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Comparing Interpolation Methods for Estimating Spatial Distribution of Topsoil pH and EC (Case Study: Karimabad Rangelands, Hamadan Province, Iran)

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ABSTRACT Soil alkalinity and salinity are serious problems in arid and semi-arid regions, and therefore monitoring of soil pH and electrical conductivity (EC) is necessary in any region. The present study aimed to properly interpolate soil pH and EC as soil quality indices in a semi-arid mountainous area with annual precipitation of 342.4 mm. The study area is the Karimabad rangelands in Hamadan Province, western Iran. A total of 266 composite soil samples were collected from 0-25 cm soil depth in a systematic random design. Soil samples were processed for pH and EC analysis and then further used for interpolating based on the optimal interpolation method for the study area. The overall soil pH and EC ranged from 7.3-7.9 and 0.33-2.13 dS m^{-1}, respectively, presenting the slightly alkalinity and salinity problem in the region. The results showed the accuracy of spatial prediction of interpolation methods, particularly inverse distance weighting and radius basis function. However, based on root mean square error, the radius basis function was the most appropriate interpolation method to predict spatial distribution of soil pH and EC of topsoil in the study area. While salinity and alkalinity were low, still monitoring these soil indices is highly recommended to prevent the salinization and alkalization in the study area.

Key words: *Geostatistic, Radial basis function, Salinity, Soil alkalinity, Spatial variability*

1 INTRODUCTION

Salt and sodium accumulation in soil surface and hence desertification and land degradation are problems that the world facing today (Allbed and Kumar, 2013). Whether salinization and sodicity are natural or human made phenomena in an area, the result is the same, suppressing land capability. Salinization and sodicity could disperse soil particles, accelerating erosion (Farifte *et al.*, 2005). While over 20 percent of terrestrial lands are damaging due to salinization and sodicity, some countries like Argentina, Iran, and Egypt are struggling much more, almost 30 percent,

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compare to other countries (Ghassemi *et al.*, 1995). From 165 million hectares land area, 44.5 million hectares are experiencing salinity and sodicity in Iran (Banaei *et al.*, 2004). Furthermore, considering FAO guideline for soil description (2006), Iran suffers from salinity problem and exposes to further salinization. Therfore, monitoring these soil properties should be considered as a priority in Iran, as the most significant threats to the soils are (Qadir *et al.*, 2008). Moreover, as water shortage is a real concern in Iran, drought events plus salinization and alkalization could accelerate soil degradation leading to desertification of the lands. These emerge the necessity of monitoring soil alkalinity and electrical conductivity (EC) in the country. Land assessment is crucial to sustainable management of land resources (Qadir *et al.*, 2008).

However, monitoring soil properties is always time consuming and costly, particularly in large area (Goovaerts, 1998; Allbed and Kumar, 2013); and therefore, interpolating and mapping the soil parameters are new requirements (e.g., Kazemi Poshmasari *et al.*, 2012; Asadzadeh *et al.*, 2012; Cruz-Cardenas *et al.*, 2014). Mapping soil properties not only enhances the understanding of the spatial and temporal variability (Simakova, 2011), but also decreases the cost and time of excessive soil sampling. To estimate and interpolate soil properties, geostatistical and geomathematical concept and theory is often used in large-scale studies (Cruz-Cardenas *et al.*, 2014; Ding and Danlin, 2014). Interpolation and geostatistical analysis reveals the pattern of spatial soil properties, improving ecosystems managements (Bijanzadeh *et al.*, 2014).

Geostatistic and geomathematics models regional variables by using spatial statistics. It could simplify heterogeneity and complexity inherent in natural ecosystems, consequently orientate the values of the samples (e.g., soil sample) in the ecosystems (Goovaerts, 1998) and provide continuous spatial data based on point sampling (Li and Heap, 2014). So, geomathematic and geostatistic can be used to map spatial distribution of soil properties (e.g. pH and EC) to recognize the critical areas. In fact, it can feature the pattern of soil pH and EC distribution, providing a quantitative map with a minimum variance (Krasilnikov *et al.*, 2008).

