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Soil-Forming and Evolution Related to the Geological Formations, A Case Study of the Southern Part of Urmia Plain

Hengameh Javadi *
Mohammad Hassan Masihabadi **
Reza Sokouti ***
Ebrahim Pazira****

ABSTRACT

The objective of this article was to study the effect of geographical features and geological formations on some physicochemical properties of soils in order to better identify the soil and optimize land management for sustainable agriculture in the southern part of the plain. Urmia, with an area of 35000 (ha) in the province of Western Azarbaijan, Iran. In this investigation, satellite images, aerial photographs, topographic and geological maps were used to identify and distinguish different land forms, soil series classified based on geomorphological and geophysical methods. 30 soil profiles were drilled and the FAO standard dimensions were described. Samples were taken from five soil profiles in each genetic horizon and transferred to the laboratory. The soil moisture and temperature regime was determined as Xeric and Mesic. The soils of the studied area were classified as Fluventic Inceptisols and grid subgroups. The most dominant formations in the Barandoz and Ghasemlou river basins were limestone and lime, which is one of the determining factors in rock formation in different soils in the study area. On the other hand, physiography and topography have also played an important role, so that the upper terraces have more developed soils and some sloping regions have younger and less developed soils. With the decrease in height and proximity to Lake Urmia, the effect of the groundwater level and its salinity on the profiles is evident. Meanwhile, the river bank has young and uncovered soils due to the sediments of the current era.

KEY WORDS: Soil evolution, Urmia plain, geological formation, physiography.

*Ph.D. student of Soil Science, Department of Soil Science, Islamic Azad University, Science and Research Branch of Tehran, Tehran, Iran. CP: 5715784501, Tel :(+98) 9145505489, necklace.h@gmail.com, https://orcid.org/0000-0001-8177-9041

**Professor of Soil Science Department of Islamic Azad University, Science and Research Branch of Tehran, Tehran, Iran. CP: 1394934311 Tel :(+98) 9121307990. Corresponding author Email address: H.masih@yahoo.com, https://orcid.org/0000-0003-3650-9426

***Associate Professor, Department of Soil Conservation and Watershed Research, Agriculture and Natural Resources Research Center of West Azarbaijan, Agricultural Research, AREEO, Urmia, Iran. CP: 5717115759, Tel :(+98) 9144480614, rezasokouti@gmail.com, https://orcid.org/0000-0001-8662-9886

****Professor of Soil Science Department of Islamic Azad University, Science and Research Branch of Tehran, Tehran, Iran. CP: 1346815473, Tel :(+98) 9121860376, ebrahimpazira@gmail.com, https://orcid.org/0000-0003-0258-1710

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Formación de suelos y evolución relacionada con las formaciones geológicas, un estudio de caso en la parte Sur de la Llanura de Urmia

RESUMEN

El objetivo de este artículo fue estudiar el efecto de los accidentes geográficos y las formaciones geológicas en algunas propiedades fisicoquímicas de los suelos con el fin de identificar mejor el suelo y optimizar la gestión de la tierra para la agricultura sostenible de la parte sur de la llanura de Urmia, con un área de 35000 (ha) en la provincia de Azarbaijan Occidental, Irán. En esta investigación, se utilizaron imágenes satelitales, fotografías aéreas, mapas topográficos y geológicos para identificar y distinguir diferentes formas de tierra, series de suelo clasificadas en base a métodos geomorfológicos y geofísicos. Se perforaron 30 perfiles de suelo y se describieron las dimensiones estándar de la FAO. Se tomaron muestras de cinco perfiles de suelo en cada horizonte genético y se transfirieron al laboratorio. El régimen de humedad y temperatura de los suelos se determinó como Xeric y Mesic. Los suelos del área estudiada se clasificaron como Inceptisoles y subgrupos de rejilla de Fluventic. Las formaciones más dominantes en la cuenca del río Barandoz y Ghasemlou fueron la piedra caliza y la cal, que es uno de los factores determinantes en la formación de rocas en diferentes suelos en el área de estudio. Por otro lado, la fisiografía y la topografía también han desempeñado un papel importante, de modo que las terrazas superiores tienen suelos más desarrollados y algunas regiones inclinadas tienen suelos jóvenes y menos desarrollados. Con la disminución de la altura y la proximidad al lago Urmia, el efecto del nivel del agua subterránea y su salinidad en los perfiles es evidente. Mientras tanto, el margen de los ríos tiene suelos jóvenes y sin recubrimiento debido a los sedimentos de la época actual.

