Effect Of Land Use Over Spatial Variability Of Nitrogen Mineralization And Some Of Chemical Soil Properties In Mirabad Area Of Iran

Abstract

Understanding of the biology and ecology of soil is increasingly important for renewal and sustainable ecosystem. The aim of this study was to investigate the spatial variability and zoning of nitrogen mineralization, organic carbon and calcium carbonate influenced by the user of apple orchards, crop production and pasture, and compare the two interpolating method kriging and inverse distance weighting in Mirabad area, North West of Iran. The results show that the kriging method is best method interpolation for unsampled points for ammonium, nitrate, and organic carbon. Also was determined that the spherical model for interpolation values of ammonium, organic carbon and calcium carbonate equivalent and the exponential model as the best model for Interpolation values of nitrate were determined. Results indicated that spatial dependence nitrogen mineralization of soil is medium and this reflected the effect of the users on the spatial distribution of these properties. Results obtained from variance analysis by application MSTATC showed that these properties are influenced by the different users. Spatial distribution maps of biological, chemical and physical soil properties were provided by integrating geostatistical out puts and GIS.

Keywords: Nitrogen mineralization, organic carbon, calcium carbonate equivalent, geostatistics, GIS, biodiversity.

Introduction

Information of Soil chemical status order to sustainable production in agriculture is very important because soil is a complex, dynamic system that is composed of several components. Nitrogen mineralization from different sources of organic matter in cultivated land, orchard and pasture for maintaining soil fertility is not negligible and as one of the most complex processes in the nitrogen cycle, in addition, to the activity of soil microorganisms are affected by environmental factors. The amount of organic matter in soils is dependent on soil organic carbon. The other hand, much of the Iranian soil is composed of calcareous- gypsum [19], which amount of lime in many areas of the country will exceed of 50% [13]. The existence these elements can affect soil pH. So, knowledge of soil properties in different areas of management of agricultural and fertilization can be beneficial, as much as traditional agriculture led to the depletion of soil organic matter and nitrogen mineralization rates also significantly reduces [7]. Types of land use, soil nitrogen cycle can influence through changes in soil properties, biotic and non-biotic and the quality of organic matter [12].Changes in land use, changes ecosystems of sub surface that loss of biodiversity and often depletion of soil carbon [8]. Soil intrinsic properties are changing of view spatial and temporal from small scale to large scale because these properties affected by soil parent material or soil management practices, fertilization and crop rotation [18]. Therefore, in order to better understand and factors such as manage and pollution and finally achieving good agricultural operations, need to recognize and quantify heterogeneity and variability of soil properties [3]. Geostatistic science based on the theory of spatial variable and as one of the branches practical statistics, Aşkın and Kizilkaya (2006) from geostatistical method and kriging used for interpolating and estimate the distribution pattern of nitrogen biomass in pasture in northern Turkey. Zhang et al (1997) investigated the application of geostatistics in soil science and geostatistics were introduced as a useful tool in solving problems related to soil science. Using from mentioned methods along with the use of GIS, adds accuracy and cause of saves time and reduces the volume studies conducted.

Materials and methods

The study area has located in the western part of Souldoz plain surrounded by Urmieh, Miandoab, Piranshahr and Naghadeh cities in the west Azerbaijan province of Iran at 36˚59′north latitude and, 45˚18′ east longitude within the Universal Transverse Mercator projection (UTM) zone 38S. Mirabad pasture is a virgin site where has been selected as bench mark. The altitude varies from 1310 m to 1345 m with average 1325 m above sea level. The monthly average temperature ranges from -1.4 ˚C in January to 24.6 ˚C in July and precipitation ranges from 0.9 mm in July to 106.6 mm in March according to recently 25 years period during 1980 till 2006[9]. The sampling sites were designated as having all three lands use types: apple garden, crop production, and pasture (Fig.1)