During the past two decades, interpolation algorithms have drawn much attention for their direct implementation, financial benefits, and estimation of unsampled locations in the study area (Robinson and Metternicht, 2006; Krasilnikov *et al.*, 2008; Asadzadeh *et al.*, 2012; Kazemi Poshmasari *et al.*, 2012; Yao *et al.*, 2013; Bijanzadeh *et al.*, 2014; Li and Heap, 2014). However, the effectiveness of each estimation and interpolation method depends on its accuracy in each area and consequently the spatial pattern and soil attribute correlation (Zhu *et al.*, 2004; Li and Heap, 2014). Different interpolation algorithms may apply to choose the optimal interpolation method for a study area. Robinson and Mehemicht (2006) found the geostatistical and interpolation methods most suitable to map the continuous soil parameters. Yao *et al.*, (2013) suggested sequential Gaussian co-simulation (SGCS) algorithm to properly model local uncertainly on geostatistical simulation of soil salinity. Kriging-based estimators are suggested as appropriate interpolators to provide accurate and unbiased linear estimation of spatial soil properties (Laslett *et al.*, 1987; Kravchenko and Bullock, 1999; Bucence and Zimback, 2003; Yao *et al.*, 2013). However, ordinary kriging method is useful only when a normal dataset of soil properties is available (Juang *et al.*, 2001). Furthermore, optimal estimation procedures like kriging methods minimize the estimation variance and local spatial variability that is not always favorable to management decisions. Interpolation techniques may provide similar (Zare-Mehrjardi, 2010) or even more accurate (Castrignano and Buttafuoco, 2004) variable estimation compare to kriging methods. Therefore, a proper geostatistical simulation algorithm to produce an accurate continuous spatial data depends on different factors such as soil heterogeneity and sampling intensity and distribution in a specific area (Su *et al.*, 2004). In summary, different geostatistical and interpolation methods should evaluate to determine the most accurate method to interpolate site-specific soil properties such as soil pH and EC. Interpolation techniques are classified to deterministic and stochastic interpolators. The former includes inverse distance weighting (IDW), global polynomial (GP), local polynomial (LP), radius basis functions (RBF) interpolates from mathematical formulas but the other uses probability models. Three most common interpolation methods are ordinary kriging (OK), IDW and RBF techniques to generate prediction maps of environmental variables (Nalder *et al.*, 1998). This research aims to evaluate the efficiency of interpolation techniques to interpolate soil pH and EC in the Karimabad rangelands. Soil pH and EC dataset were employed to test different deterministic interpolation techniques; including IDW, GP, LP, and RBF for soil pH and EC mapping in semi-arid mountain area in western Iran, Hamadan Province.

2 MATERIALS AND METHODS

2.1 Site Description

The study area, Karimabad rangelands, is almost 5780 ha, located in the Hamadan Province, west of Iran (48˚ 48´ - 49˚ 00´ E and 34˚ 34´ - 34˚ 38´ N) with the altitude range of 1640 to 2222.86 m and the average annual precipitation of 342.4 mm. The soil texture is mainly loam and sandy clay loam. As it is a part of a quaternary alluvial, the infiltration rate and soil depth is suitable for cultivation. Different types of erosion affecting the study area are described as rill erosion west and northwest areas), sheet erosion (central, northeast, and east areas), and stream channel erosion (central part), Considering the physiography of the region, the northwest and west areas are mainly high hills features, covering with rangeland ecosystem. East and northeast are plateaux and upper terraces features under the crop cultivation practices. South areas is steep mountain features dominated by semi-steppe rangeland. The central part is also plateaux and upper terraces features with no cultivation practices (Karimabad Physiography Report, 2010). Figure 1 show the location of the study area in Iran and Hamadan Province and sampling points as determined by global positioning system (GPS) receiver (Garmin Nüvi. 7xx model).

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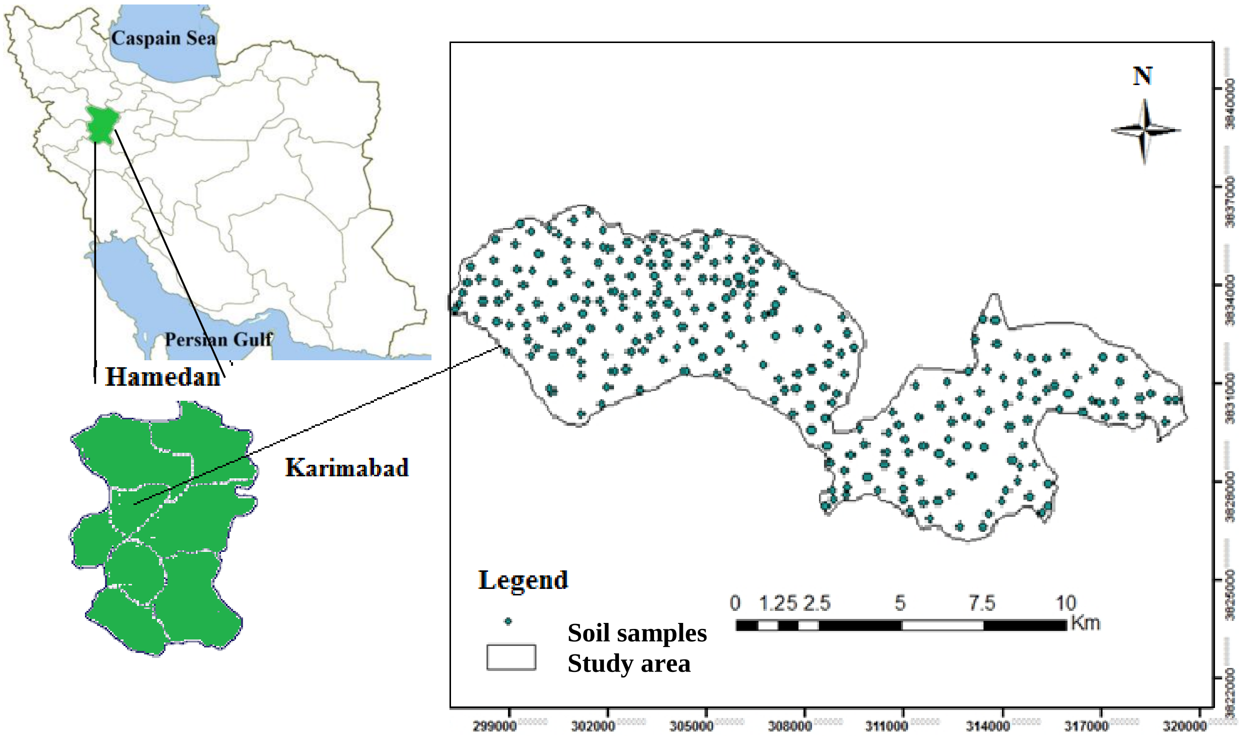

