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Land suitability assessment for urban green space using AHP and GIS: A case study of Ahvaz parks, Iran

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Abstract

Soil is a vital parameter for planting design in urban green spaces especially in adverse climate conditions. In this study, the utilization of analytic hierarchy process (AHP) in surveying land suitability for urban green space from measured criteria like suitability indices, including physical (i.e. clay, silt, sand, bulk density, penetration resistance), chemical (i.e. electrical conductivity, sodium absorption ratio, organic matter, Olsen phosphorus, water soluble potassium and DTPA-extractable of Fe, Zn, Cu, Mn) and heavy metal (i.e. total Ni, Cd and Pb) properties of soil and topography attributes (i.e. slope degree) data were investigated. The subjective value judgment, in light of questionnaire survey was utilized for pair-wise comparison after standard AHP method in a structure of four criteria (suitability indices) alongside related sub-criteria (19 factors). AHP method and GIS techniques were combined to create suitability map. The outcomes demonstrated that less than 8.86% of the all study region has no restriction and 34.54% has extreme restrictions for green space land use. The southern part of the riverside parks had higher suitability, whereas the northern area had lower suitability. The real limiting variables include soil compaction, soil salinity, and Zn deficiency; albeit direct mild accumulations were for lead in Ahvaz riverside parks. This study delineates the efficacy of AHP and weighted overlay model for the soil suitability investigation of green space in the study territory. In light of the outcomes, bulk density and organic matter are the most vital indices of soil in urban green space.

Keywords: Urban soil; Green spaces; AHP; Ahvaz

1. Introduction

Green space adds to the personal satisfaction in different ways including air and water purification (Yang *et al*., 2005), wind and clamor filtering (Fang and Ling, 2003), sequestering of CO (Nowak, 1993; Nowak and Crane, 2002; McHale *et al*., 2007), generation of O (Jo, 2002), diminishing stress (Ulrich, 1981), enhancing mental and emotional wellness (Hartig *et al*., 1991; Conway, 2000), increasing social incorporation (Coley *et al*., 1997), advancing the improvement of social ties (Kuo *et al*., 1998), revival of the city inhabitant, giving a feeling of serenity and peacefulness (Kaplan, 1983), directing microclimates, lessening the warmth island impact in urban areas (Shin and Lee, 2005), and influencing house costs (Kong *et al*., 2007). Schroeder (1991) has demonstrated that indigenous habitats with vegetation and water, incite more relax and less upsetting states in spectators when contrasted with urban scenes with no vegetation.

Site assessment for urban green space includes the examination of site conditions to give information and data so that the planting design can take advantage of the current conditions and avert issues that will affect the result of the planting operation (Craul and Craul, 2006). However, the precise assessment of suitable site comes as an overwhelming test and confused errand since different components such as physical, chemical and mechanical properties of soils, topography, and drainage elements and their cooperation are required to

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be assessed at the same time. Accordingly, recognizing suitable site for protection and creating green spaces is the first vital step with a specific end goal to guarantee their roles and functions (Craul and Craul, 2006).

Human activities change soil in urban environments and these changes are caused by different land uses in the urban environments (Craul, 1999). Heavy car traffic, traffic density and external lead to the soil structure destruction and loss of soil pores and thus soil is compacted (Jim, 1998b). Surface layers or subsurface's compaction of the soil is a significant problem that exists in most urban soils and it is an obstacle to proper root extension and slow air and water movement. Regardless of the limitations of soil properties municipal utilities including channels, cables and stones, demolition wastes, brick, old cobblestones and building foundations and other concrete structures in plantation bed have made many areas as an unfavorable environment to the growth of plants, especially trees. A number of studies have shown that urban soil has higher bulk density than the natural soil (Short *et al*., 1986; Jim, 1998a-c). In Hong Kong, Jim (1998a) showed that 66 percent of the tested soils have higher bulk density than the critical level for root extension which is 1.6 g/cm^2 (Mullins, 1991). In contrast low bulk density (e.g. 1 g/cm^2) is reported due to high urban soil diversity (Strain and Evans, 1994). The amount and type of soil organic matter varies because of high primary practices in the urban area (Beyer *et al*., 1996; Carreiro *et al*., 1999; Pouyat *et al*., 2002). Waterlogging and soil salinity conditions along with low quality of irrigation water are among the limitations that have a significant impact on plant growth (Velmurugan *et al*., 2016). These factors may weaken urban green spaces development in Khozestan region. In addition to waterlogging and salinity conditions, nutrient element, compression and soil compaction, lack of suitable aeration, climate constraints including low precipitation and very high temperatures in summer and high evaporation that have caused harsh conditions for common plant growth that make Khozestan's green spaces lack suitable quality. As a result of salinity stress caused by reduced water potential, ion imbalance, impaired ion homeostasis or toxicity of some ions are resulted. The transformation of water status reduces the yield and the initial stage development of plants. Salt stress which contains osmotic and ionic stress (Flowers, 2004) is presented as the concentrations of total soluble concentration or osmotic capability of soil moisture (Katerji *et al*., 2005; Pascal *et al*., 2005, Munns, 2002). Salt stress has various impacts on different plants and they have various tolerance degrees against salt stress. Plants' main processes such as growth, energy, lipid metabolism, protein synthesis and photosynthesis are affected by salt stress. Some researchers argue that soil salinity reduces plant growth, yield and quality (Solaiman *et al*., 2007; Dong *et al*., 2008), nutrient uptake (Setter and Belford, 1990) and root development (Jackson and Drew, 1984) and damage the root framework (Malik *et al*., 2002; Bramley *et al*., 2007).

Aimless planting of vegetation, especially trees, without thought of slope stability can possibly prompt to slope failure and causes damage (Craul and Craul, 2006). Soil conservation is likewise most urgent for establishment of vegetation in urban green space. The greater part of the planting designs considered so far are thought to be on level topography, which is the most widely recognized circumstance in the project of landscape plan. However, there are numerous cases where planting must be done on slopes, or it is sought to have plants on planned slopes as a part of the project design. An imperative thought in planting on a slope is the stability of the slope at first and after the planting is done. Along these lines, it is suitable to first examine the essentials of slope stability and utilize the data to regular landscape planting circumstances.