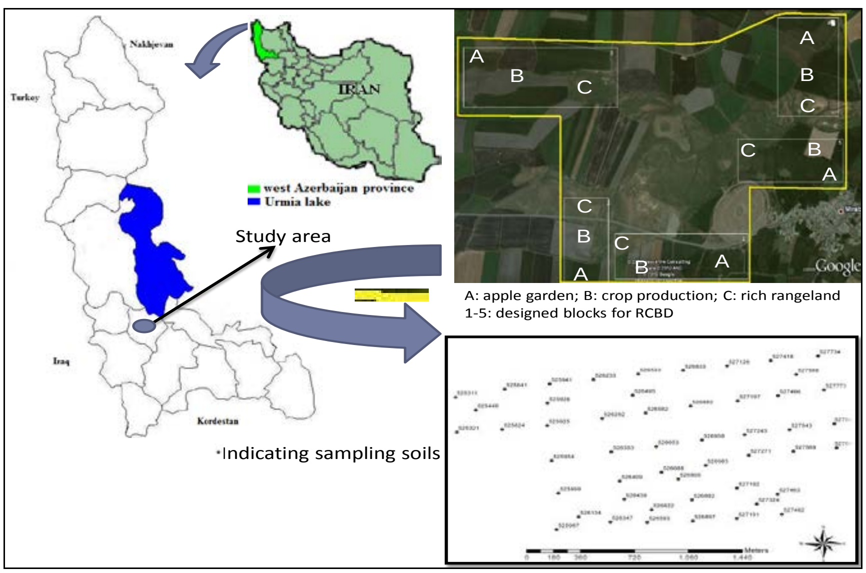


Fig.1. Map of the study area showing the sampling design.

The whole study area is covered by plateau and soil order is inceptisol (Soil classification map of Iran). It means that the impact of climatic, geology and geomorphology factors to all study area is equal.

Sampling and Soil analyses

For obtaining the precise estimation, rectangular grids are designed (300 m ×300 m) to have 65 sampling points. Soil samples were systematically collected from the upper 30 cm. The collected soils were then sieved through a 2 mm-mesh and analyzed for organic carbon [14], calcium carbonate equivalent [16].

Soils for nitrogen mineralization analysis were kept at 4°C and soil nitrogen mineralization measured by Spectrophotometer [1].

Statistical and geostatistics analyses

For normality of data distribution and the correlation coefficent was SPSS applied and analysis of variance and compare of mean, MSTATC and an experiment was also conducted in the randomized complete block design, and Excel was used to graph drawing applications. To study the spatial relationship of biological indices of land values as indicators we need to model modify and implement the access variable in the whole area. Geostatistics consists of a linear, spherical, exponential and gaussian models variogram, and The Highest R^2 and the smallest RSS are two diagnostic criteria for selecting the best statistical model. Modify the variable structural properties in the area and the changing process is assessed. The semivariogram γ (h), describes the spatial structure of the data and is calculated by using the following equation [5]:

$$\gamma = \frac{1}{2n(h)} \sum_{i=1}^{n(h)} \left[z(x+h) - z(x) \right]^2 \quad (1)$$

Where ɣ is the semivariance for the interval distance class h, n (h) is the number of pairs of the lag interval, Z (x) is the measured sample value at point i, and Z (x + h) is the measured sample value at position (x+h). Geostatistics parameters consists of a Nagget effect (Co), sill (C+Co) and range of parameter (A0) [17]. Criterion for classifying the spatial dependence of soil properties describes as the ratio of nugget variance to sill which it depends on the sampling mesh, expressed in % following as: If ratio of nugget variance to sill is less than 25%, then the variable has strong spatial dependence if the ratio is between 25 % and 75%, the variable has moderate spatial dependence, and otherwise, the variable has weak spatial dependenc [6]

Fitting the models

A useful tool is for the analysis of spatially correlated data are geostatistics methods. These global interpolation methods have some advantages compared to common interpolation techniques, like the inverse distance weighting and kriging. The semivariogram calculation is followed by the kriging estimation. Kriging is a geostatistics technique that provides estimates for unsampled locations on the basis of a weighted moving average interpolation. In inverse distance weighting which interpolation estimates are made based on values at nearby locations weighted only by distance from the interpolation location.

Testing analysis

Conducted to evaluate and compare the estimates, the assessment of cross validation (Jacknife), are to assess the accuracy of the issue [10]. Three statistical parameters Mean Bias Error (MBE), Mean Absolute Error (MAE) and Root Mean Square Error (RMSE) are used. Positive and negative values of the parameter estimate and the low estimate of the actual amount is more than or equal to zero in the ideal case. If it is close to zero, indicating the more decimal method is more accurate [11]:

$$MAE = \frac{1}{n}\sum_{i=1}^{n}\left|\left[Z^*(x_i) - Z(x_i) \right]\right| \quad (2)$$

$$RMSE = \frac{1}{n}\sqrt{\sum_{i=1}^{n}\left[Z^*(x_i) - Z(x_i) \right]^2} \quad (3)$$

n= a number of points which were, Z*(xi) = estimated e value of points (xi), z (xi) = is the average of the observed values.