Figure 1 General location of the study area and spatial pattern of sampeling points

2.2 Soil Analysis

In order to classify and map the soil properties, land unit (LU) map based on physiographical features was obtained from Natural Resources and Watershed Management Office of Hamadan Province. To assess soil surface alkalinity and electrical conductivity, 266 composite soil samples (consisted of 2 soil samples per LU) were collected from 0-25 cm soil depth in summer 2012 and air-dried for a week to proceed for further analysis in the laboratory. The air-dried samples were passed through 2-mm sieves, and then, soil acidity/alkalinity (pH) and EC were measured in a 1:1 mixture of soil: water (Sparks *et al.*, 1996) using pH meter (Sartorius PP-15, USA) and EC meter (Mettler toledo, Switzerland), respectively.

2.3 Spatial Prediction Method

Geostatistic methods, not interpolation techniques, need to meet the normality assumption (Esri, 2001). Therefore, prior to any interpolation, the normality of both soil pH and EC values were tested using Kolomogorov-Smirnov test. In addition, any correlation between soil EC and pH was also explored using Pearson correlation test in SAS v.9.1 software package. ESRI ArcGIS v.9.3 was used for interpolating soil pH and EC.

2.4 Inverse Distance Weighting (IDW)

Simply, IDW interpolation assumptions suggest that the closer a sampled point is to the predicted cell, the higher weight it takes in cell's value calculation procedure (Bilgili, 2013). Therefore, unmeasured points' values are determined by the measured values surrounding the desired point. The interpolating procedure was done based on Eqs. 1 and 2 as following:

$$Z(S_0) = \sum_{i=1}^{N} \lambda_i Z(S_i) \quad (1)$$

$$\lambda_i = d_{i0}^{-P} / \sum_{i=1}^{N} d_{i0}^{-P}, \ \sum_{i=1}^{N} \lambda_i = 1 \quad (2)$$

where $Z(S_0)$ was predicted value at S_0 position, $Z(S_i)$ was the value at S_i, N was total number of interpolation points, λ_i was assigned weights to measured points, d was the distance between predicted and measured points (Pierce and Clay, 2007). Considering the adjustable nature of the distance order (1, 2, 3, etc.), IDW consider a flexible method.

2.5 Global Polynomial (GP)

The GP interpolation method mainly captures the coarse-scale trends in the area of interest (Pierce and Clay, 2007). The GP method is a quick but less accurate interpolation technique; however, it is recommended for the variables with smooth fluctuation (Steinberg and Steinberg, 2015). As soil pH and EC values in the study area fluctuated gradually, the global polynomial was also applied in data mapping. GP technique fits a smooth surface based on mathematical function in different orders (1, 2, 3, etc.).

2.6 Local Polynomial (LP)

Local polynomial interpolation method (suggested for fine-scale studies) is a moving average procedure; somehow, integrating with global polynomial method (Schuam, 2008). Despite the GP method, it uses data with localized window not the global. It determines unmeasured points by fitting polynomials within specified overlapping neighborhoods. LP technique fits different specified order (0, 1, 2, 3, etc.).

