Bulletin of Environment, Pharmacology and Life Sciences
Bull. Env. Pharmacol. Life Sci., Vol 3 [11] October 2014: 141-145

Online ISSN 2277-1808
Journal's URL:http://www.bepls.com
CODEN: BEPLAD
Global Impact Factor 0.533
Universal Impact Factor 0.9804

ORIGINAL ARTICLE

Spatial assessment of SAR and EC of Groundwater for Agricultural purposes (case study: Dezfoul- Andimeshk Plain)

Fereshteh Zarif[1], Hossein Eslami[2]
1 -Department of Water Engineering, Shoushtar Branch, Islamic Azad University, Shoushtar, Iran
2-Department of Water Engineering, Shoushtar Branch, Islamic Azad University, Shoushtar, Iran
Corresponding Author email: eslamyho@gmail.com

ABSTRACT
In arid and semiarid regions such as Iran, aware of the quality of groundwater can have a very important role in maintaining the stability and sustainability of water resources. Groundwater quality assessment for the management of the agricultural industry with the aim of using these resources in agriculture is important. This paper uses data from a sample of 105 wells in the Dezfoul- Andimeshk Plain for EC and SAR spatial analysis using geostatistical Kriging, Co-kriging and inverse distance weighted method. Results showed cokriging exponential model with the lowest RMSE than other two methods are more accurate and less error. Map prepared by this method represents the SAR increases from the northwest to the south and southeast. Spatial distribution of EC with auxiliary variable of TDS, EC represents an increase from north to south. Most of the classes are C3S1 and therefore groundwater of Dezfoul- Andimeshk Plain, given the necessary measures can be used for agricultural use.
Keywords: *Ground water quality, kriging, EC, SAR*

Received 21.05.2014 Revised 02.07.2014 Accepted 10.09. 2014

Introduction

In many parts of the world due to geographical features and climatic conditions are hot and dry areas of the component. Due to low rainfall in the area, or even the only way to supply water needed for agriculture, groundwater resources are used and if this operation was performed in a variety of extraction from aquifers, so any change in this table, it can affect the way of life of people living in these areas. Thus, the importance of groundwater resources, knowledge resources, has long been of interest. Electrical conductivity is the best indicator of the degree of salinity [1].Low quality water usually contains dissolved salts are plenty of types and Long-term irrigation and irrigated land without observing the principles concerning the use of saline water, leading to the accumulation of salts or sodium causes soil to the root crops and irreparable damage to the soil, plants and the environment enters [2]. Dezfoul-Andimeshk Plain is one of the agricultural centers of Iran and because of the good climate; farming is done all year round. Hence, knowledge of the quality of groundwater resources for agricultural purposes is important. One of the effective methods is to use geostatistical methods to analyze spatial variations of groundwater.

Kresic [3] introduced the kriging interpolation as the best and most powerful tool for groundwater data. Izadi et al. [4] estimated the spatial SAR and groundwater chloride levels of Boukan area using geostatistical methods; they showed that kriging more carefully. Ghafouri et al. [5] conducted a statistical evaluation of the quality of groundwater in the plain of Darab and concluded that kriging is better than other methods, based on kriging, groundwater quality map was prepared in GIS environment. Banezhad et al. [6] conducted a water quality assessment in Razan plains, to supply water needed for agriculture using GIS. The results showed that the study area is divided into three zones based on the quality of groundwater for agriculture were good quality, medium, and poor.

Taghizadeh et al. [7], to determine the spatial variability of groundwater quality in Rafsanjan, interpolation methods of Kriging, Co-kriging and IDW were used and concluded that the preferred method of kriging and cokriging. Wellington and Dominique [8] assess the impact of land use on water quality were examined. D'Agostino et al. [9] using kriging and co-kriging method, spatial and temporal variations of nitrate in groundwater were examined and cokriging was selected as more accurate method to estimate changes in nitrate. The purpose of this study was to evaluate the groundwater quality of Dezfoul- Andimeshk Plain on EC and SAR and to identify areas suitable for agriculture.

MATERIAL AND METHODS

Dezfoul- Andimeshk Plain as the largest plains in the northern province of Khuzestan, Iran is located. The fields with an area of over 2,070 square kilometers include between latitudes 32° 2' to 32° 36' East and Longitude 48° 9' to 48° 47' North is located. The plain is divided into three categories in terms of topography, mountainous area, hilly area, plain area. The mountainous area that includes the area of north and northeast, plain zone at the beginning of an extensive and fertile plain of Khuzestan is located. In terms of Climate; study area is part of the tropics, where the winters are dry and hot summers. Average annual rainfall is 400 mm rainfall, mean temperature of 3 ° C in winter and 49 degrees Celsius in summer. Hottest and coldest months are January and July respectively.