For the assessment and proper planning for current and future green spaces an appropriate algorithm is needed. It is attempted to perform this assessment by a number of methodologies. The main step in site assessment is to determine the weight of factors that the effective criteria on the quality of green spaces. Moreover, the existence of different and numerous criteria makes green space quality assessment complex (Elsheikh *et al*., 2013). The analytic hierarchy process (AHP) approach is one of the techniques for weighting the factors and weights of these criteria. AHP is a flexible, strong and simple approach and it is the best way to make decision when the contrasting decision criteria make selection among the options difficult (Saaty, 1980). AHP is a technique for complex decisions. Therefore, AHP helps the programmer to choose one of the best options to resolve the problems. In group decision making, the use of other's ideas and opinions helps to reduce decision-making errors and improve the quality and speed. This through the simultaneous use of quantitative and qualitative criteria could effectively help the analyses of issues related to landscape quality. The goal offers the objective, which demonstrates the favored or expected results. Solutions can be revealed in a few courses, for example, managing by speaking out, drawing thoughts from alliance partners, environmental examining, perusing and conferencing, authorizing reports, creative endeavors and different approaches to gain information. Considering stakeholders, all criteria alongside related sub criteria and options must be explored at the same time. Ultimately, various criteria and partner's perspectives should be determined inside a system of understanding and common compromise (Haralambopoulos and Polatidis, 2003). Combining AHP and GIS helps the decision support system by providing suitable maps. The model designed in GIS is capable of rate the urban land uses based on the green space score as a decision maker to check the suitable places (Khahro *et al*., 2014). The highest and most beneficial use of GIS is in land suitability assessment, land use suitability mapping and analysis (Javadian *et al*., 2011). Akıncı *et al*. (2013) applied AHP method for weighting factors and GIS for mapping and process data to decide appropriate lands. The factors in the study are rated between 0 and 10. Combining GIS and AHP methods is applied by different researchers for quality assessment and land suitability (Zhang *et al*., 2016; Chaudhary *et al*., 2016).

The complexity of urban land suitability is borne from the way that diverse factors control urban land suitability in various situations; and that these variables shift in their level of impact through space and time. In this way, this study was carried out in the southwestern Iran to: (1) investigate the impact of soil properties on the land suitability for urban green space in saline & sodic conditions, and (2) explore the capability of AHP and GIS in land suitability of urban green space.

2. Materials and Methods

2.1. Study site

Ahvaz (50°15'- 51°51' N and 31° 20' - 32°53' E) is based on the banks of the Karun river and is situated in southwest of Iran being the capital and most crowded city in Khozestan. The population in 2013 was 1,065,831 bringing about a normal population density of around 20,520 for every km. Karun is Iran's most effluent and the only navigable river. A large portion of the urban green space of Ahvaz city is created in west and east sides of Karun river. In this study, riverside parks of Ahvaz city of less than 25 years old have been considered as a study area (Fig. 1). The city has a normal elevation of 17 meters above sea level. The average annual precipitation and temperature in this city are roughly 250 mm and 5°C (January) to 55°C (July), separately. The potential evaporation was measured by evaporative pan approach and it was around 3000 mm annually. The major plants in the western and eastern side are *Ucaliptus* sp., *Prosopis* sp., *Conocarpus erectus*, *Clerodendron inerme* and *Phoenix dactylifera*.

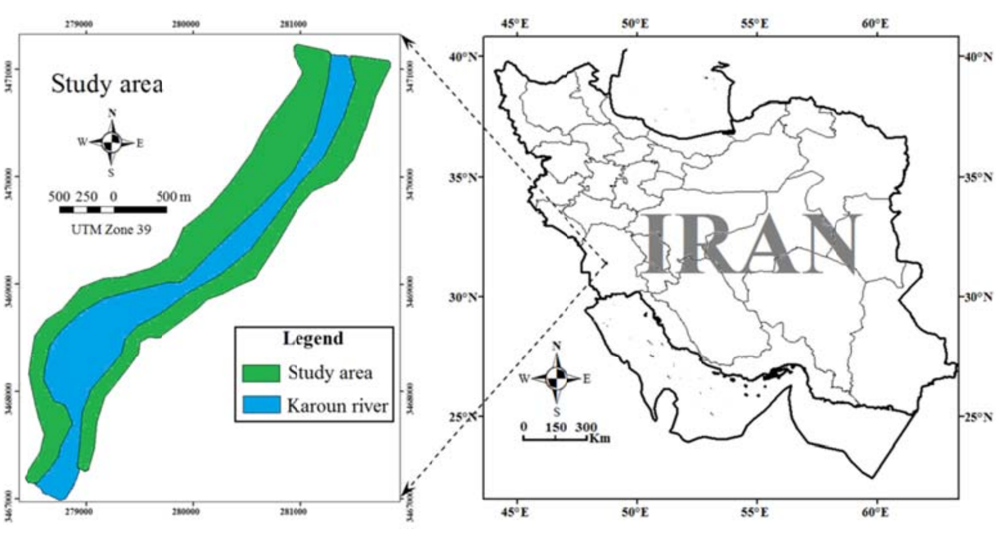

Fig. 1. Location of the study area

The soil moisture and temperature regimes are ustic and hyperthermic, respectively. In this area pedological soil horizons are lost such that the surface horizons O and *A* cannot be observed and they are not distinguished from one another in subsurface soil, illuvial horizon E and diagnostic alluvial horizon. In most parts of the study area, subsurface soil has high compaction and is variable in terms of color, texture, structure and stone content. A small number of profiles have homogenous materials and non-layer at a depth of 100 cm or higher. Waste contamination with cement, mortar, concrete, brick segments and other materials is common in most sectors.

2.2. Experimental design

To ensure the representativeness of the soil profiles, sampling plots were recognized after preliminary survey on the soil morphology, degree of slope, and vegetation cover, so that at least one sample was collected for each land unit. Thus, systematic sampling in two overlying soil depths in urban green space were utilized for soil factors in total of 100 plots (quadrats of 10 m × 10 m) in riverside parks; 50 plots in every site. The geographical location of each sampling point is recorded by GPS and soil properties are studied as specific topographic and erosion features.

2.3. Soil properties & topographic attributes

Two sorts of soil samples, to be specific disturbed and undisturbed were considered. Undisturbed samples were obtained by core sampler with a core in 5.45 cm diameter and 3.85 cm length to measure bulk density and aggregate stability. The aggregate mean weight diameter (MWD) was calculated from the equation:

$$\mathrm{MWD} = \sum_{i=1}^{n} W_i \overline{X}_i \qquad (1)$$

Where $\overline{X}_i$ is the mean diameter of each fraction and W_i is the proportion of aggregate weight residual on each sieve to total sample weight (Kemper and Rosenau, 1986). The hand penetrometer (Eijkelkamp model) is used to specify the penetration resistance of soil. The base of the hand penetrometer is measuring the highest penetration resistance of a cone over a distance of about 10 cm. The penetration resistance is calculated by means of a compression spring. A number of cones and compression springs are accessible. Based on the expected penetration resistance, a certain combination of a cone and a compression spring is chosen. In case the expected penetration resistance is high, a cone with a small surface and a compression spring with a large maximum force are chosen and vice versa.