2.7 Radial Basis Functions (RBF)

The RBF method is a series of accurate interpolation methods, using classic equation based on the distance from the origin or between interpolated and measured points (Aguilar *et al.*, 2005), minimizing the curvature of the surface area. RBF predicted value is expressed as sum of the two following components of (Eqs. 3 and 4):

$$Z(x) = \sum_{i=1}^{m} af_i(x) + \sum_{j=1}^{n} b\psi(d_i) \qquad (3)$$

Where $\psi(d_i)$ was radial basis function, d_i was the between measured and interpolated (x) points, f_i(x) showed trend function, *a* and *b* were coefficients calculating based on the resolution of *n* + *m* linear function (as described below):

$$(x_k) = \sum_{i=1}^{m} a_i f_i(x_k) + \sum_{j=1}^{n} b_j \psi(d_{jk}) \text{ for } k = 1, 2, 3, \ldots, n$$
$$(x_k) = \sum_{j=1}^{n} b_j f_k(x_j) = 0 \text{ for } k=1,2,3,\ldots,m \qquad (4)$$

Five different functions; including, completely regularized spline (CRS), spline with tension (ST), thin-plate spline (TPS), multi-quadratic function (MQ), and inverse multi-quadratic function (IMQ) were evaluated in this research as follows based of (Eqs. 5 to 9):

$$\text{CRS: } \psi(d_i) = ln(\frac{cd}{2})^2 + E_1(cd)^2 + \gamma \qquad (5)$$

$$\text{ST: } \psi(d_i) = \ln(\frac{cd}{2}) + I_0(cd) + \gamma \qquad (6)$$

$$\text{TPS: } \psi(d_i) = c^2 d^2 \ln(cd) \qquad (7)$$

$$\text{MQ: } \psi(d_i) = \sqrt{d^2 + c^2} \qquad (8)$$

$$\text{IMQ: } \psi(d_i) = \sqrt{d^2 + c^2}^2 \qquad (9)$$

d presents distance between measured and interpolated points, *c* was a smoothing factor, *r* was Euler’s constant, I_0 was the modified Bessel function.

2.8 Comparison of interpolation method

Cross validation and validation based on independent dataset are frequently methods used to compare different interpolation methods. Due to the small sample size, cross validation method was used in this research. The method consists of removing a sample point and using the remaining sample points to interpolate the value of it, comparing with the measured value (Mueller *et al.*, 2004). Here, both mean error (ME) and root mean square error (RMSE) of measured and interpolated values were used to test the accuracy of the interpolations as following (Eqs. 10 and 11):

$$MRE = \frac{1}{n}\sum_{i=1}^{n}\left(\hat{Z}(x_i) - Z\,(x)\right) \quad (10)$$

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}[\hat{Z}(x_i) - Z(x)]^2} \quad (11)$$

Where $Z\,(x_i)$ was the measured value for location *I*, $\hat{Z}\,(x_i)$ was the interpolated value for location *i*, *n* is the sample size. The lower RMSE and ME values showed higher accuracy in the interpolation method (Webster and Oliver, 2001).

3 RESULTS

The average of soil pH was about 7.74 with the minimum and maximum amount of 7.40 and 7.90, respectively, suggesting neutral soil in the region (Table 1). Considering the coefficient of variation of soil pH (1.96%) in the study area, the area could be classified in very low variability class based on Warrick (1998) spatial variability classification. As a soil quality indicator, soil EC ranged from 0.40 to 1.90 with the average of 0.84 and the coefficient of variation about 32.5% (Table 1) is moderately variable (12<CV<62%) (Warrick and Nielsen, 1980). Since some geostatistical analysis should meet the normality assumption, skewness, kurtosis, and normality test were applied on dataset. The kurtosis and skewness (Table 1) as well as Kolomogorov-Smirnov normality test showed no normal distribution for soil pH and EC ($p < 0.05$), even after data transformations, kriging and co-kriging methods were not applicable on the datasets (Steinberg and Steinberg, 2015). Therefore, the above mentioned interpolation methods viz. Inverse distance weighting, local polynomial, global polynomial and radial basis functions were used to interpolate and map soil pH and EC in the study area. Furthermore, the correlation analysis showed a very weak negative correlation between soil pH and EC in the study area (Table 2).

3.1 Accuracy of Interpolation Methods

The values of ME and RMSE of cross validation, indicate that RBF-IMQ and RBF-MQ interpolation methods had minimum ME and RMSE for soil EC and pH, respectively, while LP4 interpolation had the maximum error (Table 3). In fact, the higher order of local polynomial method provided higher RMSE and ME errors. In addition, the LP4, LP3 had high ME values in comparison with other methods for both soil pH and EC mapping. While RBF-IMQ and RBF-MQ methods were the most accurate ones for soil EC and pH mapping, the RMSE of RBF-CRS and RBF-ST methods were the next lowest for soil EC and pH interpolations. Therefore, radius basis function could be recommended as the best interpolation methods in the study area to interpolate pH and EC, minimizing the curvature of the surface area. However, IDW method could also suggested if with any reason RBF methods would not preferred for the region (Table 3).