Mapping

Geostatistics analysis and fitting the best model based on the correlation coefficient and the sum of squared residuals and also evaluates the best method of interpolation based on the validation statistics, geostatistic parameters enter the GIS and distribution map for the physical, chemical and biological soil will be obtained.

Results

Descriptive statistics of soil properties

Descriptive statistical parameters of soil properties are shown in table 1. The results show that the all Properties distribution was not normal and convert the data logarithmic makes reduce skewness and the data were normalized. Bryjda and et al (2000) found that the scale of a region often properties non-normal distribution. Coefficient of variation (CV) is a measure of the relative variability that of nitrate in the lowest and highest ammonium. Low coefficient of variation can be caused by intrinsic factors such as parent material behavior which is variable. High coefficient of variation can be caused by the combined effect of management factors on ammonium (fertilizer and different users of the lands) and intrinsic factors such as the topography, extreme changes in texture and drainage conditions and vegetation in the area, because the biological properties including properties that are strongly influenced by management

Table 1
Descriptive statistics for selected properties of soils (n = 65).

Soil properties	Mean	Min	Max	S_d	CV	Skewness	kurtosis
NO_3^- (µg.g $^{-1}$)	3.07	1.08	6.92	1.83	1.59	0.68	-1.04
NH_4^+(µg.g $^{-1}$)	26.95	2	58.32	16.01	97.12	1.11	-1.17
OC (%)	3.39	0.79	8.33	2.03	59.88	1.1	-0.17
CCE (%)	27.38	4.15	58.34	16.81	61.39	0.54	-1.1

Sd: standard deviation, CV: coefficient of variations, OC: organic carbon, CCE: calcium carbonate equivalent

Variance analysis of soil properties

For all data before doing statistical analysis using software MSTATCT, was conducted normality test data, and if it was not normal data were normalized by using appropriate conversion. Then was conducted statistical analysis on data. To evaluate the impact of land use on properties randomized complete block design with 5 repetitions (5 blocks) and three treatments of crop, apple orchard and pasture was established. The results of the analysis of variance table (2) show that the amount of ammonium and nitrate, and therefore nitrogen mineralization, organic carbon there are significant differences in between users in the level of 1% and in terms of calcium carbonate equivalent there is significant differences in between users in the level of 5%. According to the mean comparison (Fig.2) most ammonium and nitrate are in pasture soil. Nitrogen mineralization in pasture more than garden and crop soils, that the reason for this can be attributed to the higher organic carbon content. Increase in the amount organic carbon and organic carbon readily biodegradable, will be cause speeding up this process that results indicated organic carbon is high in pasture. Also are not performed tillage farming and operations in the pasture, thus, the soil organic carbon storage in the soil and does not disappear biological balance does not disappear and increases mineralization of organic nitrogen. According to the comparison of the mean (Fig. 2) most amount calcium carbonate equivalent is in the pasture and less amount is the garden, because during the dry period in garden and crop users, irrigation is carried out at least 12-10 times that this will cause of transfer lime from the surface layers of soil and this will be reduce lime in two other user.

Table (2)
Table of variance Analysis of properties studied

Variable	d_f	Mean square			
		NO_3^-	NH_4^+	OC	CCE
block	4	0.044	0.018	0.028*	0.012
user	2	0.211**	0.189**	0.168**	0.265*
error	8	0.024	0.017	0.003	0.052
CV		25.18	9.04	10.18	18.24

