Basrah Soils; Geochemical Aspects and Physical Properties- A Review

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Abstract

The sediments of Basrah soils are mainly clayeysilt and siltyclay with subordinate amount of sand. Starting from Qurna toward Arabian Gulf, the sand fraction decreases and silt size increases downstream. The fine textures of these soils aided in retain water in soil and development of salt crust under high degree of evaporation. And hence the development of saline soils mainly in low land area. Basrah Soils are characterized by their wide spectrum of mineralogical composition, non-clay minerals(Calcite, dolomite, Quartz , halite , gypsum and feldspar), clay minerals (Kaolinite, Illite, Montmorillonite, Palygorskite, Chlorite, and Mixed-layred clay minerals), and heavy mineral (Opaque, pyroxene, hornblende, chlorite, biotite, epidote, garnet, Kyanite, staurolite, celestite, zircon and tourmaline).The organic matter content has wide range in present soils, it is amount depends upon the intensity of vegetation cover and the rate of plant remains oxidation. The detrital supply of clastic materials controlled the concentration of silica and aluminum, plant nutration controlled the concentration of Fe and K, climatic condition and hydrogologic setting controlled the accumulation of Na, Ca and Mg in Basrah soils. The values of major elements in Basrah saline soils survive seasonal fluctuations because of precipitation and dissolution alternative processes.

ترب البصرة:الملامح الجيوكيميائية وخواصها الفيزيائية

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الخلاصة

ترب البصرة ذات أنسجة غرينية طينية و طينية غرينية مع كميات قليلة من الرمل. بدأ من القرنة نزولا باتجاه الخليج العربي الجزء الرملي للرسوبيات يقل بينما يزداد الجزء الغر ين ي. النسيج الناعم لهذه الترب ساعدها على الاحتفاظ بالماء لفترة طويلة تحت ظروف التبخر العالي وساعد بالتالي على نشوء الترب الملحية لا سيما في المناطق المنخفضة. تمتاز ترب البصرة بوجود طيف واسع من المحتوى المعدني: المعادن اللاطينية (الكالسايت و الدولومايت والجبس والهالات والكوارتز والفلدسبار) والمعادن الطينية (الكاؤلينايت والالايت و المونتموريللونايت و الباليغورسكايت و الكلورايت والطبقات الطينية المختلطة) والمعادن الثقيلة (المعادن المعتمة و البايروكسين و الهورنبلند و الكلورايت والبايوتايت و الابدوت و الغارنيت والكايانايت و والستورولايت و والسيلستايت و الزر كون والتورمالين). كمية المادة العضوية في التربة قيد الدراسة ذات مدى واسع و تعتمد على كثافة الغطاء النباتي و معدل أكسدة البقايا النباتية. كمية المواد الفتاتية المجهزة لمنطقة البصرة تتحكم بتراكيز السليكا والألمنيوم، تغذية النباتات تتحكم بتراكيز الحديد والبوتاسيوم، كما تتحكم الظروف المناخية بتركيز الكالسيوم والمغنسيوم و الصوديوم في ترب البصرة، عموما تراكيز العناصر في ترب البصرة تعاني من التغايرات الفصلية بسبب عملية الإذابة والترسيب المتعاقبة.

Introduction

Basrah area has simple topographic features; the regional slope is about 26.7 cm/ km with a general southeast trend toward the Arabian Gulf (Al-Khaiat, 2002). Kareem (1992) pointed out that there are six geomorphological units in Basrah area; River levees, estuarine river levees, silted tidal flats, Tidal flats, Marshes and swamp deposits, and Dune sand. Based on the tectonic subdivision of Iraq, Basrah area occurs with the Zubair Subzone (Buday and Jassim, 1987).

Quaternary sediments in Basrah governorate have large Arial extent. These sediments contributed by Tigris and Euphrates Rivers, as well as, Dust fall out. According to parson(1957), the plain is built up mostly of deltaic, lacustrine and fluviatile sediments connected mutually by many facial variations and replacing each other horizontally and vertically as a result of periodical repeated phases of accumulation and erosion, moreover, Kukal and Saadllah (1970), proved the existence of some brackish – estuarine deposits within the Mesopotamia Quaternary sequence.