PALABRAS CLAVE: Evolución del suelo, llanura de Urmia, formación geológica, fisiografía.

Introduction

Although the study of the geological factors helps a deeper understanding of how soil formation and transformation. Few studies have been done about the role of geological formations and landforms on soil characteristics. Different characteristics of parent materials do not change at the same rate (Rabenhorst & Wilding, 1986). Over time and soil development, changes in the soil are less controlled by parent materials and are more likely to be determined by climates and topographies (Caspari et al., 2006). Under these conditions, the morphology of neighboring soils formed on different materials tends to be similar. However, the color, stratification, and reaction of materials are influenced by high-speed soil-forming processes (Buol et al., 2011). On the contrary, some of the characteristics of soil parent materials are very stable and they affect their effects on a long time on the soil.

Clay and sand materials can be made heavy and light texture soils respectively (Costantini & Damiani, 2004). Other materials which have large amounts of weather-sensitive minerals produce loamy soils. Also, the type of parent matter controls the severity of soil processes due to its effect on the texture and specific surface of the soil (Wilding et al., 1983). Generally, soil development in sandy material is faster due to better penetration of the weather, and the thickness of the soil in these materials is deeper (Schaetzl & Anderson, 2005).

Sarvak Formation is a typical example of Kermanshah limestone, which is transformed into two tectonic units of Sanandaj-Sirjan and Zagros Folded. Their constituent materials include fine-grained, intermediate-to-thick, and radial-shaped limestones, whose topography is characterized by rock outcrop and debris, shallow soil, thinness vegetation, and low erosion. In contrast, clastic and shale formations which form at the bottom of the hills, are susceptible to degradation mainly due to Marl. Formations of Amiran, Keshkan, and Ilam are parts of Gurpi, Gachsaran and Aghajari forms of this category. These formations include marl, chert, and shale with layers of limestone and conglomerate. Such formations play the greatest role in soil erosion and its various consequences including sediment production. Differences in the morphological, physical and chemical characteristics of soils reflect the difference in the chemical composition of materials (Irmak et al., 2007). The least amount of lime is found in soils from igneous formations and its maximum in soils from calcareous and dolomite formations. Marls in dry areas are considered to be material with high sensitivity to erosion and the origin of sediment production (Sheklabadi, 2000).

As a result, the degree of development of the horizons and the depth of the soil in this organization is low. Soils formed on calcareous rocks of the Cretaceous have a calcareous and petrochemical horizon more than the calcareous horizons, while in the wetter regions; the clay accumulation horizon has been formed (Rabenhorst & Wilding, 1986). Leaching, clay accumulation, carbonates, and salts were the main soil-forming process in the Azarak Basin in northeastern Jordan (Khresat & Qudah, 2006). In the Azarak region, the process of clay accumulation at a wetter time of the past has led to an increase in clay in the lower horizons and as a result of the formation of an Argillic horizon, and the state of the soil horizons are the result of the clay formation, alteration, and destruction. On the other hand (Egli et al., 2008) showed that weathering of soils is strongly related to the climate. Moazallahi and Farpoor (2009) in their studies in Kerman, the region concluded that the soil properties and many of the pedogenic properties of the soil such as the formation and deposition of calcium carbonate depend on the weather (Moazallahi & Farpoor, 2009). In arid and semi-arid regions, the types of complications of limestone and gypsum are observed. Calcium carbonate accumulation is a common characteristic and a very important soil-forming process in arid and semi-arid soils (Gunal & Ransom, 2006). Calcium carbonate is produced as a result of complex processes of dissolution, transfer; sedimentation, and re-accumulation of carbonates that are either present in soil material or from external sources that are added to the soil (Blank & Fosberg, 1990).