To decrease the impact of micro variations in soil attributes, every disturbed sample was dug from various points and combined into a composite sample. Disturbed soil samples were dried by air and sieved to pass through a 2 mm mesh. The electrical conductivity of the saturated extract of the soil samples was measured by electrical conductivity meter device and reaction with soil acidity by pH meter devise in saturated paste. Organic carbon was measured by Walkly & Black method. To measure the concentration-bioavailability of heavy metals (lead, cadmium and nickel) and micronutrients (iron, zinc, copper and manganese) in soil the DTPA extractor with calcium chloride and triethanolamine solution are used and the solution pH is set at 7.3. Then the elements contained in the extract are measured by atomic absorption devise (Lyndsay and Nerol, 1978). Particle size distribution was determined by hydrometer. The absorbable phosphorous was measured by Olsen method and using a spectrophotometer. Calcium carbonate is measured by titration with caustic soda. To measure the concentrations of heavy metals the chemical digestion method is done by HCl and HNO_3. In each sampling unit the slope degree is measured by Silva inclinometer.

2.4. Statistical Analysis

AHP is one of the most comprehensive systems designed for multi- criteria decision-making because this technique is capable of considering different quantitative and qualitative criteria. This process involves different factors in decision-making and has high flexibility. This method in combination with GIS can be used as a tool to determine the appropriate green space sites. In AHP according to the experts decision-making is done based on the following five stages:

1. Setting objectives, criteria, sub-criteria and factors; AHP model used in this study is shown in Figure 2. In this study, the objective is at the highest level which is the green space quality. The topography, physical and chemical properties and soil heavy metal are also considered as the criteria that have 1 to 9 factors in its subset;

2. Hierarchy process development from the higher and average level to the lowest level;
3. The formation of pair-wise comparison matrix at lower levels using pair-wise comparison of the components (Table 1);
4. Matrix consistency test;
5. Integration of the weight values to obtain an optimum decision

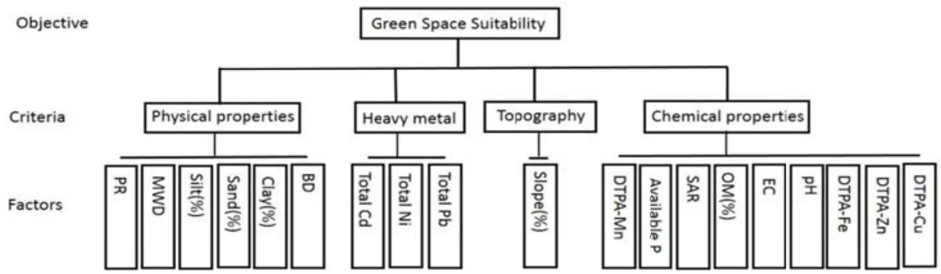

Fig. 2. Decision tree model for the AHP

Table 1. Scales for pair-wise AHP comparisons (Saaty and Vargas, 1991)

Intensity or importance	Description
1	Equal importance
3	Moderate importance
5	Strong or essential importance
7	Very strong or demonstrated importance
9	Extreme importance
2,4,6,8	Intermediate values
Reciprocals	Values for inverse comparison

For each matrix the consistency ratio (CR) which is obtained by dividing consistency index (CI) by random consistency index (RI) with the same dimension (Table 2) is a good criterion to judge the consistency of that matrix. If this value is less than or equal to 0.1, system consistency is acceptable, otherwise it is necessary to revise the judgments.

In the AHP process the components of each level are compared with their respective components in higher level pair-wisely and their weight is calculated. All comparisons in AHP process are pair-wise. These judgments are converted by Saaty (1980) into quantities between 1 and 9 as presented in Table 1 and thus the pair-wise comparison matrix is formed; the using this matrix the relative weight of the components is calculated. Equation 2 presents the pair-wise comparison matrices.

$$A = [a_{ij}] = \begin{bmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{n1} & \cdots & a_{nn} \end{bmatrix} \quad (2)$$

In pair-wise comparison matrix the weight of each component on its own is equal to 1 so all components in the pair-wise comparison matrix's diameter is equal with 1. The weight of each component relative to the other components is determined by the experts.

In this study, five experts are selected as the decision-maker according to their experience in the field of green space quality. Criteria and sub-criteria prioritization is performed based on decision makers' judgment so that the relative weight is calculated by the sum of the scores determined by all experts for various constraints by weight calculation. To calculate the relative weight of each factor in pair-wise comparison matrices first according to equation 3 by dividing each element by the sum of its column the paired comparison is normalized and in other words the resulting matrix is a normalized matrix.

$$a_{ij}{}^{*} = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}} forallj = 1, 2, \dots, n \quad (3)$$

Where n = No. of elements of a column.

Then by averaging each row of the normalized matrix the weight of elements intended to determine the quality of green space is obtained by equation 4.

$$W_i = \frac{\sum_{j=1}^{n} a_{ij}{}^{*}}{n} foralli = 1,2, \dots, n \quad (4)$$

Equation 5 presents the relationship between pair-wise comparison (A) and weight vector (W) (Saaty, 1980).

$$AW = \lambda_{max} W \quad (5)$$

λmax is the significant validating factor for pair-wise comparison used to calculate the consistency index according to equation 6 in AHP. In this equation n is the length of the comparison matrix obtained by Table 2.

$$CI = \frac{\lambda_{max} - n}{n - 1} \qquad (6)$$

Then, CR can be calculated using Equation 7.

$$CR = \frac{CI}{RI} \qquad (7)$$

Where: RI is calculated by a random pair-wise comparison matrix (Table 2). The CR calculated in this study for soil physical properties, soil chemical properties, heavy metals and topography criteria are 0.0435, 0.0324, 0.0642 and 0.0567, which suggests all matrices are compatible.

With the help of calculated weight for the criteria and covering the weights by GIS the green space quality index map is set. In this study land quality classification is according to the experts' opinion. Hence, low quality represents land units with high limitations for green space. Moderate quality also indicates land units that have some limitations and high quality land units that have no restriction for green space. Therefore the quality map is prepared and the percentage of each quality class is calculated by ArcGIS software 10.

