Evaluation of Soil Salinity Variations by Using Kriging Method: A Case Study

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Abstract: Soil salinity is one of the causes of soil degradation in the world. The soil salinity occurs due to various reasons including saline formations, poor quality of accessible water resources, chemical pollution, inaccurate agriculture etc. Iran is also among the main countries faced with the soil salinity. The research has been done in Yazd's area in order to examination of soil's salinity (electricity transfer) with exploitation of geostatistical procedure. Geostatistical factors are used by Kriching. The 150 points have been done in order to determination of amount of electricity transfer in horizontal and vertical state by electromagnetic inductor device. Based on the obtained results, the marginal parts of the study area are more salty and with getting closer to the center the salinity decreases. Rocky heights are one of the reasons for the soil salinity decline in this part. Due to the increasing salinity zones, it is recommended to apply the preventive measures as soon as possible in this area..
[Asghari A, Shojaei S, Khosropur M. **Evaluation of Soil Salinity Variations by Using Kriging Method: A Case Study.** *Stem Cell* 2017;8(1):26-29]. ISSN: 1945-4570 (print); ISSN: 1945-4732 (online). http://www.sciencepub.net/stem. 6. doi:10.7537/marsscj080117.06.

Keywords: Geostatistical, Kriching, Salinity, Soil degradation.

1. Introduction

Extension of soil's salinity is an important issue in most of countries. Salination rate of land in some countries such as Iran, Egypt and Argentina is 30% more than other countries and among of 19 million hectare of agriculture land in Iran almost 50% have salinity and sodium problem (Daempanah et al., 2011). Of 6.8 million hectares those are suffered to different degrees of salinity, 4.3 million hectaredon not have other limitations except of salinity (Moameni, 2011).

Undoubtedly, one of the main goals of this research is saving time and cost, while taking into account the accuracy of prepared maps. There are various methods and techniques for modeling soil parameters (such as salinity) and obtaining without information points which among these methods and techniques the regression simple estimators till the advanced non-linear regression methods (Mckenzie and Ryan, 1997) the geostatistical estimators (Navarro-Pedreno et al., 2007) can be mentioned. Study of the resources showed that the Kriging utilizing as a geostatistical estimator can be effective in the identification and monitoring of areas affected by the salinity. But in some of the researches which have used the kriging method, the estimation accuracy was low (Jordan et al., 2004). In the regression models, which are considered as another estimating method, the spatial dependency of the parameters are not considered (Lopez-Granados et al., 2005). In the co-kriging method or other estimation methods such as regression - kriging, which are in fact a subset of the geostatistical methods, the spatial correlation of the objective and secondary parameters is also considered. Therefore, many sources have suggested using the Kriging methods in order to prepare the salinity maps (Bishop and McBratney, 2001). Pozdnyakova and Renduo (1999) research can be mentioned as an example of these researches which they studied the salinity of some soils in California. In this study, isotropic variogram and the impact radius of 700 meters were concluded. Also, in the co-kriging method to modify the estimates of sodium adsorption ratio, the electrical conductivity variable was used as auxiliary data. In Algeria, Walter et al, (2001) were prepared the salinity maps by using the kriging method. In this study, degree of the salinity was separated from low to very high. In this regard, structural ground conditions, topography changes, water quality and type of use, had a great influence on the spatial correlation which its result was the impact radius of 4000-meter. Ardahantiglu et al, (2003) studied the spatial variations of exchangeable sodium percentage, electrical conductivity, acidity and the amount of boron in the saline soils in Iğdır plain in Turkey. To conduct this study, logics with an area of 1000 meters by 1000 meters at depths of 0-30, 30-60 and 60-90 cm with 100 meters distance were sampling. The semivariogram analysis showed that there are similarities in patterns of the spatial variability of

exchangeable sodium percentage, electrical conductivity and the amounts of soils boron.

Nowadays, researches are trying to monitor saline area by using different methods to recognize and mapping from this type of soil. In a same research, Taghizadeh-Mehrjardi et al [3], have done a numeral ability of electric transfer by using Kriging regression model in Ardakan area.

The purpose of this study is to prepare the soil salinity map in Sistan region. First, accuracy of the salinity estimation would be measured by using Kriging, Co-Kriging, inverse distance and regression kriging methods; finally, the salinity map of the area would be extracted by choosing the best geostatistics method.

2. Materials and Methods

The study has been done in Yazd city (figure 1).

Fig 1. Location of the study area

To proper sampling of studied area, at the first 150 count have been read state by using electromagnetic inductor device. Then the points have been covered to attach layers by using usual Kriging with local variogram. The samples were dried in open space and sieved (by 2mm sieve) before transferring to laboratory (shojaei, 2014).