*P < 0.05; **P < 0.01

OC, organic carbon; CCE, calcium carbonate equivalent

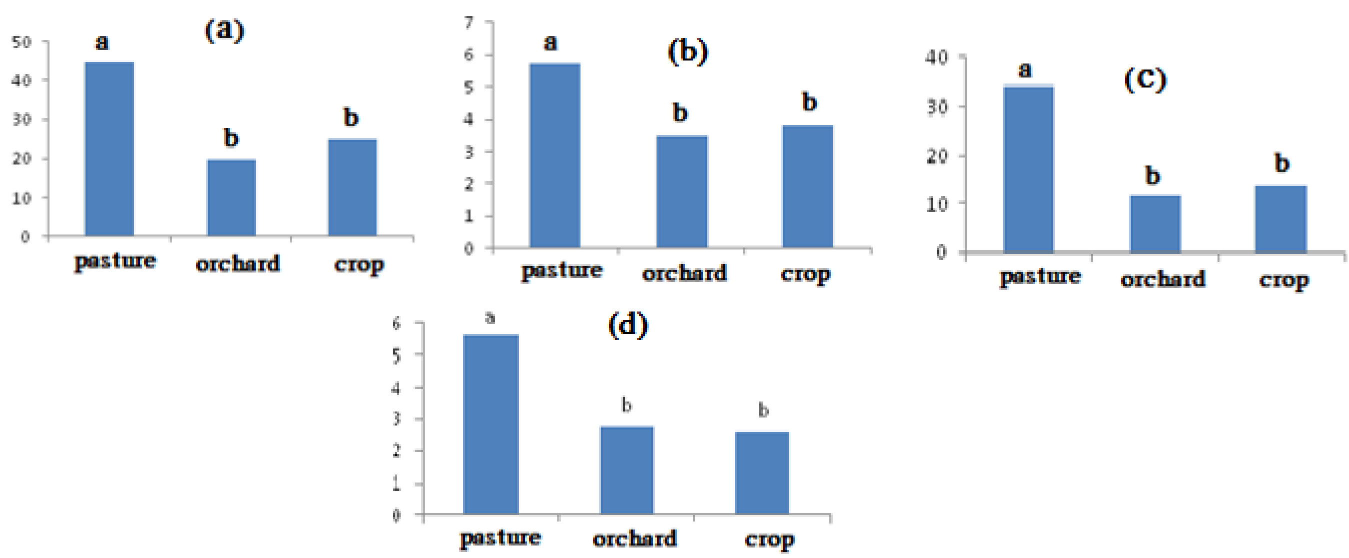


Fig.2. Comparison of the mean of different user (P≤0.05), a) ammonium, b) nitrate, c) calcium carbonate equivalent, d) organic carbon

Semi-variogram analysis of soil properties

Semi-variogram parameters are presented in table 3. Normality test was performed using SPSS software and after normalization was used in geostatistical modeling. High accuracy (R^2) and fewer errors (RSS) selection criterion are for best model geostatistics. The results show that the ammonium, organic carbon and calcium carbonate equivalent obey from spherical model, nitrate from exponential model (Fig. 3). Effective range is between the ranges of 4110 for nitrate to 781 for calcium carbonate equivalent are fluctuate. Effective range of soil properties is function of the scale, sampling distance and landscape position. According to the spatial dependence for the ammonium and nitrate is the mean dependence and the this issue is implies that these properties are related to the management factor and intrinsic factors (parent material, etc.) is unaffected in this changes and is influenced by the study scale and this reflects of the effect of the user on the spatial distribution of the properties. Calcium carbonate equivalent and organic carbon is stronger spatial structure than any other the properties and geostatistical interpolation has higher accuracy and dependent on intrinsic factors and management factors has not involved in these changes.

Table 3
The best fitted isotropic models to variograms and geostatistics parameters of studied propertie

Soil properties	model	C_0	C_0+C	A0/ m	C0 / C0+ C /%	R^2/ %	RSS
NO_3^- (µg.g $^{-1}$)	Exponential	0.089	0.18	4110	50.3	73	1.180×10^{-4}
NH_4^+(µg.g $^{-1}$)	Spherical	167.5	349.6	2374	50	99	6.91
OC (%)	Spherical	0.0163	0.0735	852	22.17	99	1.277×10^{-6}
CCE (%)	Spherical	8	340.1	781	2.35	996	116

C_0: nugget, C_0+ C: sill, A_0: range of parameter, C0/C0 C /%: Ratio correlation, R^2: correlation coefficient, RSS: reduced sums of squares; OC, organic carbon; CCE, calcium carbonate equivalent