Owliaie et al. (2006) concluded that the physical and chemical properties of Iran's soils in a dry and semi-arid climate are completely dependent on the calcareous rock, which has been influenced by chemical and physical evacuation over time, and the existence of lime-rich soils brings. Based on geological maps in Urmia, a large part of the soils of the Urmia plain and its surrounding areas are located on quaternary sediments, and most of the agricultural, livestock and natural resources activities are concentrated in this formation (Soltani Sisi, 2005). These quaternary sediments have been expanded on two sides of Lake Urmia and cover a relatively large surface and are more uncoated to semi-hard sand and clay-sand, often forming agricultural lands and fields (Farzamnia et al., 2013). The watershed basins, the rivers leading to the Urmia plain, consist of Cretaceous and Third Age formations, especially Eocene and Miocene, which are sensitive to erosion because of their marl content. In these basins carbonate formations are characterized by different weathering processes with surface erosion, low sediment yield, mountainous geomorphology and steep slope (Ahmadi & Feiznia, 1999).

Review of the research results has shown that to preserve the land and increase the possibility of exploitation of the soil, it is necessary to provide Physico-chemical, morphological data related to the soil and to classify them so that they can be properly planned for their management in different conditions of the land. However, soil-specific studies have been conducted for analyzing the relationship between soil formation and management with geological and topographical factors are low. Therefore, this study aimed to study the effect of landform and geological formations on some physicochemical properties of soils to better identify soils to optimize land management and promote sustainable agriculture.

1. Materials and Methods

1.1. Study Area

The study area includes the southern part of Urmia plain with an area of 17000 (ha) in the West Azarbaijan Province, Iran, is located between the coordinates of 500786 and 528396 E to 4132305 and 4159466 N. (Figure 1). The height of the Urmia plain is 1,350 meters above sea level in length and the shape of the land in the study area are alluvial plain, piedmont, and the lowlands. Geologically, the catchment area is more covered by the Oligomiocene Formations, which is Permian limestone. The climate of Urmia station with an average temperature of 8.9 ° C in summer is roughly hot, and cold in winter. The rainy season begins in late October and the beginning of November and continues until May. The average long-term rainfall in Urmia (1965-2017) is 339 mm and is a total of 120 days of the frosty period.