From metrological point of view, the climate of lower Mesopotamia is arid with dry summer and cooler winter, the rain is irregular and falls only during winter, the average annual precipitation in Basrah area is about 140 mm, and evaporation from 50 to 250/600 mm a month (January and July means) (Plaziat and Younis,2005). The ground water flow in Lower Mesopotamia basin is toward southeast i.e. toward Arabian Gulf., this water exhibit a seasonal and spatial variation according to geological, hydrological and environmental impact (Al-Khaiat, 2002). The low level of Basrah surface and the availability of much surface water such as Arabian Gulf, Marshes, Shatt Al-Basrah, and Shatt Al-Arab River and its tributaries causing the high water table level, which increases the soil salinity under high evaporation rate.

Shatt Al-Arab River and its tributaries play a major role in Basrah Plain build up, Albadran *et al*., (2002), clarify that sedimentation exceeds the erosion processes of this river. The soils of Lower Mesopotamia plain are classified as alluvial azonal soil, these soils are transported in nature (secondary soils), i.e. soils which consist of mater that is transported from the place of weathering and is accumulated somewhere else. Basrah soils are extremely calcareous (20 to 30% lime) and saline, they have completely different characteristics if compared with soils of fluviatile plains in other parts of the world (Buringh, 1960). According to Al-Taie,(1969)cited in Al-Dabagh (1988) the soil of Mesopotamia could be categorized into three groups; torrifluvents which occur on river levees, torrerts occur in low land areas, and salorthids common in the lower Mesopotamian plain.

Basrah soils is a part of lower Mesopotamia soils, so to realize their origin and the factors behind their spatial chemical, mineralogical, and textural variations we need to discuss all the available data about the soils of the area extend from Qurna at the north to the Fao in the south (Fig,1). Thus the task of the present study is to reevaluate Basrah soils in the light of available published chemical, mineralogical, textural, hydrogeological, geomorphological data.

Textural analysis

Texture is related to the size of the fragments in the soil. Grain size analysis of the soils under study showed that there is some spatial and vertical variations in grain size distribution (Fig.,1 and Fig., 2) .and indicated that the sand fraction decreases gradually down stream, whereas silt fraction increases in the same direction, this phenomenon related mainly to the water energy i.e. hydrodynamic conditions of Shatt Al-Arab River. Basrah soils could be classified as siltyclay and clayeysilt at the northern and southern part respectively. There is a notable pattern of grain size distribution along the study area; the clay fraction in northern part (Al-Medina) is relatively higher than that of southern part (Fao). The distribution pattern is more or less attributed to the flow rate of the Shatt Al-Arab River which in turn affected by the ebb and tidal current of Arabian Gulf.. There is a remarkable increase in sand fraction of the studied soils found at Jisser khalid in comparison with Qarmat Ali (Fig., 2), this fact could be attributed to meandering of Shatt al Arab and the junction of this river with Qarmat Ali River (Fig, 2). In general the spatial litholgical variation of Basrah plain is gradual rather than sharp, thus the dendritic pattern of Khor Al-Zubiar tidal flats bears witness of the lithological homogeneity of Basrah plain west of Shatt Al-Arab River.

Shatt Al-Arab Plains are characterized in general by their very low content of sand in comparison with silt and clay fraction i.e. the dominancy of fine fraction. This fact reflects the low capacity of Shatt Al-Arab River to transport sediments as suspended load due to low discharging rate. In addition to dust storms which contribute a considerable amount of silt fraction to the Basrah area, dust storm are very common phenomenon in the desert areas surrounding the Arabian Gulf, the dust phenomena are more frequent in summer, especially during June and July, Foda *et al.,* (1985) estimated dust sedimentation rates in Arabian Gulf of 0.8 mm/year.

Chemical composition

Organic matter (O.M) in soils plays a major role in enhancing the agricultural ability of soils. The amount of O.M in soils depends upon temperature, soil moisture, and rain fall (Al-Nuaimi, 1990 in Al-Mossawi, 2005). Basrah soils are generally posses low amount of O.M except at Al-Mudiena area where there is high percent of O.M were recorded (12-22%, with an average value of 19%) (Al-Taih, 1998). Most of Basrah Soils are poor in O.M. which could be related to aridity of the climate which in turn causing the decreases of soil moisture and oxidizing the O.M mainly during dry season. Nevertheless, high percent of O.M were detected in Al-Mudiena area due to their high plants remains contents possibly because they are represent the basin of ancient marsh, inasmuch as marshes are usually heavily cultivated. It is worth to be mentioned that high O.M content (more than 2%) effect the engineering properties of soil i.e. the strength and compressibility of soils as illustrated by Mahmood (1997).

