are consisted of sodium and calcium bicarbonate. The latter does not led to significant changes in groundwater quality, but in the South and West parts anhydrite and halite minerals deteriorate groundwater quality. At the same time, due to increased extraction of water in the plains now there is a huge drop in underground water. This in turn could lead to the spread of pollution in the region. Finally it is recommend to adopt comprehensive management to prevent pollution and incurring much more damages on vital resources.

References

Adhikary, P. P., Dash, C. J., Chandrasekharan, H., Rajput, T. B. S. and Dubey, S. K. (2012). Evaluation of groundwater quality for irrigation and drinking using GIS and geostatistics in a peri-urban area of Delhi, India. Arabian Journal of Geosciences, 5(6), 1423-1434.

Ale sheikh, A.A., AbdolghaderiBokani, N. and Hojjat, S.A. (2008). Modeling of ground water contaminations using Geostatistical analysis (case study: Shiraz Town). Eleventh symposium of Iran geology council. Iran Topography Organization. Tehran.

Dagostino, V., Greene, E. A., Passarella, G. and Vurro, M. (1998). Spatial and temporal study of nitrate concentration in groundwater by means of coregionalization. Environmental geology, 36(3), 285-295.

Deepak, S., & Singh, N. U. (2013). Water quality index for Ground Water (GWQI) of Dhar town MP, India. International Research Journal of Environmental Science, 2, 72-77.

Demir, Y., Erşahin, S., Güler, M., Cemek, B., Günal, H. and Arslan, H. (2009). Spatial variability of depth and salinity of groundwater under irrigated ustifluvents in the Middle Black Sea Region of Turkey. Environmental monitoring and assessment, 158(1-4), 279-294.

Dhakad, N. K., Shinde, D. and Choudhary, P. (2008). Water quality index of Ground water (GWQI) of Jhabua Town, MP (India). Journal of Environmental Research And Development Vol, 2(3). 443-446.

Faryabi, M., Kalantari, N&Negarestani., and Negarestani, m. (2010). Evaluation of Factors influencing Groundwater Chemical Quality Using Statistical and Hydrochemical Methods in Jiroft Plain. GEOSCIENCES, Vol77 20(): 115-120.

Freeze, R. A. (1975). A stochastic-conceptual analysis of one-dimensional groundwater flow in nonuniform homogeneous media. Water Resources Research, 11(5), 725-741.

Hooshmand, A., Delghandi, M., Izadi, A. and Ahmad Aali, Kh. (2011) Application of kriging and cokriging in spatial estimation of groundwater quality parameters. African Journal of Agricultural Research, 6(14), 3402-3408.

Hung, I. (2001). Assessment of Kriging Accuracy in the GIS Environment.
Jamshidzadeh, Z., and Mirbagheri, S. A. (2011). Evaluation of groundwater quantity and quality in the Kashan Basin, Central Iran. Desalination, 270(1), 23-30.
Johnston, K., VerHoef, J. M., Krivoruchko, K., & Lucas, N. (2001). Using ArcGIS geostatistical analyst: Esri Redlands.
Mahdavi, M. (2004). Applied Hydrology. Vol. 2, 5th Edition, University of Tehran Press.
Marengo, E., Gennaro, M. C., Robotti, E., Maiocchi, A., Pavese, G., Indaco, A., and Rainero, A. (2008). Statistical analysis of ground water distribution in Alessandria Province (Piedmont—Italy). Microchemical journal, 88(2), 167-177.
Nas, B. (2009). Geostatistical approach to assessment of spatial distribution of groundwater quality. Pol J Environ Stud, 18, 1073-1082.
Nath, V. R., and Helen, H. M. (2013). Evaluation of ground water quality in Neyyattinkara Taluk, Kerala. Journal of Chemical & Pharmaceutical Research,5(4).
Pawar. S., Panaskard, B. and V. M. Wagh. (2014).Characterization of groundwater using water quality index of solapur industrial, (case study:Maharashtra, INDIA). International journal of Research in Engineering & Technology, 2(4), 31_36.
Siska, P. P., & Hung, I. K. (2001). Assessment of kriging accuracy in the GIS environment. In 21st Annual ESRI International Conference, San Diego, CA.
Venkateswaran, S., and Deepa, S. (2015). Assessment of Groundwater Quality using GIS Techniques in Vaniyar Watershed, Ponnaiyar River, Tamil Nadu.Aquatic Procedia, 4, 1283-1290.
Zamzam, A. and Rahmani, M. (2009). Assessment of chemical quality of ground waters using Wilcox and shooler diagrams. first international conference of water resources management.