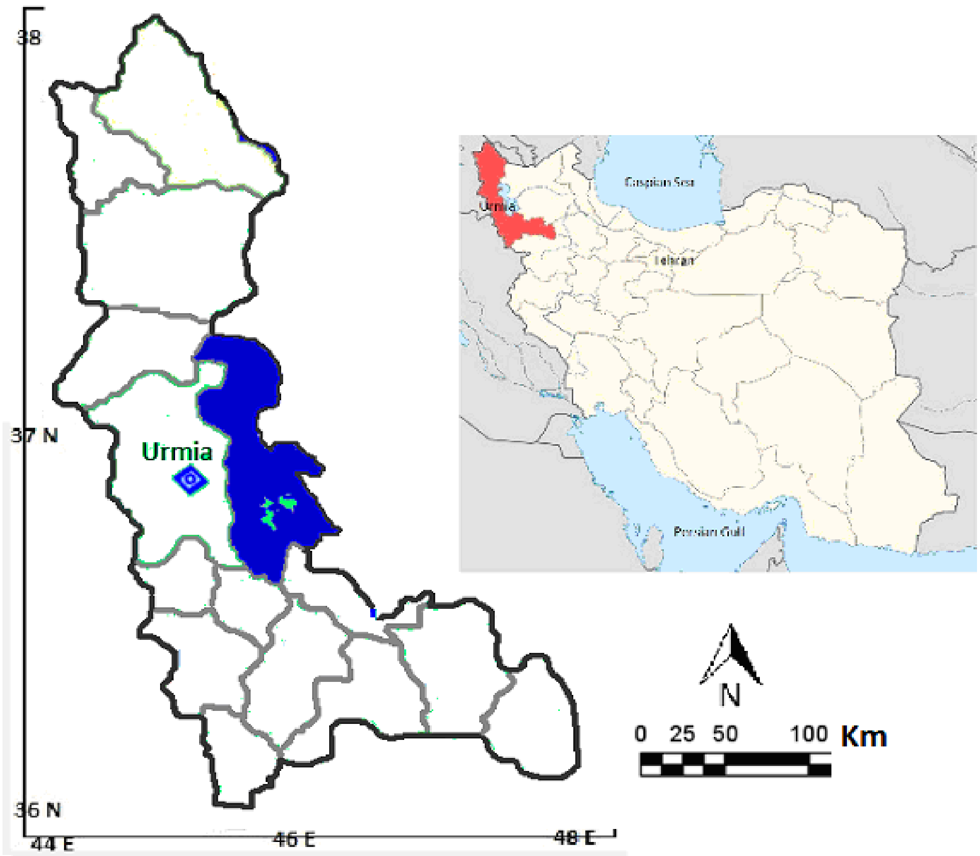


Figure 1. Location of the study area in the West Azerbaijan province

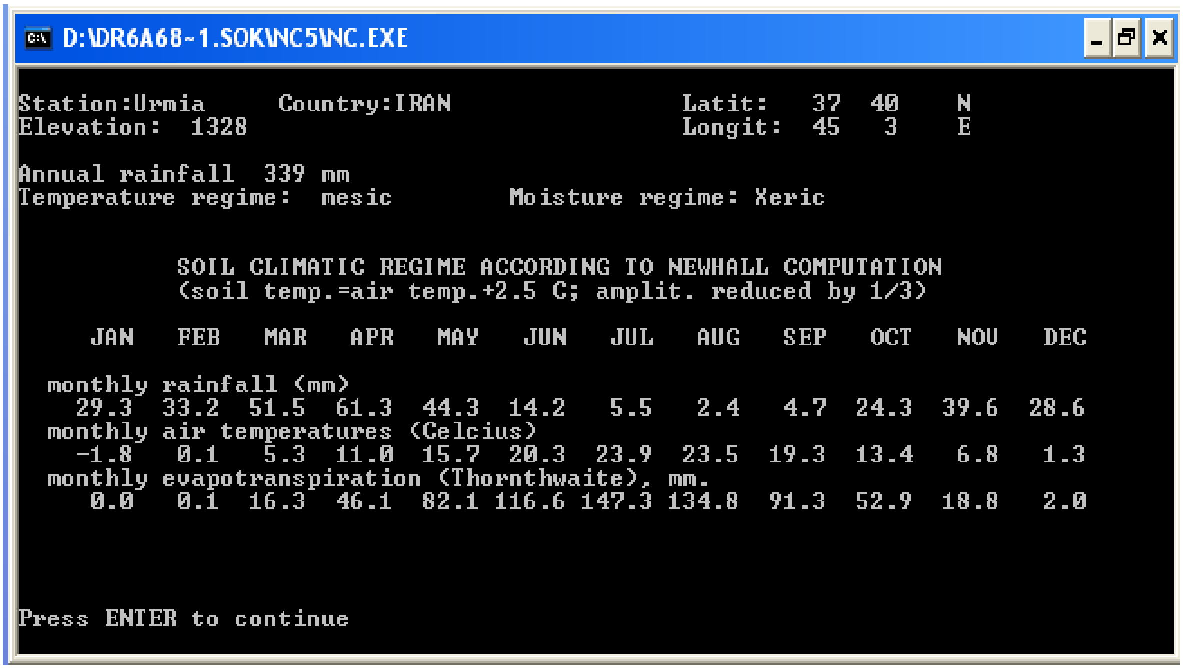
1.2. Research Method

In this research, satellite imagery, aerial photos, topographic maps, and geological maps were used to identify and distinguish different forms of land. The separation of soil series was carried out based on geomorphologic and geophysical processes. The coordinates of the study were determined from topographic maps, satellite imagery, and aerial photos and transmitted to the Global Positioning System. 30 soil profiles were drilled and described by the guidelines for soil mapping. Five soil profiles were selected and after sampling every genetic horizon, transferred to the laboratory.

The soil samples were then air-dried and passed through a 2 mm sieve. Experiments including determination of soil texture by hydrometer (Gee & Bauder, 1986), determination of bulk density by paraffin (Blake & Hartge, 1986), measurement of calcium carbonate equivalent Chloridic acid neutralization and titration with profit, Gypsum measurements by means of acetone method (Nelson, 1982), soil reaction, electrical conductivity of saturated flower extracts by conductivity method, organic matter using modified Valky and Black, capacity Cation exchange was carried out using sodium acetate (Rhoades, 1983). The classification of soils in the American classification system up to the family level was carried out based on the 2014 key (Smith, 2014).