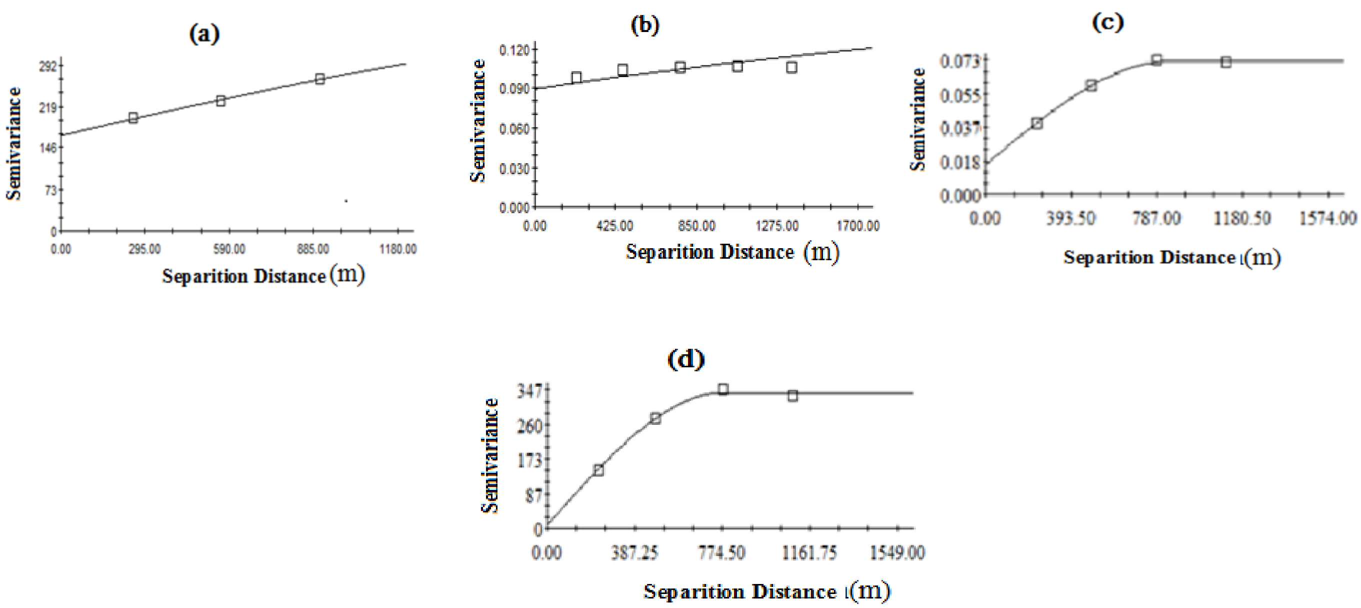


Fig.3. Isotropic spherical models variogram fitted to properties of studies, a) ammonium, b) nitrate, c) organic carbon, d) Calcium carbonate equivalent

Kriging and inverse distance weighting Interpolation methods evaluating

Table 4, validation statistics is measured for the soil properties and indicating the best Interpolation method. According to Validation statistics for Calcium carbonate equivalent inverse distance weighting method and for ammonium, nitrate and organic carbon kriging method is acceptable accuracy and validity. Shahbazi et al (2013) in a study on the impact of land use orchard, pasture and crop on biological properties in Mirabad lands of Naghadeh, used two Interpolation Kriging and inverse distance weighting and showed that for Microbial biomass carbon and enzyme urease kriging method is better.

Table 4
Validation statistics for the Properties

Soil properties	Method of interpolation	MAE	MBE	RMSE
NO_3^- (µg.g $^{-1}$)	kriging	0.29	0.007	0.33
	inverse distance	0.21	0.011	0.35
NH_4^+(µg.g $^{-1}$)	kriging	12.45	0.51	15.28
	inverse distance	13.18	1.57	15.87
OC (%)	kriging	0.14	0.008	0.18
	inverse distance	0.15	0.02	0.2
CCE (%)	kriging	8.05	0.14	11.15
	inverse distance	7.95	-0.34	10.98

MAE, Mean Absolute Error; MBE, Mean Bias Error; RMSE, Root Mean Square Error; OC, organic carbon; CCE, calcium carbonate equivalent