Table 1 A descriptive summary of measured soil pH and EC

Variable	Mean	Std Dev	Std Error	CV	Minimum	Maximum	Skewness	Kurtosis
pH	7.74	0.15	0.008	1.96	7.40	7.90	-0.744	-0.685
EC	0.84	0.27	0.014	32.5	0.40	1.90	1.142	4.873

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Table 2 A summary of Pearson correlation analysis between soil pH and EC in Karimabad rangelands

Variables	pH	EC
pH	1.00	-0.04
EC	-0.04	1.00

The values shows the Pearson correlation coefficients, N =266

Table 3 The prediction accuracy of different methods

Methods	Root mean square error (RMSE)		Mean error (ME)	
	pH	EC	pH	EC
IDW1	0.1088	0.1501	-0.0002285	-0.002923
IDW2	0.1014	0.1385	-0.001472	-0.00202
IDW3	0.09691	0.1324	-0.003099	-0.00067
IDW4	0.09554	0.1303	-0.004623	0.0006285
LP1	0.09813	0.1387	-0.002633	0.001224
LP2	0.1041	0.1411	-0.005127	-0.00407
LP3	0.126	0.1685	-0.005871	0.004519
LP4	6.524	12.04	-0.3667	0.6139
GP1	0.1501	0.2762	-0.001992	0.0001064
GP2	0.1508	0.2496	-0.0000096	0.001047
GP3	0.1508	0.243	-0.0000096	-0.0003394
GP4	0.1279	0.2148	-0.0001184	-0.0003862
RBF-CRS	0.0958	0.1197	-0.001791	0.001043
RBF-ST	0.09573	0.1214	-0.001688	0.0006253
RBF-MQ	0.09538	0.1227	-0.0000052	0.0006375
RBF-IMQ	0.09664	0.1195	-0.001747	-0.0000045
RBF-TPS	0.1028	0.1267	-0.0044	0.0008919

3.2 Mapping Soil Acidity/Alkalinity (pH)

As suggested by cross validation analysis, RBF-MQ method was applied to interpolate and map soil pH of the study area (Figure 1). According to Soil Survey Staff (1993), the local minima area (~7.4) was mainly located on the west side, where the rangeland ecosystems was dominated and rill erosion occurred. The moderate areas (7.4 < pH < 7.9) was distributed on northwest and south in rangeland ecosystems even when the erosion or slope was high. The local maxima area (~ 7.9) was mainly observed on the east and northeast side that cultivation was the main management practice. Therefore, soil pH distribution was not a manner of topography or physiography. It seems that land use and management practices were the main factors to influence soil pH spatial pattern. However, considering the overall pH range in the study area, the soil was very slightly (7-7.4) to slightly (7.4-7.9) alkaline, causing no serious problem in the study area.

3.3 Mapping Soil Electrical Conductivity (EC)

Cross validation analysis showed RBF-MQ interpolation method could interpolate soil EC_e more accurately (Table 3), showing in Figure 3. According to FAO guidelines for soil description (2006), the local minima area (~ $0.33 dSm^{-1}$) was mainly observed on the south part where rangelands covered the area and rill erosion dominated. As it was clear in the map

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(Figure 3), the moderately EC area was widely spread across west, east, and northeast areas where both rangeland and agriculture lands could observed in the study area. Part of the north area was the local maxima with the maximum value of 2.13 dS m^{-1} EC. Considering the EC classification in loam and sandy loam soils, the minima area was non-saline soil suitable for most crop cultivation or plant reclamation projects. However, the local maxima is slightly saline and should be considered in reclamation and irrigation projects.