Measured samples of ground water resources, including qualitative characteristics of the samples studied and appropriate distribution was chosen. According to the 105 wells sampled (for 2013 measurement) a good distribution in the study area were selected.

Indicators of water quality

EC is measured with the use of electrical conductivity meter. Unit of measure EC is Siemens/ cm or mhos/cm. SAR rate is calculated using the following formula where the concentrations are expressed in terms of mEq per liter [10]:

$$SAR = \frac{Na^{+}}{\sqrt{\frac{Ca^{++} + Mg^{++}}{2}}}$$

Interpolation methods

IDW

IDW assumes that the samples are clearly a more closely than more distant samples are similar. To predict areas not measured, IDW method uses the values of the predicted position. Measured values closest to the prediction location have greater impact on predicted values than those further away.IDW method is therefore assumed that each measured point has a local effect on the predicted decreases with increasing distance. Where the position is expected to close a more than the greater distance and weight. Hence, this method is called inverse distance weighting method and the general formula is as follows:

$Z(S_0) = \sum_{i=0}^{N} \lambda i. z(si)$

$Z(S_0)$ is observed values in S_0; $Z(S_i)$ is estimated values in S_i, λi: Weights assigned to each measurement point, and the weight is reduced with distance. N: The number of measurement points around the area that is expected to be used in the estimation.

Kriging

It is a local and random estimation method for estimating the value of unsampled points that used the values of sampled areas. Variogram in kriging is essential key and In fact, it is the spatial correlation between two points, but it is assumed that the value of a variable is within closer distance of most similar and the correlation decreases with increasing distance. The general equation of kriging to estimate values of a variable can be expressed as follows:

$Z(S0) = \sum_{i=0}^{N} \lambda i. Z(si)$

λi in the formula is a set of weights which are chosen so as to $Z(S_0)$ is an unbiased estimate with minimum error of $Z(S_0)$.

Cokriging

Cokriging uses the data of types of variables. The main variable is z1 and z1 autocorrelation and mutual correlation between z1 and the other variables used to predict better. Using data from other variables to help predict is fascinating but the associated cost. Cokriging has Need more estimates as autocorrelation estimates for each variable as well as the bilateral correlation between the variables. Models cokriging is as follows:

$Z1(S) = \mu 1 + \varepsilon 1(S)$

$Z2(S) = \mu 2 + \varepsilon 2(S)$

Ordinary cokriging attempt to predict the Z1 (S0) but it use data of Z2 (S) to better predict uses.

The best interpolation method selection

To choose the best interpolation method to convert point data to regional data, Cross-Validation technique is used. In this method in every stage, one observing point is omitted and with rest of observing point, that point will estimated. For estimating carefulness RMSE criteria are used that consist of:

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}\left[Z^*(xi) - Z(xi)\right]^2}{n}}$$

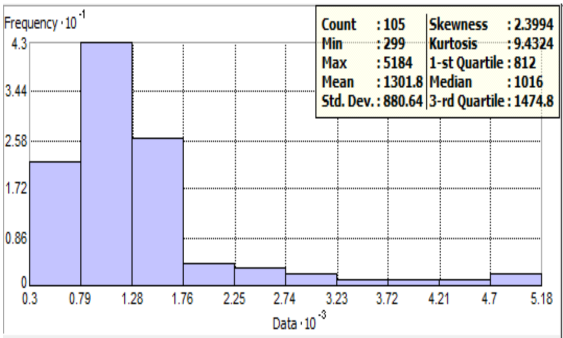
RMSE: Root Mean Squared Error, Z*(Xi): The estimated values, Z (Xi): The observed values, n: The number of observed samples.

RESULTS

In this study, three methods of interpolation kriging, cokriging and inverse distance weighted for spatial analysis of SAR and EC variables were evaluated. In order to study of spatial correlation and structure of EC and SAR variables using GIS software, variograms of the data were analyzed. According to the data in Table 1 and plotted the histogram, it is clear that both EC and SAR variables with high skewness and non-normal data. Next, in order to normalize the data, a logarithmic function is used.