2. Results

The basin of the Barandoz Chay River, with an area of 1203 km2, consists of two major branches, Barandoz and Qasemlou, and originates from the Dalamper, Banhool and Helaleh mountains at the borderlands of Iran and Turkey. The mainstream extends 75 kilometers westward to the east after passing the Urmia Plain Discharged to the Urmia Lake. The maximum height in this basin is 3500 meters above sea level (masl) and the minimum height at the outlet is 1250 (masl). The two rivers flow from the southwest to Urmia. Based on the average rainfall and temperature of the Urmia station, the soil moisture and temperature regime were determined as Xeric and Mesic respectively using NEWHALL software (Fig. 2).



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Station:Urmia      Country:IRAN                  Latit:   37  40    N
Elevation:  1328                                 Longit:  45   3    E

Annual rainfall  339 mm
Temperature regime:  mesic        Moisture regime: Xeric

           SOIL CLIMATIC REGIME ACCORDING TO NEWHALL COMPUTATION
           (soil temp.=air temp.+2.5 C; amplit. reduced by 1/3)

     JAN    FEB    MAR    APR    MAY    JUN    JUL    AUG    SEP    OCT    NOV    DEC

  monthly rainfall (mm)
    29.3   33.2   51.5   61.3   44.3   14.2    5.5    2.4    4.7   24.3   39.6   28.6
  monthly air temperatures (Celcius)
    -1.8    0.1    5.3   11.0   15.7   20.3   23.9   23.5   19.3   13.4    6.8    1.3
  monthly evapotranspiration (Thornthwaite), mm.
     0.0    0.1   16.3   46.1   82.1  116.6  147.3  134.8   91.3   52.9   18.8    2.0


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Figure 2. Soil moisture and temperature regime of the study area

2.1. Soils

Along the path of the Barandoz river from the catchment to the Urmia plain toward the Urmia Lake, the characteristics of the soils are as follows.

Soil 1: Soil is very deep, dark brown (10YR 4/4) with moderate texture and clay structure on a dark-browned layer (10YR 4/4) with a heavy texture and a relatively cuboid Strong structure.

The soil classified as Fine loamy, mixed-mesic - Typic Calcixerepts.

Soil 2: Very deep, dark brown (10YR 4/4) with moderate texture and clayey structure and the material is dark to dark brown (10YR 4/4) with medium texture and cuboid structure. The corner is fairly strong

The soil classification is Fine Loamy Mixed, Mesic-Fluventic Haploxeropts.

Soil 3: Soil is very deep, brown (10YR4/3) with moderate texture and clay structure on a brownish layer with a relatively strong cubic structure. The above layers are placed on a dark gray (10YR 4/2) with very heavy texture, and in the lower layer there is a grayish-gray to very dark gray (10 YR 3/4) with a very heavy texture It has a very solid cubic structure.

The classification of this soil is Fine Mixed, Mesic-Fluventic Haploxerepts.

Soil 4: Moderately deep, dark brown (10 YR 4/4), moderate texture and clay structure is located on a dark brown (10 YR 4/4) with moderate texture and weak cortical cubic structure. These layers are also on a layer with more than 75% gravel and sandy texture.

This soil classified as Loamy over sandy skeletal, mixed, mesic-Fluventic Haploxerepts.

Soil 5: Soil is very deep, dark gray (10YR 4/2) with a very heavy texture and clay structure on a very dark gray layer (10YR 3/2) with very heavy texture and building The column is fairly strong. The above classes are located on a very dark gray (10YR 3/2), medium-sized, and poorly-formed cortical structure, which is generally on a dark brown layer (10 YR 2/2) and light texture and cuboid structure with weak corners.

The classification of this soil is Fine Mixed, Mesic-Typic Haplaquepts.