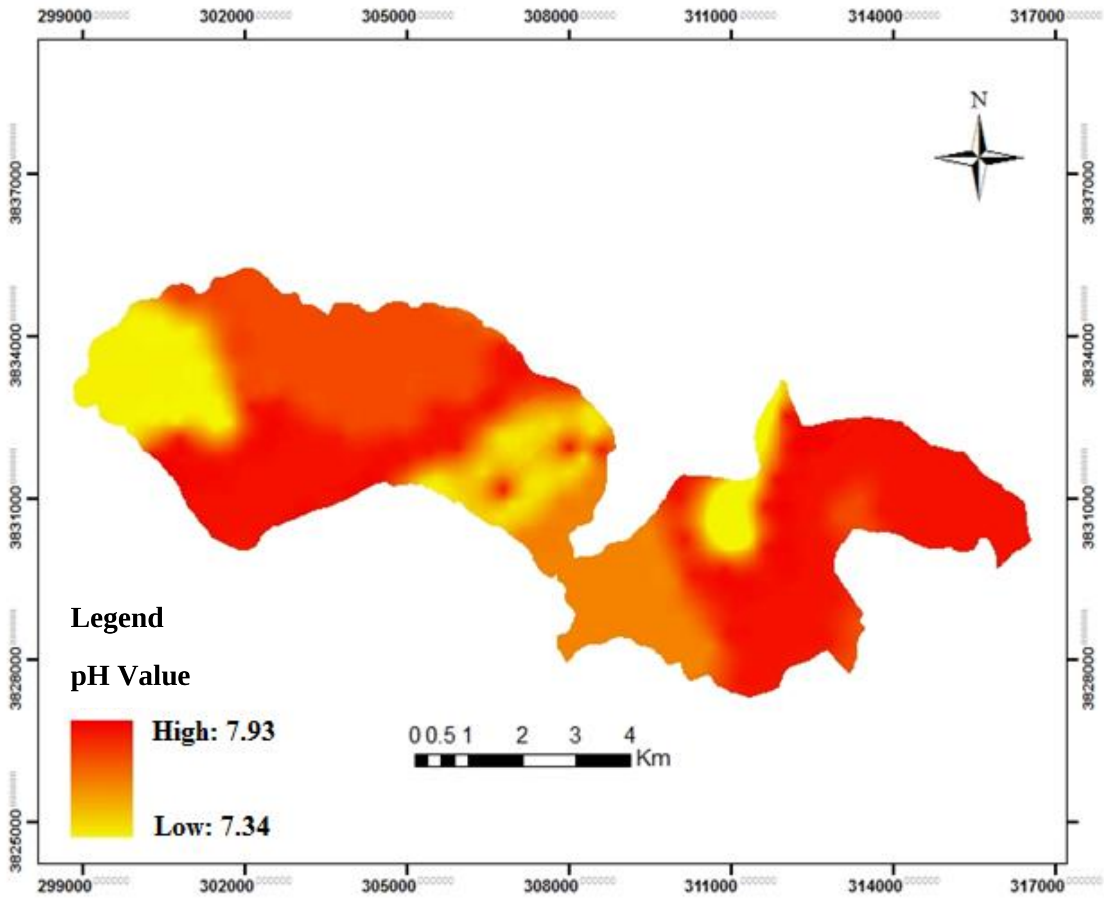

Figure 2 Topsoil pH distribution map using RBF-MQ interpolation method

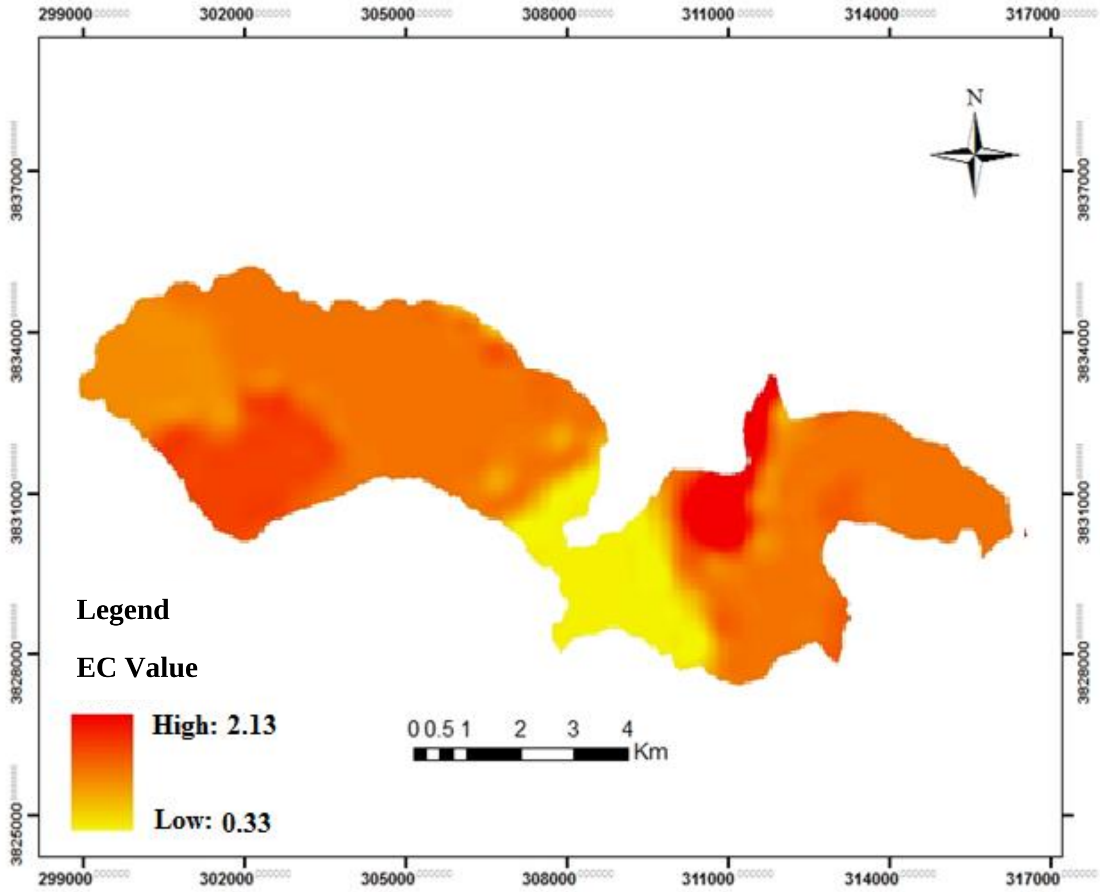

Figure 3 Topsoil EC distribution map using RBF-IMQ interpolation method

4 DISCUSSION

The four interpolation methods (IDW, LP, GP, and RBF) for estimation of topsoil pH and EC in Karimabad rangelands were compared. The results showed the interpolation methods and the models' parameters could influence precision for estimation of topsoil pH and EC in the study area. The accuracy depended on spatial pattern and soil attribute correlation (Zhu *et al.*, 2004; Li and Heap, 2014). Here, radius basis function (RBF) was the best method to interpolate soil pH and EC in this study, considering RMSE and ME values. While LP4 was the least appropriate interpolation method, Global polynomial (GP) was the next worse one to interpolate soil pH and EC spatial pattern, suggesting no obvious coarse-scale changes in the soil pH and EC in Karimabad rangelands.

One of the problem in interpolation techniques was inaccurate estimation of the mean values (Yao *et al.*, 2013) due to the local maxima and minima that could underestimate the high-risk area (Xie *et al.*, 2011). In this study; however, the soil pH and EC were generally low with no serious alkalinity and salinity problem (pH <7.9, EC < 2.13 dS m^{-1}) (Figures 2 and 3) and no high-risk spots all over the region. Therefore, the soil pH and EC could accurately estimate by RBF-MQ and RBF-IMQ methods (Table 3), respectively, in Karimabad rangelands. In addition, inverse distance

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weighting method (Table 3) almost showed the same accuracy as RBF model for both soil pH and EC values. Considering the homogeneity of soil properties in the study area, our findings also confirmed that both interpolation methods of RBF and IDW could be suggested for datasets with fine-scale variation. Although, there