Soil pH plays a major role in soil fertility and plant nutrition. Because of its active role in the elemental mobility and cation exchange capacity (C.E.C) between plant roots and the surrounding medium, the optimum condition for C.E.C took place when pH value ranged between 6 and 7 (Al-Nuaimi, 1990 in Al-Mossawi, 2005). Owing to the last author, the soils understudy could be classified as alkaline and neutral soils. In these soils H^+ and Al^{+3} are not the main ions they are replaced by alkaline elements. Based on Al-Mossawi, (2005), the value of soil pH depends upon the following factors; water (irrigation and rain water), Carbon dioxide gas, the added fertilizers (nitrogen, sulfurous, and organic fertilizer), soil carbonate contents.

The average chemical composition of Basarh soils in comparison with other soils is shown in Table (1). Silica (SiO_2) form the dominant components in Basrah soils which could be reflects the high resistance of quartz to physical and chemical weathering during transportion from their source to the place of deposition. Most of quartz are in form of fine grained clastic materials, the fine quartz grains may adsorb some metals such as copper and then fixed it in soils (Al-Dabagh, 1988). The second components is Alumina (Al_2O_3), the clay minerals form the host of this element, the value of alumina in Basrah soils is higher than that of Iraqi soils (Western Desert), which indicate the activity of primary mineral alteration processes, such processes causing the neoformation of clay minerals for example palygorskite. Iron forms 4.4% of the total measured components. Clay minerals and detrital heavy minerals form the sole source of the iron. Owing to Rose et al., (1979), the low iron contents recorded in soils of cultivated areas of Basrah possibly related to high plant exhausting of this element because Fe is necessary for the enzymatic synthesis of chlorophyll in plants. The arid climate of Basrah area where the evaporation exceeds precipitation and moisture is lost from the soil to leave saline conditions and the precipitation of salts such as carbonate and gypsum, such processes causing the enrichment of present soil samples with calcium(Table,2), whereas, most of Mg related to the smectite and palygorskite clay minerals. Most of SO_3 confirmed to the occurrences of authigeic gypsum as well as detriral gypsum fragments. The high percent of Loss On Ignition (L.O.I) reflects the high contents of carbonate, O.M., and gypsum. The organic matter enhances the soil agricultural abilities but has a bad effect on the concrete foundations.

Alkali elements are common in alkali soils which developed most commonly under arid conditions, these soils are characterized by the accumulation of soluble salts of Mg and Na, they are usually found in depression where they originate by evaporation under shallow ground water conditions. Sodium accumulated in soils of semiarid region especially those with fine texture; the concentrated of Na in soils causing _swelling and dispersion of clay minerals, which inhabit the percolation of water and_air in soils, as well as the developments of sodic soils. Potassium forms one of main alkali elements, most of K derived from K-feldspar, muscovite, and biotite minerals, in present soils illite (mica soil) form the main source of Potassium. It is well known that river contributed low amount of K, because large part of K exhausted during river course by adsorption on clay mineral surfaces and by plants because K form one of the main plant nutrient elements. The abundance of K varies horizontally and vertically, which attributed to the chemical weathering and processes of transportation and sedimentation. Awad, (1986) and Al-Mossawi (2005) pointed out that the solution of Basrah soils characterized by the following ions owing to their abundance ;Na^+ Ca^{++} Mg^{++} K^+, cation ; Cl^- , $SO_4^=$, and HCO_3^- , which merely means that Na^+ forms the dominant exchangeable cation, whereas Cl^- indicates that the Basrah soils are affected by the invasion of saline water during the tidal currents.

Sabkha soils have a wide distribution in Basrah area, there are two main types of sabkha; coastal and inland (Al-Khaiat,2002). These soils developed in low land area where the G.W is close to the ground surface, so under evaporation the ground water moves up ward by capillary action leading to the precipitation of salt on soil surface. The general chemical composition of soil solution of both types of sabkha were illustrated in Table(3 and 4), there is a clear seasonal variation in cation and anion concentrations, this variations reflect the continuous effect of dissolution and deposition of these ions during wet winter and dry summer respectively.