Table 1 - Descriptive statistics of variables

Variable	Min	Max	Mean	Standard deviation	Coefficient of variations	Med	Skewness	Kurtosis
EC(µmhos/cm)	299	5184	1301	880.6	0.676	1016	2.39	9.4
SAR(mmol/l)0.5	0.28	7.16	1.86	1.409	0.758	1.45	1.93	6.8



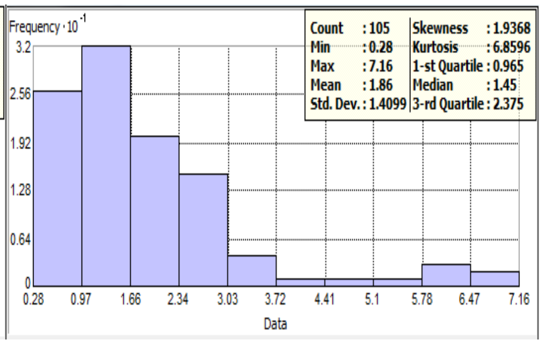


Figure 1- Frequency Histogram of Ec Figure 2- Frequency Histogram of SAR

According to Table 2 summarizes the results of interpolation for the variables EC and SAR groundwater using three methods of geostatistical kriging and cokriging and IDW indicate that cokrigings exponential model with the lowest RMSE, as a method of more accurate than kriging and IDW method is selected.

Table 2 - Results of the evaluation of interpolation methods for mapping groundwater quality parameters

Interpolation method	Kriging	Cokriging	IDW			
			Power 1	Power 2	Power 3	Power 4
Assessment criteria	RMSE	RMSE	RMSE	RMSE	RMSE	RMSE
EC	741.7	597.6	770.58	818.05	877.3	924.1
SAR	1.223	0.893	1.24	1.28	1.35	1.41

Nugget effect than the sill (C0/C0+C) is an indicator of the strength of the spatial variables. If this ratio is less than 0.25, which is indicative of strong spatial correlations and if this ratio is between 0.25 - 0.75 moderate spatial dependence can be represented as the ratio greater than 0.75 would be indicative of a weak spatial dependence [11]. According Table (3), Nugget effect than the sill is zero. That shows a strong dependence on the spatial variable. Variogram models fitted to the experimental data showed that the exponential model fit (Table 3). Figs 3 and 4 show the variogram exponential variables.

Table 3 - Results of the geostatistical analysis of water quality parameters in cokriging

Variable	Model	Nugget (C0)	Sill (C0+C)	Range (m)	C0/C0+C	Spatial correlation
EC	Exponential	0	0.2639	21207	0	strong
SAR	Exponential	0	0.4131	22862	0	strong

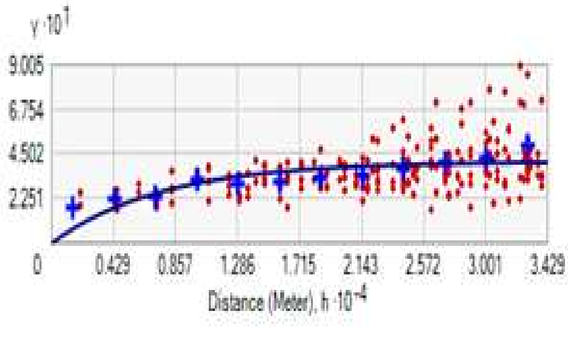


Figure 3- Variogram of SAR

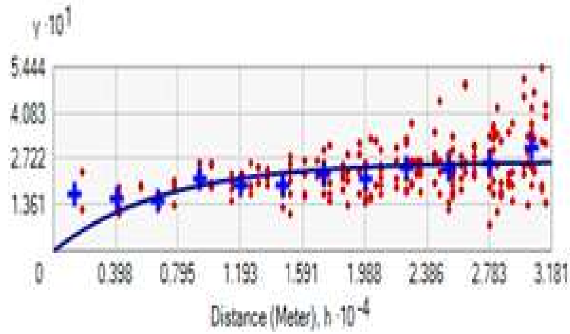


Figure 4- Variogram of EC

Auxiliary variable used for cokriging interpolation method. To select the auxiliary variables, each variable has a higher correlation with the original variables is selected. Mg variable having the highest correlation (R = 0.96) with the SAR as an auxiliary variable is selected. TDS as well as the variable having the highest correlation (R = 0.98) were considered as auxiliary to the EC.