is various factors affecting the accuracy of soil pH and EC interpolation such as, sample size and the distance between the samples, still interpolation method could be suggested for proper spatial pattern interpolation as suggested by previous researches (e.g., Kravchenko, 2003; Xie *et al.,* 2011). In addition, the spatial structure is another important factor (Kravchenko, 2003; Li and Heap, 2014). In fact, the interpolation methods with lower RMSE and ME could accurately map the soil pH and EC comparing to other methods. Usually, when the interpolation error is small, the coefficient variation is also small and vice versa (Xia *et al.,* 2011); and therefore the model is more precise. However, both RBF and global polynomial interpolators showed almost equal range of RMSE in this study, the RBF method is more preferred as GP are usually good enough just to present coarse-scale changes (Zhu *et al.,* 2004). Therefore, the RBF method was preferred here in this study. Therefore, with an acceptable accuracy and low interpolation error RBF-MQ and RBF-IMQ chose for pH and EC spatial pattern interpolation in Karimabad rangelands. However, the accuracy of interpolation methods was a relative concept and depends on the interpolation purposes. Most previous studies had suggested geostatistical methods (e.g., co-kriging and kriging) as more accurate methods to assess soil parameters (Li and Heap, 2011; Gozdowski *et al.,* 2015). However, there was some evidence of the similar accuracy of both geostatistical and nongeostatistical to monitor different soil properties (Karydas *et al.,* 2009). Two main purposes of soil pH and EC interpolation was understanding the spatial pattern and locating the alkalinity and salinity problems in the study area, and therefore RBF methods was more preferred as it reserves the local minima and maxima in soil pH and EC maps comparing to other interpolation and geostatistic methods (Xia *et al.,* 2011).