Mineralogy

The minerals of Lower Mesopotamia soils could be categorized into two groups; Non-clay minerals, and clay minerals. The first group comprises the light minerals composed of calcite and quartz, it is well known that carbonate contents is always high in the sediments of Basrah area, carbonate minerals with in the studied sediments ranges between 35-82% with an average value of 60% (Al-Taih, 1998). The high carbonate contents resulting from continuous evaporation of ground water under the prevailed arid climate. Based on Albadran (2006), the carbonates are originated from fragments of macrofauna shells (aragonite), dertital carbonate (Low-Mg calcite), authigenic (as microcrystalline calcite) carbonate rock fragments. Gypsum also occurs multisources were suggested for this mineral; authigenic by direct precipitation from ground water due to evaporation, by replacement of Ca^{++} of the soil by Na^{+} and Mg^{++} of ground water, therefore soils containing gypsum are prevented from becoming alkaline, some secondary gypsum has been blown from the gypseferous desert areas and deposited in Basrah soils under consideration (Buringh, 1960). Quartz forms the main light silicate minerals owing to its high resistance to erosion. Feldspar occurs in low percent, this occurrence reflects the relative rapid transportation of sediments by river mainly during flooding phase. The clay fractions of all the sediments have similar clay assemblages of illite, palygorskite, smectite, kaolinite, and chlorite, the order of abundance varies from one area to another (Table, 5). Palygorskite has a wide areal distribution, it is recorded in all studied sediments samples (Table,5). Palygorskite in Basrah area is a matter of controversy, some authors adopted the detrital origin and others believed with the in place origin as a result of direct precipitation of palygorskite from evaporating soil waters (Albadran and Hassen, 2003). Kaolinite is a common mineral in Basrah soils, owing to Grim (1962), the presence of carbonate material in Basrah soils reflects the detrital origin of kaolinite. Furthermore, illite-montmorillonite mixed layered clay minerals were also detected; this phenomenon reflects an intermediate phase of illite and chlorite diagenetic alteration to montmorillonite.

The heavy mineral assemblages form about 1% of the present soil samples. The heavy mineral assemblages comprises number of minerals; Opaque, Pyroxene, Hornblende, Chlorite, Biotite, Epidote, Garnet, Kyanite, Staurolite, Celestite, Zircon and Tourmaline (AL-Jabbri, 2005). These minerals derived from igneous, metamorphic and even sedimentary rocks crops out in the catchments area of Tigris, Euphrates Rivers and their tributaries.

Conclusion

Basrah soils are transported a zonal soils, their sediments were contributed from north, northwestern and western parts of Iraq and other neighboring countries. The texture of Basrah soils is of fine grained and classified as siltyclay and clayey silt, this texture can retained water for long time, so most of Basrah soils are water logged, the subsequent evaporation brought about the deposition of evaporites minerals as surface crust. The wide spectrum of mineral contents reflects the multisource of Basrah soil sediments. Most of clay minerals are detrital in origin, nevertheless; some of them such as playgorskite were formed in place (i.e. neoformation).

The pH value of Basrah soils neutral to slightly alkaline and it is a function of water type supplied to the soil, carbon dioxide dissolved, carbonate contents and type of fertilizer added. The diagenetic alteration of clay minerals in Basrah soils is active as shown by the presences of mixed layered clay minerals, this alteration possibly attributed to the available of Ca, Na and Mg . On the other hand, the spatial variations in studied chemical components were related to geological and environmental impacts.

Table (1) Average chemical composition of Basrah soils and other soils both domestically and abroad.

Author Comp.	Vinogradov, 1959 USSR	Shacklette, 1971 U.S.A	Buday and Hack, 1980 Western Desert/ Iraq	Al-Marsoumi, 1989 Iraq		Present study
				Shethatha	Hit	
SiO_2	70.63	n.a	37.5	40.84	38.59	32.9
Al_2O_3	13.48	12.47	3.9	4.38	3.43	9.1
Fe_2O_3	4.22	3.57	4.1	1.86	1.48	4.4
TiO_2	0.77	0.5	n.a	0.39	0.25	n.a
CaO	1.29	3.36	20.70	22.95	30.95	16.2
MgO	0.99	1.53	3.0	3.06	30.81	4.9
SO_3	0.21	n.a	n.a	1.96	5.13	3.5
Na_2O	0.85	1.62	n.a	0.65	1.38	1.23
K_2O	1.64	2.77	1.3	1.03	0.75	0.9

n.a = not analyzed

Table (2) Chemical analyses results of Basrah soils in percent (based on Al-saad, 2006*, Al-Amre, 2005, Hosain, 1986 in Al-Taie , 2005***, and Al-Jabbri, 2005****).**