Table 2. Random consistency index(RI) (Saaty, 2000)

N	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.53	1.56	1.57	1.59

3. Results and Discussion

3.1. Soil physical suitability

The descriptive statistical outline of the accessible information set for soil physical properties of western and eastern sides of Karun river is introduced in Tables 3 and 4, separately (clay, silt, sand, bulk density, and penetration resistance). As indicated by the Soil Taxonomy, the predominant soil textures in western and eastern sides are resolved as sandy loam and sandy clay loam in surface layer (0-30 cm), separately (Table 3). Sandy loam texture was just seen in subsurface layers (30-60 cm) in riverside parks (Table 4). The average values of sand and clay content in eastern side were significantly 1.70 and 0.83 times more than those for western side in surface layer, individually. Considering Table 3, soils of western and eastern sides were appeared to contain more than 68.4 and 57.1% sand in their surface layers, separately. The particle size distribution of subsurface layer is the same as surface layer in this study region (Table 4). According to Key (1982) it became clear that inactive sand particles not only do not help to establish a stable structure but also reduce storage of plant-available moisture by excessive drainage and aeration (Jim, 1998b, c).

The mean of BD in surface and subsurface layers of western side samples were 1.62 g/cm^3, (ranging from 1.06 to 1.90 g/cm^3) and 1.63 g/cm^3, (ranging from 1.33 to 1.90 g/cm^3), separately. The average amounts of BD in eastern side were significantly 1.061 and 1.073 times more than those for western side in surface and subsurface layers, separately. The bulk density greater than 1.60 grams per square centimeter in coarse-textured soils is an obstacle to root development (Foil and Ralston, 1967, Heilman, 1981; Landon, 1991). Subsequently, the soils of eastern side surpassed this critical limit significantly than the western side; consequently, they are not very much adjusted for normal plant development. Jim (1993) showed that in urban soils compaction is within the range of 1.4 square centimeters to 2.2 square centimeters. Henceforth, because of high BD, restrictions have been found in water storage capacity, aeration and drainage for root development (Jim, 1998 b, c). BD was set up as the significant restricting variable of soil physical suitability in this area (Fig.3b). The outcomes revealed that if there should be an occurrence of BD under half of the study region has no restriction for green space (Table 5).

Another parameter showing soil compaction is penetration resistance (PR) which depends on the estimation of the most noteworthy infiltration resistance of a cone over a distance of about 10 cm such as hand penetrometer apparatus. PR has its minimum, maximum, mean and standard deviation figures of 1.36, 5.5, 3.8, 1.10 and 2.10, 5.4, 4.5, 0.9 MPa in western and eastern part of riverside parks, separately (Table 3). The average value gotten for PR in western side was significantly 1.18 and 1.17 times as great as those for eastern side in surface and subsurface, respectively. Our outcomes are consistent with past studies that have stated that higher PR was obtained by increasing BD in urban soils. Wuddivira et al. (2013) uncovered that PR is increased by midrange clay concentration. Clay content affects the PR dynamic by changing the cohesiveness of soil particles and its structural stability (Blanco-Canqui *et al*., 2005).

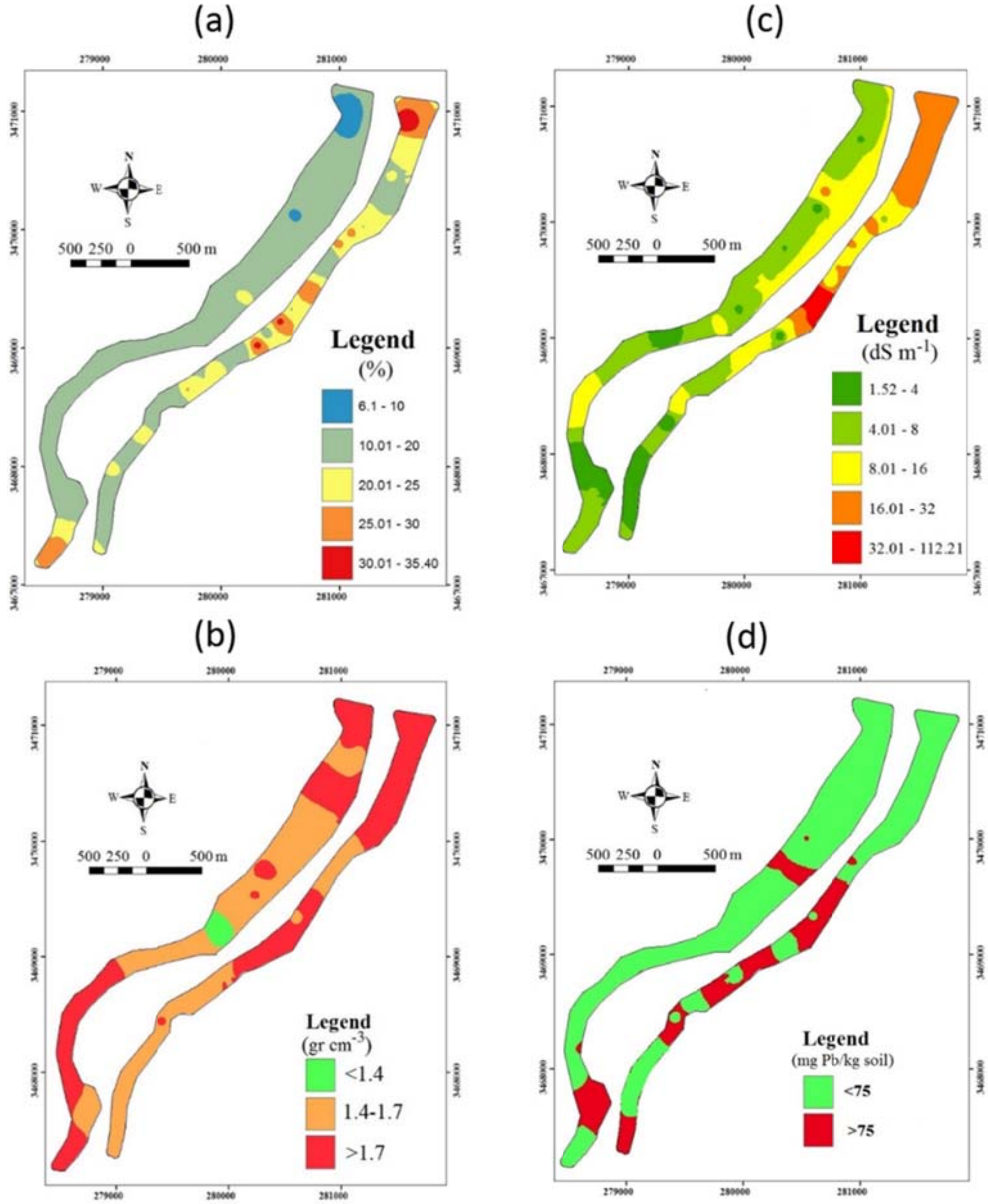

Fig. 3. Land suitability Map of the a) Clay particle, b) Soil bulk density (BD), c) Soil electrical conductivity (EC), d) Total lead of soil, in Ahvaz riverside parks