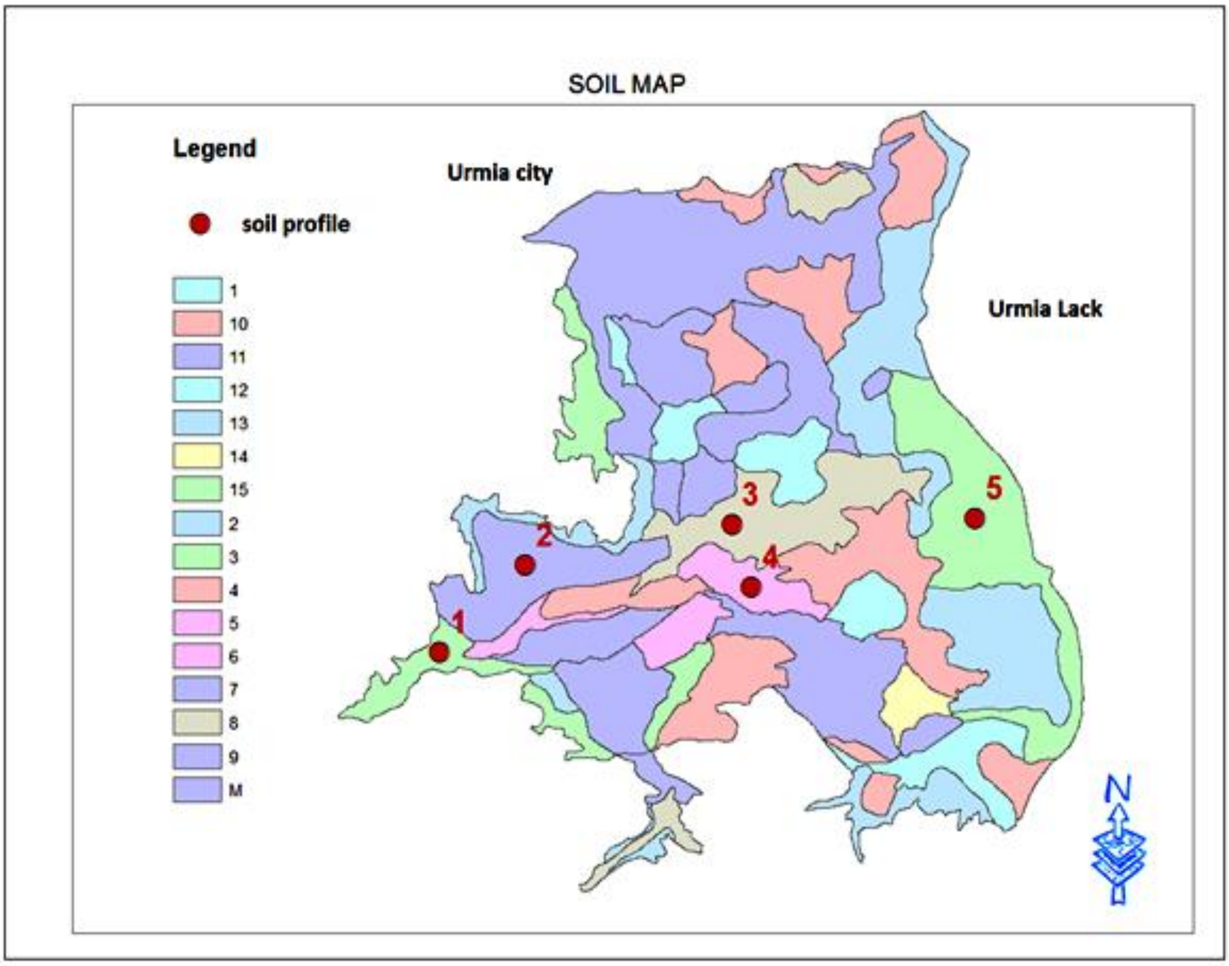


Figure 3. Soil series in the study area

Some of the physicochemical, morphological characteristics of selected soils are presented in Table 1.

Table 1. Some characteristics of the soil sample in the study area

profile	Depth (cm)	layer	texture	Ec ds/m	pH	OC(%)	TNV(%)	SAR
1	0 - 20	AP	L	0.59	7.9	0.83	11.0	
	55	Bw1	CL	0.62	7.8	0.51	23.5	
	135	Bk1	CL	0.35	7.9	0.18	11.0	
2	0 - 20	Ap	L	0.46	7.9	1.19	5.5	
	50	Bw1	L	0.34	7.9	0.59	4.0	
	80	Bw2	L	0.32	8.0	0.59	4.5	
	130	Bw3	L	0.40	8.0	0.61	4.5	
3	0-30	AP	SiL	2.11	7.6	1.17	13.3	
	60	Bw1	Cl	1.14	7.9	1.17	16.3	
	100	Bg1	SiC	1.01	8.0	0.84	19.8	
	145	Bg2	SiC	0.97	8.2	0.43	15.8	
4	0-30	AP	L	0.83	7.6	0.88	19.0	
	55	Bw1	L	0.61	7.9	0.50	19.5	
	130	Cz	S	0.69	7.9	0.40	14.3	
5	0-30	A	SiC	28.04	8.0	1.52	27.0	70
	80	Bg1	C	24.7	8.3	0.44	22.5	87
	130	Bg2	SiL	10.97	8.4	0.02	29.3	61
	150	Bg3	SL	9.47	7.9	0.17	19.0	59