Here, the RBF interpolation for both soil pH and EC accurately showed the spatial pattern in Karimabad rangelands and revealed soil pH influenced by land use while EC did not. Soil pH ranged from very slightly to slightly alkalinity level with the maximum at agricultural lands. The relationship between crop cultivation and soil pH in agriculture lands was widely accepted (e.g., Dalal and Mayer, 1986; Munthali and Phiri, 2013). This is a major management problem in precipitation-limited climate such as the current study area with the annual precipitation of 342.4 mm. In such an area, a carbonates rich layer (caliche) observed beneath the soil surface due to insufficient calcium and magnesium leaching (Lybrand *et al.,* 2013). As high pH levels might suppress the plant growth and yields (Mitchell and Soga, 2005; Kazemi Poshmasari, 2012), proper irrigation schedule could suggest to prevent the serious pH increase in Karimabad agricultural lands. While some of the studies suggests soil pH and EC relationship, no strong correlation was observed here (Table 2). Soil EC did not respond to land use changes as soil pH. Soil EC was at its minimum amount in the high erosion area in the south part ofstudy rangelands (Figure 3), suggesting the effect of soil and organic matter removal due to erosion might influence soil overall electrical conductivity in terrestrial ecosystems (Mitchell and Soga, 2005). However, soil erosion could indirectly influenced by land use in different ecosystems (Yang *et al.,* 2003). In overall, land use and erosion could be considered to develop a management framework for the study area to maintain and improve soil quality. Moreover,

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during the drought period, regularization of the irrigation in agriculture lands would minimize and prevent the acceleration of the alkalinity problem in the study area. In addition, much higher sampling intensity/density associated with temporal trend analysis seems necessary to monitor soil pH and EC in the region now that we have not faced any serious salinity and alkalinity problems yet.

5 CONCLUSION

To monitor soil salinity and delineate salinity prediction map, topsoil pH and EC were evaluated in Karimabad rangelands, Hamadan Province. The study shows the smooth spatial variability of soil pH and EC with no values greater than salinity threshold in Karimabad rangelands, Hamedan Province. All interpolation methods are appropriate to predict the spatial distribution of soil pH and EC in the study area. However, the interpolation results in the local minima and maxima boundary areas might be less accurate. Considering low RMSE, ME, and suitability of RBF method to identify local minima and maxima areas, RBF method is recommended in the study area. In other words, RBF method successfully interpolate soil pH and EC spatial distribution in Karimabad rangelands, Hamedan Province. Of course, higher sample size and more frequent sampling is highly recommended to assess the temporal and spatial trend of soil pH and EC in long term. In overall, RBF interpolation method found to be valuable tool to provide soil pH and EC prediction map in the study area. In overall, the RBF method is time effective and relatively simple strategy to predict soil pH and EC distribution in mountain areas.

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مقایسه روش‌های درون‌یابی برای تخمین توزیع مکانی اسیدیته و هدایت الکتریکی خاک سطحی (مطالعه موردی: مراتع کریم آباد، استان همدان)

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چکیده شوری و قلیائیت خاک از جمله مشکلات جدی در نواحی خشک و نیمه خشک به‌شمار می‌آیند و به‌همین دلیل پایش اسیدیته (pH) و هدایت الکتریکی (EC) خاک در این نواحی ضروری است. مطالعه حاضر با هدف درون‌یابی مناسب میزان اسیدیته و هدایت الکتریکی خاک، به‌عنوان دو شاخص کیفیت خاک، در منطقه کوهستانی نیمه خشک با بارش سالانه ۳۴۲/۴ میلی‌متر انجام شد. منطقه مورد مطالعه مراتع کریم‌آباد با پوشش غالب مرتعی در استان همدان، غرب ایران واقع شده است. تعداد ۲۶۶ نمونه خاک مرکب از عمق ۲۵-۰ سانتی‌متری خاک در قالب طرح سیستماتیک-تصادفی از منطقه مورد مطالعه جمع‌آوری شد. میزان pH و EC نمونه‌های خاک اندازه‌گیری شدند و سپس با استفاده از بهترین روش درون‌یابی در منطقه مورد مطالعه خاک به کل حوضه تعمیم داده شدند. به‌طورکلی، دامنه تغییرات اسیدیته و هدایت الکتریکی خاک منطقه به‌ترتیب بین ۷/۳ تا ۷/۹ و ۰/۳۳ تا ۲/۱۳ دسی زیمنس بر متر بوده است که نشان‌گر قلیائیت و شوری ناچیز خاک منطقه است. نتایج پهنه‌بندی بیان‌گر دقت روش‌های درون‌یابی، به‌ویژه روش‌های وزن‌دهی معکوس فاصله و تابع پایه شعاعی جهت مطالعه توزیع مکانی پارامترهای اسیدیته و هدایت الکتریکی خاک منطقه می‌باشند. هر چند که بر اساس جذر میانگین خطا (RMSE)، روش تابع پایه شعاعی بهترین روش درون‌یابی pH و EC خاک منطقه مورد مطالعه است. هرچند در حال حاضر، میزان اسیدیته و قلیائیت در منطقه مورد مطالعه کم است، اما پایش این شاخص‌های کیفیت خاک به‌منظور جلوگیری از شوری و قلیائیت خاک در مراتع کریم آباد پیشنهاد می‌شود.

کلمات کلیدی: توزیع مکانی، روش تابع پایه شعاعی، زمین آمار، شوری، قلیائیت خاک

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