Aggregate strength against breakdown while it is under the influence of destructive forces like raindrops impact on soil surface and mechanical manipulation, indicates aggregate stability (Quirk, 1978). MWD (mean weight diameter) has its mean and standard deviation figures of 0.38, 0.17 and 0.33, 0.05 mm in surface and subsurface layers of western side, individually (Tables 3 and 4). This pattern of MWD has been seen in both layers in eastern side of the river. In the soils with low organic matter and high clay content and SAR, aggregate stability decreases (Jim, 1998a-c). The pedagogical structure of most specimens is single-grained which is inadequately developed. Because of the absence of cement materials and insufficient operation of structuring processes, minimal common aggregation can be created. The outcomes reported by Troeh *et al*. (1991) uncover that clay size particles under 15% threshold limit is to be expected for stable

Table 3. Summary of statistics (maximum, minimum, average and coefficient of variations, CV) for soil properties and topographic attributes in soil surface (0-30 cm)[a]

Properties	Parameter	Fraction	Western				Eastern			
			Maximum	Minimum	Average	CV	Maximum	Minimum	Average	Maximum
Physical	Clay(%)	-	25.00	4.50	12.94a	4.55	41.50	9.50	22.72b	8.33
	Silt (%)	-	33.50	5.50	18.68a	7.81	29.50	5.50	20.22a	6.42
	Sand (%)	-	89.50	41.50	68.38a	11.94	85.00	33.00	57.06b	13.05
	BD(g cm^{-3})	-	1.90	1.06	1.62a	0.19	2.04	1.52	1.72b	0.11
	PR(Mpa)		5.50	1.36	3.80a	1.10	5.40	2.10	4.50b	0.90
	MWD(mm)	-	0.90	0.06	0.38a	0.17	0.46	0.13	0.32a	0.08
Chemical	pH	-	8.20	7.42	7.79a	0.19	8.44	7.02	7.40b	0.37
	EC(dSm^{-1})	-	17.55	1.38	5.80a	3.71	128.10	1.48	17.12b	24.83
	SAR	-	44.33	17.33	24.62a	6.93	40.60	11.81	25.38a	6.52
	OM(%)	-	5.51	0.106	1.24a	1.04	3.48	0.06	1.47a	0.81
	P (ppm)	Olsen phosphorus	110.67	9.77	25.30a	20.45	32.90	7.20	16.89a	6.73
	K (ppm)	Water soluble	46.90	7.70	20.33a	10.02	93.30	10.10	43.64a	27.46
	Zn(ppm)	DTPA-extractable	5.05	0.17	0.77a	0.96	7.86	0.26	1.64b	1.80
	Cu(ppm)	DTPA-extractable	12.37	0.38	1.45a	2.30	7.05	0.24	1.77b	1.39
	Fe(ppm)	DTPA-extractable	39.95	3.19	8.56a	6.86	22.64	4.98	9.57a	4.97
	Mn(ppm)	DTPA-extractable	20.26	9.60	15.52a	2.65	25.86	0.41	17.41a	5.59
Heavy metal	Ni(ppm)	Total	44.40	15.96	28.55a	6.90	51.16	15.86	30.38a	8.06
	Ni(ppm)	DTPA-extractable	1.81	0.33	0.99a	0.36	2.17	0.33	1.11a	0.42
	Cd(ppm)	Total	2.41	1.23	1.71a	0.28	3.07	1.14	1.84a	0.42
	Cd(ppm)	DTPA-extractable	0.21	0.01	0.09a	0.05	0.32	0.001	0.12a	0.07
	pb(ppm)	Total	108.34	61.51	68.05a	8.93	170.29	57.61	81.53b	22.62
	pb(ppm)	DTPA-extractable	2.67	0.27	0.60a	0.46	5.85	0.07	1.29b	1.18
Topography	Slope(degree)	-	2.00	0.50	0.80a	0.20	18.00	2.00	7.40b	4.05

BD: bulk density; PR: penetration resistance; MWD: mean weight diameter; EC: electrical conductivity; OM: organic matter; SAR: sodium absorption ratio.
Figures followed by similar letters in each column are not significantly different at $p < 0.05$ (LSD).

Table 4. Summary of statistics (maximum, minimum, average and coefficient of variations, CV) for soil properties and topographic attributes in soil subsurface (30-60 cm)[a]

Properties	Parameter	Fraction	Western				Eastern			
			Maximum	Minimum	Average	CV	Maximum	Minimum	Average	CV
Physical	Clay(%)		28.50	4.50	15.70a	6.21	31.50	10.50	18.52a	5.64
	Silt (%)		29.50	5.50	14.78a	6.20	31.50	6.00	18.90a	6.6
	Sand (%)		87.50	42.00	69.16a	11.88	83.50	43.00	62.58a	11.37
	BD(g cm^{-3})		1.90	1.33	1.63a	0.15	2.08	1.42	1.75a	0.13
	PR(MPa)		5.70	1.30	4.10a	1.17	5.85	2.52	4.80b	0.90
	MWD(mm)		0.42	0.25	0.32a	0.052	0.45	0.15	0.32a	0.07
Chemical	pH		8.17	7.70	7.97a	0.13	8.08	7.01	7.39a	0.29
	EC(dSm^{-1})		19.86	1.77	6.61a	4.17	84.10	1.52	14.31a	15.82
	SAR		45.30	11.07	22.78a	6.67	55.95	15.91	26.98a	8.65
	OM(%)		1.94	0.34	0.90a	0.50	2.38	0.23	1.25a	0.65
	P (ppm)	Olsen phosphorus	43.91	7.12	15.20a	8.81	34.96	7.20	14.01a	5.90
	K (ppm)	Water soluble	48.60	4.90	20.06a	10.74	96.00	6.40	37.80a	21.29
	Zn(ppm)	DTPA-extractable	2.76	0.08	0.52a	0.57	8.87	0.46	1.34a	1.10
	Cu(ppm)	DTPA-extractable	2.32	0.46	1.05a	0.46	3.01	0.27	1.49a	0.64
	Fe(ppm)	DTPA-extractable	37.68	4.65	9.77a	6.22	18.67	3.44	8.63a	3.78
	Mn(ppm)	DTPA-extractable	24.42	8.78	16.70a	3.24	28.36	8.29	19.29a	5.07
Heavy metal	Ni(ppm)	Total	48.81	11.64	28.08a	7.51	45.49	21.06	30.80a	5.45
	Ni(ppm)	DTPA-extractable	2.04	0.11	0.96a	0.39	1.87	0.60	1.08a	0.28
	Cd(ppm)	Total	2.50	1.15	1.72a	0.38	4.06	1.23	1.86a	0.62
	Cd(ppm)	DTPA-extractable	0.23	0.00	0.09a	0.06	0.49	0.01	0.12a	0.10
	pb(ppm)	Total	103.35	61.06	66.78a	8.10	130.82	58.34	76.65b	16.03
	pb(ppm)	DTPA-extractable	2.41	0.24	0.54a	0.42	3.82	0.10	1.04b	0.83