2.2. Geological formations

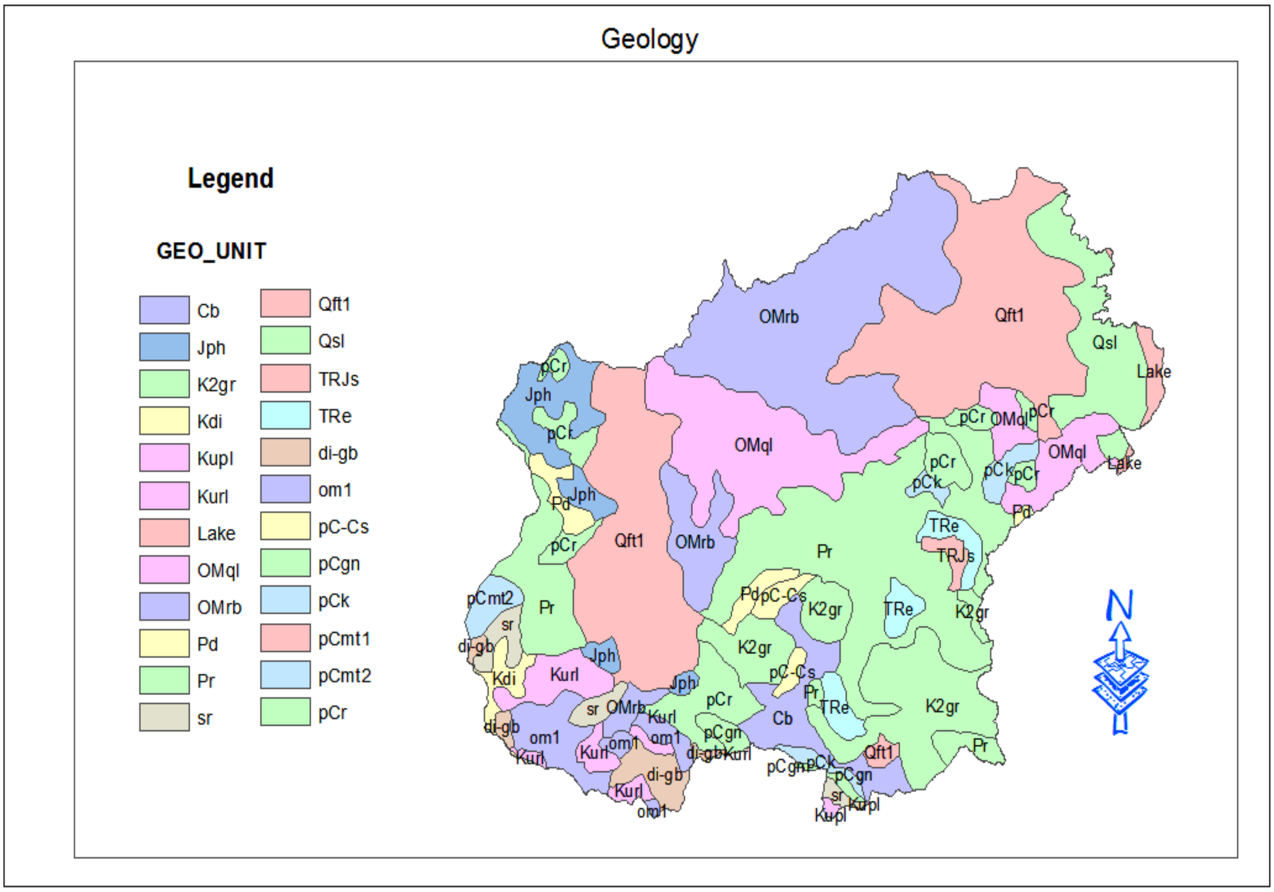
Formations in the region include the southern part of Urmia Plain and the highlands of the Barandoz chay River catchment have a variety of sedimentary rocks including dolomitic limestone and Permian limestone such as the Ruteh and Mila formations along with the new Quaternary sediments in the Urmia plain (Fig. 4).