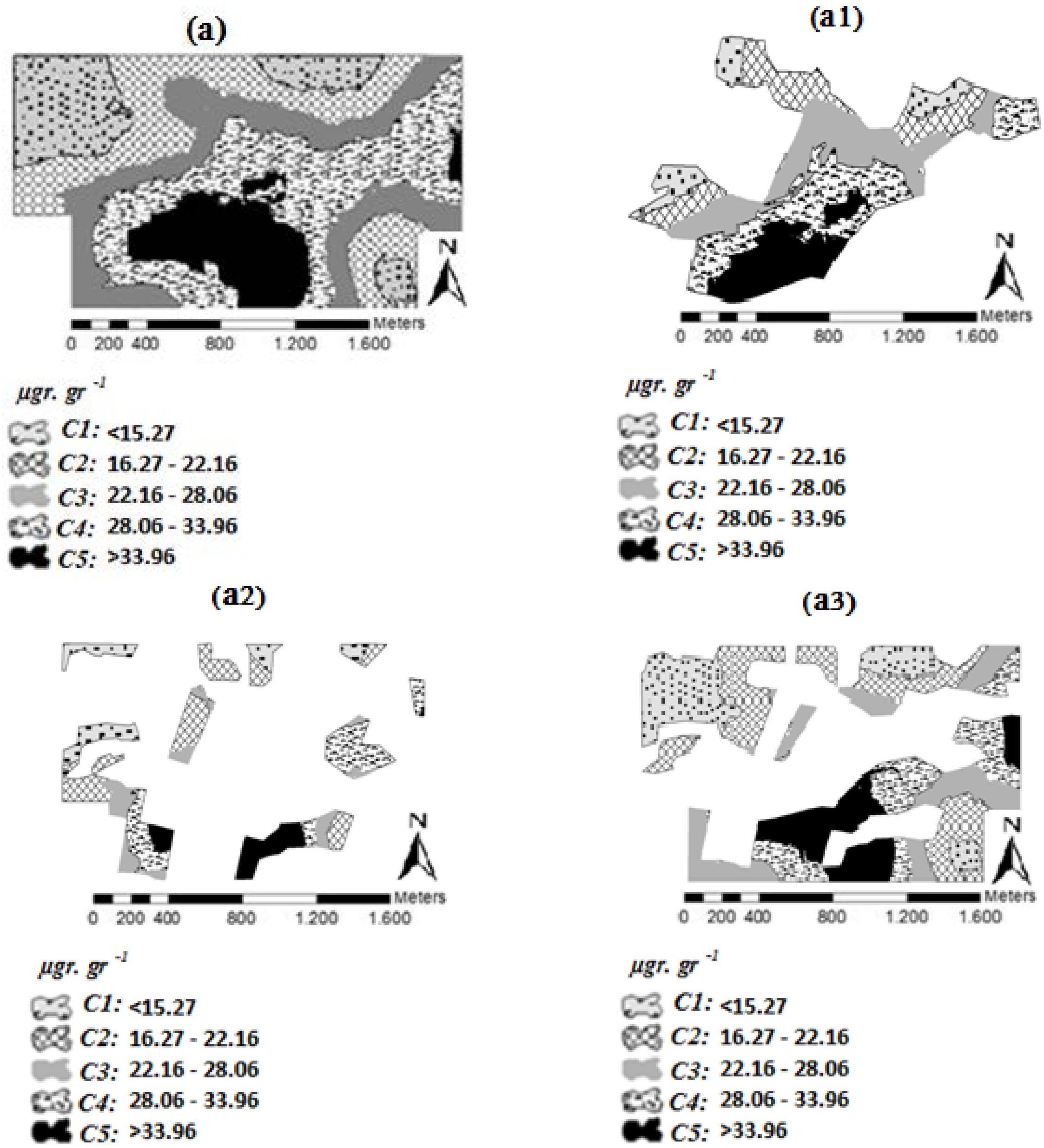
Analysis of GIS

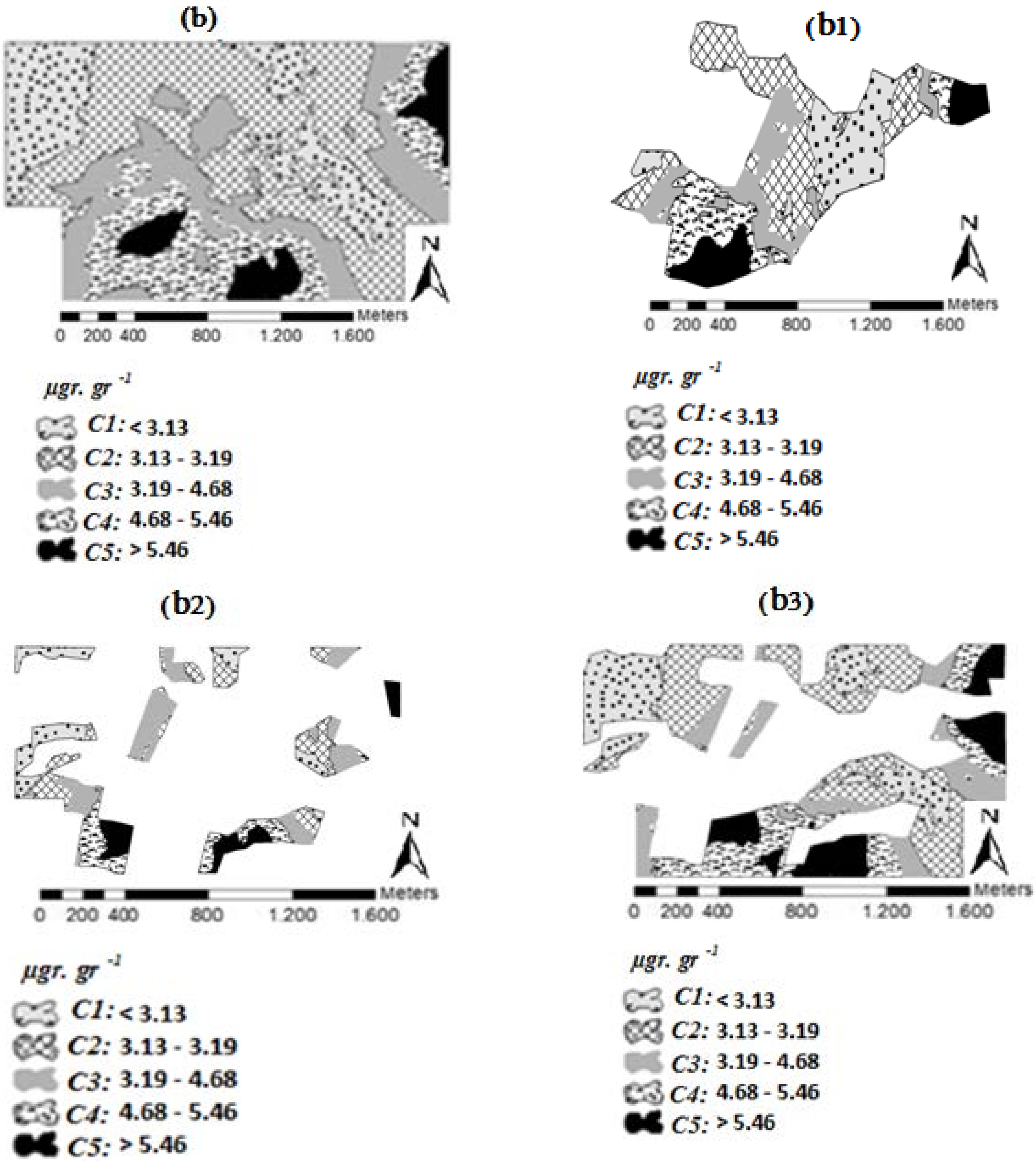
Geostatistics analysis and the best fit model based on R^2 and RSS and also evaluate the best method of interpolation based on the validation statistics geostatistics parameters enter GIS and was obtained distribution map that for calcium carbonate equivalent area map based on the inverse distance weighting method and other properties based on of kriging method. The total area study area of approximately 362 ha was calculated in GIS. Ammonium and nitrate map are based on separately user type. More details are listed in table 5.

Table 4
Zone properties area in the study area (ha)

Soil properties	C1(ha)	C2(ha)	C3(ha)	C4(ha)	C5(ha)
NO_3^- (µg.g $^{-1}$)	75.13	101.64	78.66	60.82	46.42
NH_4^+(µg.g $^{-1}$)	56.82	86.49	75.04	87.37	56.94
OC (%)	113.11	119.71	52.45	36.43	40.97
CCE (%)	87.82	94.58	72.88	50.60	56.78