BD: bulk density; PR: penetration resistance; MWD: mean weight diameter; EC: electrical conductivity; OM: organic matter; SAR: sodium absorption ratio
Figures followed by similar letters in each column are not significantly different at p b 0.05 (LSD).

Table 5. Areas and their Statistical descriptions under the three suitability categories

Factor	Class	Maximum	Minimum	Average	CV	Area (km^2)	Area (%)
EC	Low	5.00	1.52	3.66	4.07	36.95	16.50
	Moderate	10.00	5.00	7.19	5.10	107.84	48.14
	High	84.06	10.00	16.54	1.72	79.21	35.36
BD	Low	1.40	1.06	1.31	18.71	5.51	2.46
	Moderate	1.70	1.40	1.62	27.00	112.14	50.06
	High	2.04	1.70	1.77	29.50	106.34	47.48
Pb	Low	75.00	57.62	68.87	24.95	167.86	74.95
	Accumulated[a]	170.26	75.00	90.47	5.34	56.12	25.05
Clay	Low	10.00	4.50	8.08	5.61	11.66	5.21
	Moderate	20.00	10.00	15.19	6.23	155.60	69.47
	High	41.50	20.00	25.74	6.37	56.73	25.32
Chemical	Low	35.00	0.06	28.08	5.27	68.43	30.55
	Moderate	50.00	35.00	43.34	9.78	102.53	45.78
	High	92.60	50.00	58.29	7.76	53.03	23.67
Physical	Low	40.00	4.30	29.31	2.99	36.82	16.44
	Moderate	60.00	40.00	49.58	9.01	114.51	51.12
	High	96.70	60.00	69.90	7.89	72.66	32.44
Heavy Metal	Low	40.00	15.53	32.07	13.71	186.64	83.33
	Accumulated[a]	87.11	40.00	47.96	5.72	37.35	16.67
Suitability	Low	35.00	20.00	32.81	27.34	77.38	34.54
	Moderate	55.00	35.00	46.10	18.44	126.77	56.59
	High	95.10	55.00	65.21	23.29	19.85	8.86

[a] Accumulated: denotes that the land unit is in accumulate risk

aggregates for create the poor state of soil structure. Jolt and Koenigs (1972) likewise set up the deficiency of organic matter; the further abridges aggregation and ped conservation. This outcome is in concurrence with the findings of Jim (1998a-c).

Figure 4a presents the suitability and land quality in the area under study based on soil physical properties. The results show that 32.44% of the total study area, as can be seen in Table 5, has high quality for green space and 16.44% of the total area has low quality. Results also showed that in terms of physical quality the western part has higher quality than the eastern region.