SPATIAL DISTRIBUTION MAPS OF EC AND SAR

Using the spatial distribution of SAR map prepared by cokriging, the SAR value indicates increasing trend from the northwest to the south and southeast of Dezful- Andimeshk plain. The spatial distribution of EC represents an increase from north to south.

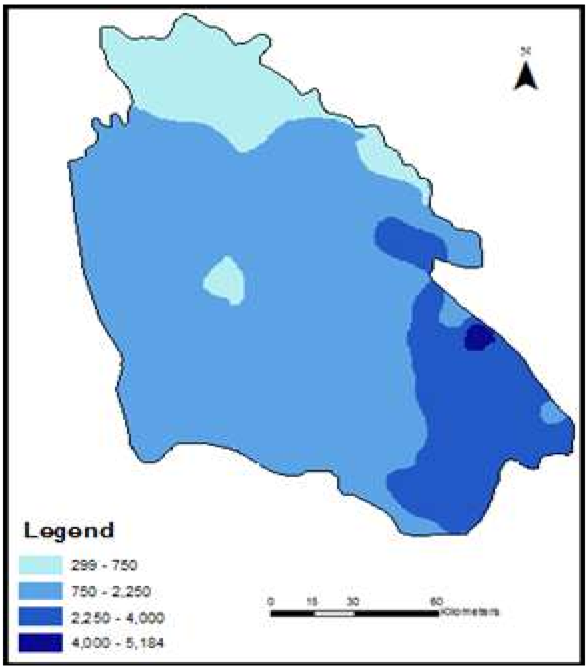


Figure 6- Zoning map of EC (mmhos/cm)

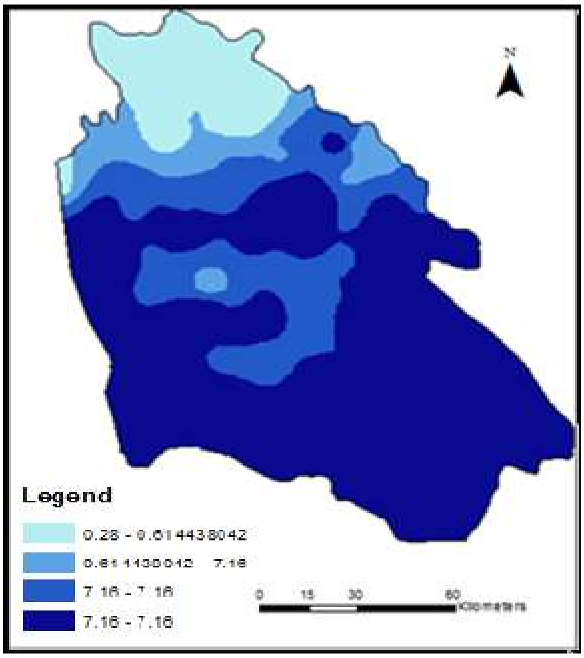


Figure 7- Zoning map of SAR $(mmol/l)^{0.5}$

According to the result of spatial distribution of SAR values, it ranges 0.28 to 7.16. Evaluation, analysis and classification of water quality variables and parameters suitability for agriculture is done according to the classification wilcox diagram (Table 4). The water quality has been divided into 12 different categories that best C1S1 and C4S4 is most inappropriate for agricultural use. Table (4) shows all fields are placed in the class S1 and more areas of Plain are placed in class C3.

Table 4 - Criteria for the classification of agricultural water from Wilcox

class	Sodium absorption ratio)SAR(	class	Electrical conductivity(EC)	Water Quality
S1	SAR<10	C1	EC<250	excellent
S2	10<SAR<18	C2	250<EC<750	good
S3	18<SAR<26	C3	750<EC<2250	medium
S4	SAR>26	C4	2250<EC	Inappropriate

CONCLUSION

Cokriging exponential model with the lowest RMSE and Nugget effect than the sill of zero as a method with higher accuracy and lower error rate in comparison kriging and IDW was selected and in order to study the spatial analysis of EC and SAR for Dezfoul- Andimeshk was used. The spatial distribution of SAR can be incremented value northwest to the south and southeast, which the SAR concluded that the most area is placed in the class S1.The spatial distribution of the EC represents an increase from the north to the south of the study area. The result is more of C3S1 class, the quality of groundwater at Dezfoul-Andimeshk for agricultural use by taking appropriate measures to be assessed. Ghomshion et al. [12], Evaluate the groundwater quality in Semnan – Sorkheh Plain using cokrigings. Rezai et al. [13], changes in groundwater quality in the study area of Gilanby means of the cokriging examined. Adhikary et al. [14], Merango et al. [15], Nas[16], chose the kriging method due to lower error rate and higher accuracy.