Kriging

In which, Z*(xi): approximate term,λ_i: weight or quantity importance depend on i sample and z(x_i): are amount of measured variable [6].

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

Assessment models

Assessment models of geostatistical models' methods.

$$\mathrm{RMSE} = \left[\frac{\sum(\mathrm{X_0} - \mathrm{X_e})^2}{\mathrm{n}}\right]^{1/2}$$

$$\mathrm{R^2} = \left[\frac{\sum((\mathrm{X_e} - \overline{\mathrm{X}}_\mathrm{e})(\mathrm{X_0} - \overline{\mathrm{X}}_0))}{\sqrt{\sum((\mathrm{X_e} - \overline{\mathrm{X}}_\mathrm{e})^2(\mathrm{X_0} - \overline{\mathrm{X}}_0)^2)}}\right]^2$$

$$\mathrm{ME} = \frac{1}{\mathrm{n}}\sum_{\mathrm{i=1}}^{\mathrm{n}}(\mathrm{X_0} - \mathrm{X_e})$$

Results

The values of electrical conductivity are shown in Table 1. Based on the results, the mean of electrical conductivity at a depth of 0-30 cm is equal to 14.20 dS/m which its minimum is 4.11 and its maximum is 30.02 dS/m.

Table 1: The statistical summary of the electrical conductivity values (dS/m) in 9 standard depths and the apparent electrical conductivity values

coefficient of variation	standard deviation	mean	maximum	minimum	depth
53.23	4.6	14.20	30.02	4.11	0-30

In this study, kriging with spherical model was used and the roots of error square and error mean of the soil salinity are shown in Table 2. The results show

Table 2: The results of the evaluation criteria of the kriging model to predict the capability of electrical conductivity in 9 standard depths (dS/m)

Total square error	error mean	depth
6.8	-0.24	**0-30**

Soil salinity map of the study area at a depth of 0-30 cm was prepared by kriging method (Figure 2). According to the figures, the salinity is more severe in the margins and with getting away from the margins the salinity decreases.

Rainfall less than 60 mm per year, dry climate, fine-grained soils, the significant reduction of the region vegetation due to the salinity spread and the abandoning large parts of agricultural lands can be mentioned as the reasons for the spread of salinity, especially in the dry seasons, in Yazd region (Zolfaghari, 2010).

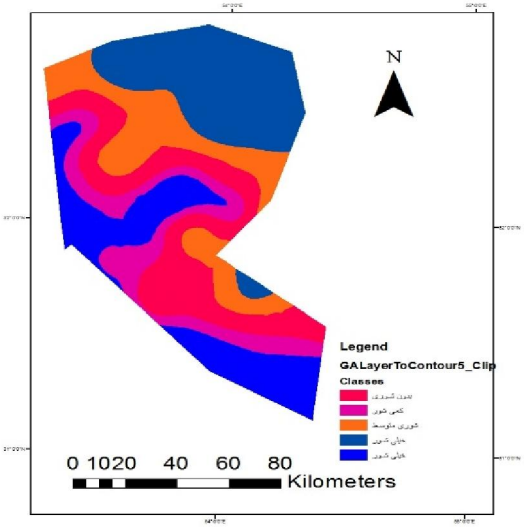

Figure 2: Maps of the capability of electrical conductivity by using the kriging model

Discussion

According to obtained results from different depths of the salinity (table 1) it can be concluded that data have many changes in domain of salinity, indicating that data are un-uniform (Shakouri et al., 2011: Nasiri et al. 2016).

In South East of Spain, Navarro-Pedreno et al (2007) studied the spatial variability of soil salinity using the geostatistics methods. In the southern part of the study area, higher salinity values were observed. In another study, Yan et al (2007) studied the spatial variability of soil salinity in a 10-hectare farm. Due to the differences in management operations and non-uniform hilliness of the farm surface, the coefficient of variation had higher value and differences of the salinity values were apparent over short distances.

In a similar study Taghizadeh-Mehrjardi et al (2014) conducted the digital zoning of the apparent electrical conductivity capability by using regression kriging and local variogram in Ardakan region. The results showed the high efficiency of the regression kriging model with the local variogram, so that the regression kriging model has reduced the percentage of prediction error in a horizontal position 21% and 28% compared to the co-kriging and kriging, respectively.

Acknowledgments

Thank Zahedan University very sincerely for the research laboratory and related equipments they have prepared for us.

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3/9/2017