* C, Area classification, the range of each of properties is given in the figure


(a)
N
0 200 400 800 1.200 1.600 Meters
μgr. gr -1
C1: <15.27
C2: 16.27 - 22.16
C3: 22.16 - 28.06
C4: 28.06 - 33.96
C5: >33.96
(a1)
N
0 200 400 800 1.200 1.600 Meters
μgr. gr -1
C1: <15.27
C2: 16.27 - 22.16
C3: 22.16 - 28.06
C4: 28.06 - 33.96
C5: >33.96
(a2)
N
0 200 400 800 1.200 1.600 Meters
μgr. gr -1
C1: <15.27
C2: 16.27 - 22.16
C3: 22.16 - 28.06
C4: 28.06 - 33.96
C5: >33.96
(a3)
N
0 200 400 800 1.200 1.600 Meters
μgr. gr -1
C1: <15.27
C2: 16.27 - 22.16
C3: 22.16 - 28.06
C4: 28.06 - 33.96
C5: >33.96


(b)
N
0 200 400 800 1.200 1.600 Meters
μgr. gr -1
C1: < 3.13
C2: 3.13 - 3.19
C3: 3.19 - 4.68
C4: 4.68 - 5.46
C5: > 5.46
(b1)
N
0 200 400 800 1.200 1.600 Meters
μgr. gr -1
C1: < 3.13
C2: 3.13 - 3.19
C3: 3.19 - 4.68
C4: 4.68 - 5.46
C5: > 5.46
(b2)
N
0 200 400 800 1.200 1.600 Meters
μgr. gr -1
C1: < 3.13
C2: 3.13 - 3.19
C3: 3.19 - 4.68
C4: 4.68 - 5.46
C5: > 5.46
(b3)
N
0 200 400 800 1.200 1.600 Meters
μgr. gr -1
C1: < 3.13
C2: 3.13 - 3.19
C3: 3.19 - 4.68
C4: 4.68 - 5.46
C5: > 5.46

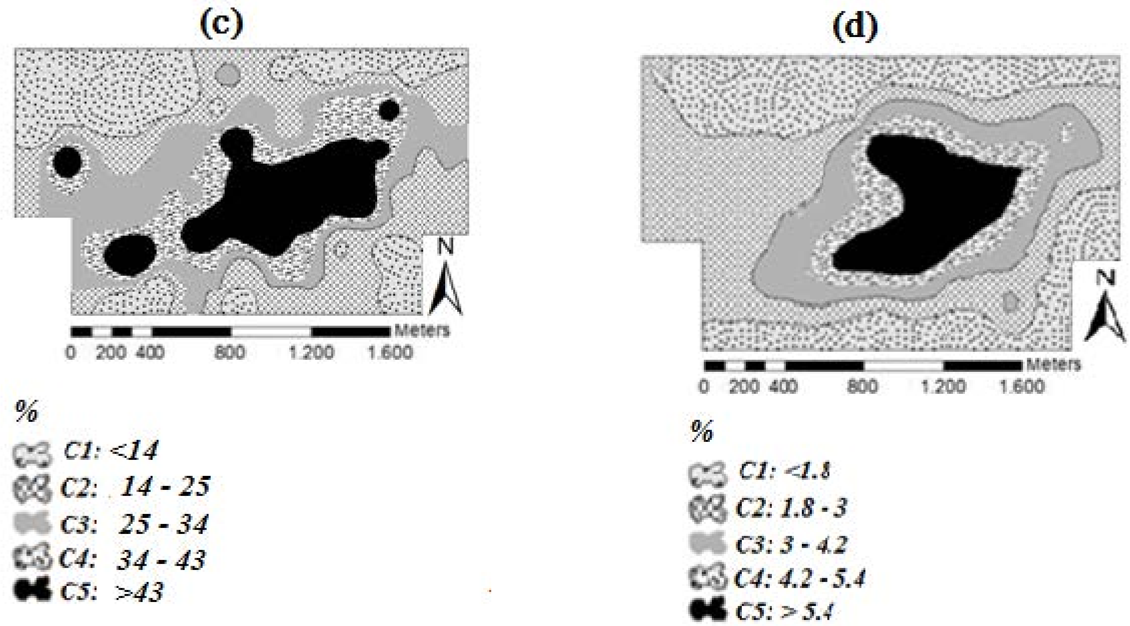


Fig.4. Created georeferenced thematic maps of selected properties. a) Map of estimated ammonium in the region; a1) Map of estimated ammonium in pasture; a2) Map of estimated ammonium in garden; a3) Map of estimated ammonium in crop; b) Map of estimated nitrate in the region; b1) Map of estimated nitrate in pasture; b2) Map of estimated nitrate in garden; b3) Map of estimated nitrate in crop; c) Map of estimated calcium carbonate equivalent; d) Map of estimated organic carbon.

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