REFERENCES

1. Alizadeh, A. (2002).Principles of Applied Hydrology. Imam Reza (AS) press.
2. Hadas,A.H. & Frenkel, H. (1982).Infiltration as affected by long-term use of sodic-saline water for irrigation.Soilsic.soc.Amer.J.46(3):524-530.
3. Kresic, N. (1997).Hydrogeology and groundwater modeling. Lewis Publishers.35 pp.
4. Izadi, A., Hooshmand, A., Delghandi, M. & Ferasati, M. (2011). Estimates place the sodium adsorption ratio (SAR) and Ground Water Chlorine in Boukan region using geostatistical methods. Irrigation Engineering Sciences (the Journal of Agricultural Science), Volume 34, Number 2.
5. Ghafouri, v.,Malekpour, N. & Mardani, A. (2011). Assessment of groundwater quality of Darab Plain of Fars province by geostatistics.Journal of Soil Water Conservation, First Year, Issue 2.
6. Banezhad,H. & Mohebzadeh, H. (2011). Evaluation of Groundwater Quality in Plain Razan - Ghaharvand to supply water needed for agriculture using GIS. Quarterly - scientific research geographical space, year XII, No. 38, University of Ahar, pp. 110-99.
7. Taghizadeh, R.F.,Zare'ian,M.,Mahmoudi,Sh.,Heidari,A. & Sarmadian, F. (2008). Evaluation of spatial interpolation methods for determining spatial changes in groundwater quality, Rafsanjan plain. Iran Watershed Science and Engineering, Volume 2, Issue 5, pp. 941-932.
8. Wellington R.L, Masamba, Dominic Mazvimavi. (2008), "Impact on water quality of land uses along Thamalak-ane-Boteti River: An outlet of the Ok-avango Delta". Physics and Chemistry of the Earth, 33, 687–694.
9. D'Agostino,V., Greene, E.A., Passarella, G., & Vurro, M. (1998). Spatial and temporal study of co regionalization.Environmental geology, 36, 285-295.
10. Srinivasamoorthy, K., Gopinath, M., Chidambaram, S., Vasanthavigar, M. & Sarma, V. (2013). "Hydrochemical characterization and quality appraisal of groundwater from Pungar sub basin, Tamilnadu, India". Journal of King Saud University, in press.
11. Cambardella C. A., Moorman T. B., Novak J. M., Parkin T. B., Karlen D. L., Turco R. F., & Koropaka, A. E. (1994). Field-scale variabilityof soil properties in central Iowa soils. Soil Sci. Soc. Am. J. 58, 1501-1511.
12. Ghomshion, M.,Malekian,A., Hosseini,Kh.,Gharahchelo, S. & Khamoushi, M. (2011). Evaluation of ground Water Quality Changes in Semnan – Sorkheh Plain using geostatistics. Quarterly - scientific research of Range and deserts of Iran, Volume 19, No 3, pp. 535-545.
13. Rezaei, M., Davatgar, N., Tajdari,Kh. & Abolpour, B. (2010). Investigate the spatial variations of some indicators of the quality of groundwater of Gilanprovince using geostatistics. Soil and Water Journal, Volume 24, No 5, pp. 941-932.
14. Adhikary, P.P., Dash, Ch.J., chandrasekharan, H., Rajput, T.B.S & Dubey, S.k. (2011). Evaluotion of ground Water quality for irrigation and drinking using GIS and geostatistics in a peri-urban area of Delhi, India. Saudi society for Geosciences.
15. Marengo, E., Gennaro, M.C., Robotti, E., Maiocchi, A.,Pavese, G., Indaco, A. & Rainero, A. (2008). Statistical analysis of ground water distribution in Alessandria Province (piedmont-Italy). Micro chemical journal, 88, 167-17.
16. Nas, B. (2009). Geostatistical Approach to Assessment of Spatial Distribution of Ground water Quality. polish j. of Environ. Stud.vol.18,No 6,1073-1082.

CITATION OF THIS ARTICLE

Fereshteh Z, Hossein E.Spatial assessment of SAR and EC of Groundwater for Agricultural purposes (case study: Dezfoul- Andimeshk Plain). Bull. Env. Pharmacol. Life Sci., Vol 3 [11] October 2014: 141-145