The igneous rocks, such as granite without age, are also exposed in parts of the region that are highly tectonized and crushed. The function of these granite influences on most limestone rocks has also led to adjacent alterations. The Colored Mélange of Ophiolite complexes is also found in the region, which is, in fact, a collection of rocks and ultrasonic layers. The Colored Mélange is seen in the main branches of the Barandoz River catchment and the mountainous highlands of Buz-sina.

Ruteh Formation consists of Permian deposits composed of fine-layered, fine-grained lime and dolomitic lime, which is found in the eastern and western parts of the Barandoz catchment, which branches originate from the mountain peaks of Helaneh.

The Mila Formation is one of the geological formations that include dolomite, limestone, shale, and marl, and is dispersed in the upstream areas and western branches of Barandoz, parallel to the Iranian border with Turkey.

Young alluvial deposits, consisting of a series of coarse deposits (rock blocks, coarse and fine rubble, sand and clay). The vast part of the Urmia Lake is composed of soft lake sediments that are swampy and muddy.



Guide
Cb - Baroot Formation (Shale Lime, Dolomite)
PeK - Kalhor Formation (Murad and Kalhor series)
Fm = pd - Drood Formation
TRe - Elika Formation
J ph - Hamadan fillites
Om1 - ophiolite colored mixes
OMrb - sandstone, gypsiferous marls
Pe.CS - Soltanieh Formation
Pc cr-Rizu Series
pr - Rute limestone
TR js - Shemshak Formation
K2gr – granite
OMQ1- limestone

Figure 4: Geological Formations of the Barandoz chay River catchment and Urmia Plain

Conclusion

Based on the meteorological data of the region, the soil moisture and temporal regime are determined as the Xeric and Mesic respectively. Geological surveys also showed that rock formations located at the Barandoz and Qasemlou catchments are limestone (Soltani Sisi, 2005). Although the amount of gypsum is also high in some formations, lime is one of the factors determining the rock in the formation of different soils in the region. On the other hand, physiography and topography have also played a significant role, so that the upper terraces have more developed soil and regions with a sloping land and less aging less evolved soils. With decreasing height and proximity to Lake Urmia, the effect of groundwater level and its salinity on the profiles is evident. In the meantime, the soils of the river margin and the channels have young and uncoated soils due to the sediments of the present age.

In this research, the selected five soil profiles were studied and classified in different situations and almost homogenous sequence. Selected soils clearly show how soil changes in terms of soil-forming factors including climate, parent materials, time and slope, and biological factors.

Soil 1 is located on the oldest sediments and upper terrace of the area. Given sufficient time and climate, opportunities for the formation of calcic horizons and the accumulation of lime in the middle layers were provided. Constantine and Damieni (2004) have also come up with this trend in their studies (Costantini & Damiani, 2004).

Soil 2, located in relatively old plains, has a lower evolutional soil and only the Cambic horizon is formed in the middle layers, and the effects of coherence and continuous sedimentation on these soils are still evident. These results are consistent with the findings of Mirkhani et al. (2005) and Farzamnia et al. (2013).

Soil 3 is located along with the soil 2 and has almost the same common characteristics. In these soils, the soil's low development time is poor and the effects of the sedimentation of the continuous periods are evident. Laurence et al. (2011) also found similar results in their research (Quénard, Samouëlian, Laroche, & Cornu, 2011). Soil 4 is located at the margin of the Barandoz River and has not a long time passed since their sedimentation, so the soils are well observed with coarse and fine sediments. Finally, the soil 5 located at the end of the Urmia sedimentary plain and the alluvial fan of the Barandoz River, has a very fine texture. Regarding its proximity to Lake Urmia and the high groundwater level is highly saline and Sodic. In this soil, salinity and sodium content are predominant on other soil properties and are known as saline and sodic soil. Vahidi et al. (2012) also reported similar results.

In general, what is evident in field studies and experimental results, has played an important role in the soil formation is parent materials. The lime in all soils, both geogenic and pedogenic, is of maternal origin. Lime has been the main contributor to most of the watershed formations. Formations such as Baroot, Soltanieh, Kalmard, Dorood, Elika, etc. all have a lot of lime and dolomite. Gypsum is also found in some basin rocks that are likely to be transported to the underlying layers and are not dominated by profiles, especially in higher elevations.

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