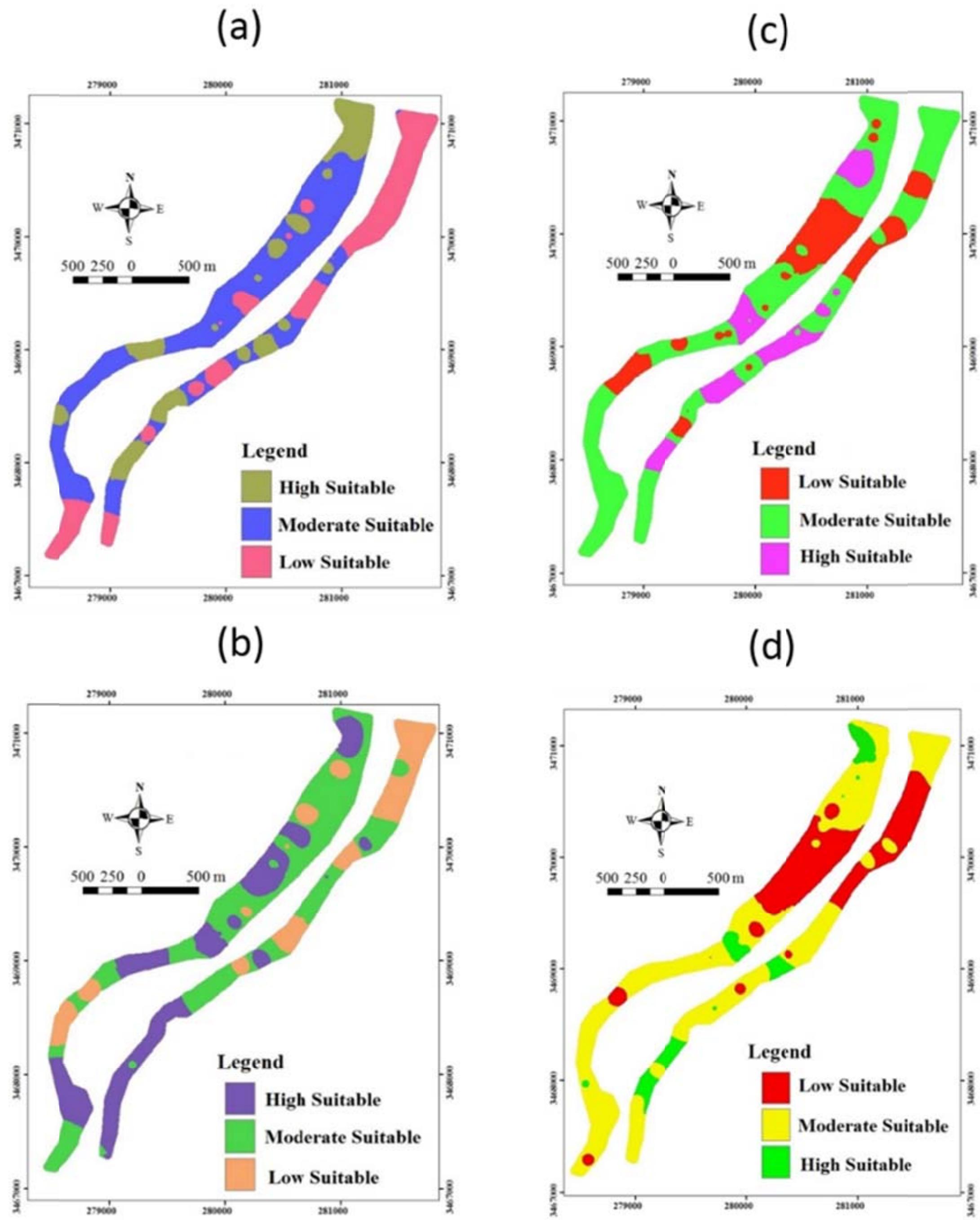

Fig.4. Land suitability map for green space of Ahvaz riverside parks in terms of a)soil physical, b)soil chemical, c)soil heavy metal and d) overall

3.2. Soil chemical suitability

Soil chemical factors are composed of soil reaction, electrical conductivity (EC), sodium absorption ratio (SAR), soil organic matter (SOM), Olsen phosphorus, water solubility soluble K^+ and DTPA-extractable of Fe, Zn, Cu, Mn (Tables 3 and 4). As expected, the soils in Khozestan region were alkaline (mean pH of all soils: 7.39-7.97) and have high EC (dS m^{-1}) and SAR contents ranging from, 1.38-17.55, 17.33-44.30 and 1.48-128.10, 11.81-40.60 in western and eastern sides of river, respectively (Table 3). The average values achieved for SAR and EC in eastern side were significantly, 1.03 and 2.95 times higher than those for western side in surface layer, respectively (Table 3). Thus, these soils are saline-sodic (EC>4 dSm^{-1}, SAR>13 and pH=8) normally formed because of low precipitation and high evaporation rates in arid and semi-arid areas of value Khozestan region. Evaporation moves the salt in ground water to the soil surface, thus the water with low salt levels leads to accumulation of salt in the soil surface due to intense evaporation. In this situation, salts entering the soil as the result of capillary rise property of saline water, precipitation, rock weathering and chemical contamination lead to soil salinization. In Khozestan region all phases of plant growth including germination, vegetative growth and reproductive growth are influence by high evaporation in this region. Ion toxicity and oxidative stress in plants are caused by to soil salinity which reduces water uptake of soil. Sodium, chlorine and boron are among the elements that have toxic effects on plants. Munns (2002) also showed that an increase in osmotic stress in the cell walls leads to cell death due to the high accumulation of sodium. Blaylock et al (1994) also showed that too much salt in soil leads to an imbalance of nutrient and some nutrients' uptake by the plant. Some soil physical properties such as surface crusting, dispersed aggregates and soil aggregation are varied under high SAR and these factors have negative impact on water storage capacity, infiltration rate, hydraulic conductivity and seedling emergence. Toxicity and specific ion deficiencies are among the chemical effects of high sodium content of soil. Thus, there is nearly no vegetation cover on urban parks in Ahvaz because of saline-sodic condition in soil. Soil salinity is the key limiting factor for soil chemical suitability in this area (Fig.3c). The findings showed that less than 35.36% of the studied area has no soil salinity restriction for green spaces (Table 5).

SOM (soil organic matter) has its mean and standard deviation figures of 1.24, 1.04 and 0.90, 0.50% in surface and subsurface layers in western side, individually. This pattern was seen in both layers in eastern side of river.

According to Craul (1999) leaves and grass can be considered as soil organic matter storage. The results of Cotrufo *et al*. (1995) and Zhu and Carreiro (1999) show that organic matter in urban soils is reduced by land use. Craul (1993) also showed that soil organic matter content of urban soils is less than 1% while forest soils have 4-5% organic matter (Craul, 1993; Jim, 1998a). Soil structural formation and its conservation are not possible without organic matter as aggregating factor. Lack of nutrients such as nitrogen and phosphorus is more evident in soils with low organic matter.

Olsen phosphorous (P) changed from 9.77-110.67, 7.12-43.91 and 7.20-32.90, 7.20-34.96 mg/kg in western and eastern side of river in surface and subsurface layer, separately. Soil salinity influence on P deficiency and significantly decreases plant phosphorus uptake as phosphate ions precipitate with Ca ions (Bano and Fatima, 2009). Nevertheless, none of the soils tested in this research have less than the critical limit of P availability (<6mg P/kg soil) (Malakouti, 1993).

DTPA-Zn and Cu shifted from 017-5.05, 0.38-12.37 and 0.26-7.86, 0.24-7.05 in western and eastern side of river in surface, individually (Table 3). The texture of sandy clay loam in eastern side of our study contained fundamentally more DTPA-extractable Zn and Cu than the texture of sandy loam in western soils, separately (Fig.4c). Previous analysts reported that Zn in clay particles is three times more than Zn in sand particles (Katyal and Sharma, 1991). In addition, the increase in total Zn has been confirmed in fine-textured soils (Frank et al, 1976). Given the negative relationship between the amount of sand and DTPA-Zn it is expected that the available Cu is reduced in the eastern river compared to the western part due to the coarse texture. In this study, a significant relationship is found between Cu, DTPA-Zn and clay content which is consistent with the results obtained by Katyal and Sharma (1991).

The average and standard deviation of Fe and Mn in the surface and subsurface layers of the western part are 8.56, 6.86; 15.52, 2.65 and 9.77, 6.22; 16.70, 3.24, separately (Tables 3 and 4). This trend is observed in both surface and subsurface layers of the eastern part of the river. Since there is a relationship between soil properties and DTPA-Fe (Katyal and Sharma, 1991), Fe deficiency in calcareous and alkaline soils can be a serious challenge. Mortvedt *et al.* (1997) also showed that the loss of soil organic matter exacerbated soil Fe deficiency and the organic matter as the main source of the forms is available to the plant. Similar to Fe, available Mn is significantly reduced. Soil pH is known as one of the key factors affecting the amount of bioavailable manganese in soils (Lindsay & Cox, 1985).

According to Zn DTPA (Tables 3 and 4) content and critical limit of this element (<2 mg Zn/kg soil) which determined by DTPA method by Lindsay and Norvell (1978), it became clear that there is zinc deficiency in the beach parks which is consistent with Malekoti (2008); Malakoti showed that zinc deficiency exists in most soils in Iran. According to the critical limit of Fe (<10 mg Fe / kg soil) obtained by DTPA, it is clear that beach parks are faced with Fe deficiency except for ten points that had available Cu (<1 mg Cu / kg soil).

Just 10 benchmark soil showed values beneath the basic availability limits for each of Cu (<1 mg Cu/kg soil). In this study, Mn available to all soils is higher than manganese critical limit (<7mg Mn / kg soil). The results of the study indicate Fe, zinc and copper deficiency in calcareous soils in riverside parks which is consistent with some previous studies (Entezari *et al*., 2007). Figure 4b is the map related to land suitability on the basis of chemical parameters. Results of Table 5 shows that 23.67% of the total area has high quality for green space and 30.55% are inappropriate for green spaces.

3.3. Soil heavy metal suitability

Table 3 and 4 summarize soil heavy metal elements (total and DTPA-extractable of Ni, Cd and Pb). The soil total concentrations of Ni, Cd and Pb varied from 15.96-44.40, 1.23-2.41, 61.51-108.34 and 15.86-51.16, 1.14-3.07, 57.61-170.29 mg kg^{-1} in surface soil of western and eastern side of river, respectively (Table 3). The entire soil samples had an alkaline pH and a significant amount of calcium carbonate (39±10%) of which both parameters could reduce bioavailability of heavy metals in soil. However, the concentrations of metals such as Ni and Cd were not high and might be lower than the threshold value for Ni (<530 mg Ni /kg soil) and Cd (<8 mg Cd/kg soil) of these soils (Iranian Environmental Protection Agency, 2012). Although, compared to the reference background values of Iranian environmental protection agency (Tables 3 and 4), moderate accumulations were found for Pb (<290 mg Pb/kg soil) in riverside parks. The average values achieved for total and DTPA- extractable Pb in eastern side was significantly, 1.19 and 2.15 times as great as those for western side in surface layer, respectively (Fig.3d). Due to surface origin point of contamination, a significant reduction in Pb with increaseing soil depth was observed. Lead in urban soils of Ahvaz originates from various origins. Pb is generally ascribed to exhaust emissions from highways, atmospheric deposition of Khozestan steel industrial company, and housing paint. Our results are consistent with the study of McClintock (2012) in urban soil of Oakland, California. One of the ways that lead to lead transmission to human body is exposure to dust. Many studies have shown that there is a direct correlation between blood Pb levels and soil Pb content (McClintock, 2012). Children due to the uptake of more than 50 percent of lead absorption compared to adults are more susceptible to lead poisoning (Laidlaw & Fillippelli, 2008; Mielke *et al*., 1983, 2007; Mielke & Reagan, 1998). Pb was the most influential element established as the major limiting factor of soil heavy metal suitability in the area. The findings showed that, 74.95% of them were highly suitable, and only 25.05% were in accumulate risk of Pb in soil (Table 5). A land suitability map was developed for soil heavy metal factors (Fig.4c) and area distribution was measured. The findings showed that just 16.67% of the area was in accumulating risk of heavy metal for green space (Table 5).

3.4. Topography suitability

Slope degree component of topography traits was utilized as a standard criteria (Tables 3 and 4) since it assumed an indispensable part in green space design in this area. Slope degree shifting from 0.5-2 and 2-18 in western and eastern side of river, separately. The most extreme designing standard indicated for a few construction projects is a slope angle of 27 degrees from the level, or a half slope (Craul and Craul, 2006). In this manner, under most moisture conditions, slope degree in the riverside parks is stable for soil materials.

3.5. Overall suitability

The comprehensive and final map of green space suitable index (GSSI) in riverside parks is shown in Figure 4d. The region that has high quality has higher GSSI and the one with low quality has lower GSSI. In general, continuous data conversion into discrete and classified information in suitability maps is based on the knowledge of experts. In this study the GSSI map of riverside parks is classified as high, medium and low quality classes.

Classifying the area under study based on GSSI can be seen in Table 5. The table results show that 8.86, 56.6 and 34.54 percent of the riverside parks have high, medium and low quality for green space. Geographically, the southern part has higher quality than the northern part.

In this study, by AHP approach 19 factors intended to determine the quality are weighted. AHP and GIS are applied for weighting factors and identifying the area under study, control the geographic information and mapping and presentation of the final results. This study showed that AHP can communicate between heterogeneous information and weight the factors by an ordered and intelligent method. This result is consistent with Akıncı *et al*. (2013), Chen (2013), Chen *et al*. (2010) Feizizadeh and Blaschke (2013) and Kumar and Shaikh (2012) who applied AHP to assess land suitability. AHP method has many advantages for land suitability and mapping to establish humane facilities, a variety of activities and environmental assessments through which suitable regions to deploy a variety of activities in the fields of agriculture, natural resources, environment soil and land capability and land evaluation can be prioritized. However, in this method the interactive relationships among the parameters can be neglected which is considered as a disadvantage of AHP method (Li *et al*., 2012).

4. Conclusion

In this study, AHP technique coordinated with GIS were utilized to assess land suitability for green space of riverside parks in Ahvaz, Iran. Four items were selected for analysis of green space suitability of riverside parks including physical and chemical properties, heavy metal of soil and topography attributes. In light of the aftereffects of the present regional investigation, direct gathering of Pb was found in soil surface of riverside parks of Ahvaz. In any case, exceptional consideration should be paid to the contamination and potential health risk of Pb. The real restricting variables of soil quality with respect to green space of riverside parks were observed to be soil compaction, micronutrient deficiency and soil salinity. Thus, addition of organic matter and micronutrient fertilizer is important to improve soil compaction and its fertility. Soil salinity is another limitation observed in riverside parks of Ahvaz. Thus, soil draining leading to improvement of soil salinity has been essential in this park. Planting of salt resistant and low water demand plants are recommended for the protection of green space in the area. The findings provide effective ways to deal with increasing soil quality and better management for green space in Khozestan. Henceforth, utilizing limitation maps of soil such as EC and BD were helpful in planting design in riverside parks of Ahvaz.

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