Component Location		SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	Na_2O	K_2O	SO_3	L.O.I	O.M
QURNA *	Ghmaij	31.36	3.32	9.72	16.1	6.93	0.81	1.12	1.1	25.07	2.2
	Jeri	39.84	5.11	10.53	14.8	6.22	1.23	0.83	0.32	19.73	n.a
	Umm-Shewakh	30.22	3.18	7.55	23.9	5.4	0.98	1.28	0.18	25.5	n.a
	Al-Alam	32.15	3.95	10.71	16.8	5.83	0.91	0.97	0.53	27.37	n.a
	Al-Jewaber	35.18	3.21	7.08	19.9	5.61	1.15	1.10	0.45	26.76	n.a
	Aldrwiza	37.5	4.87	8.79	18.4	5.3	0.96	1.23	0.29	23.73	n.a
Garmat Ali **		35	4.38	10.22	18.9	4.16	0.83	0.73	4.60	20.1	0.28
Al-Ashar *** (< 2μm soil sample)		35.3	4.52	10.2	18.5	4.12	0.8	0.75	4.5	21.23	1.5
Abu Al-khaseeb ***		36.01	4.4	10.10	16.4	4.18	0.73	0.78	4.80	21.43	1.0
Fao ***		34.2	4.15	10.22	14.1	4.48	0.84	0.75	4.85	24.21	n.a
KhorAbdullah		24.3	4.98	6.22	17.6	6.76	3.35	1.31	n.a	18.66	n.a

Table (3) Range and mean of major cations and anions and some physical properties of sabkha sediments (30-60 cm depth) Basrah area, wet season. (Al-Marsoumi *et al.* , 2004).

Component	Coastal sabkha, n=11		Inland sabkha, n= 2	
	Range	Mean	Range	Mean
Na meq./l	262-382	300	255-269	262
K meq./l	2.3-4.6	3.44	1.6-1.8	1.7
Ca meq./l	120-162	140	91-96	93.5
Mg meq./l	130-169	147	186-187	186.5
Cl meq./l	224-269	272	116-225	220.5
SO_4 meq./l	132-197	156	222-230	226
HCO_3 meq./l	2.8-6.3	4.1	2.4-2.9	2.65
Salt%	4.56-6.77	5.37	3.91-4.13	4.02
Ec mmohs	71.2-93.1	83.7	61.1-64.5	62.8
pH	7.6-7.8	7.7	7.5-7.6	7.55

Table (4) Range and mean of major cations and aniona beside some physical properties of Sabkha sediments(30-60 cm depth), Basrah area, Dry season.(Al-Marsoumi *et al.*, 2004).

Component	Coastal sabkha n=11		Inland sabkha, n= 2	
	Range	Mean	Range	Mean
Na meq./l	191-310	239	275-204	182
K meq/l	0.5-1.9	1.18	0.5-0.6	0.4
Ca meq./l	105-135	120	79-85	82
Mg meq./l	121-146	132	173-179	176
Cl meq./l	115-291	221	202-221	213
SO_4 meq./l	162-191	172	218-221	219.5
HCO_3 meq./l	1.7-3.1	2.29	1.41-1.6	1.5
Salt %	3.14-4.45	3.97	3.26-3.39	3.325
Ec. Mmohs	49-71	57	51-53	52
pH	7.7-7.9	7.78	7.7-7.8	7.75

Table (5) Mineralogical composition of Basrah soils according to their abundance.

Author	Area	Mineralogical Composition	
		Clay Minerals	Non-Clay Minerals
Albadran and Hassen 2003	Supratidal plain	K, I, P, M, I-M	n.a
Al-Amre (2005)	Garmat Ali	M., K., I, P., and Ch.	Cal., G, Q, H, and Feld.
Al-Tai (2005)	Garmat Ali	M, I, P, K, and Ch.	Cal., G, Q, and Feld.
	Al-Ashar	M, I, P, K, and Ch.	Cal., Q, G, H, and Feld.
	Abu-Al-Khaseeb	M, I, P, K, and Ch.	Cal.,Q, G, H, and Feld.
	Fao	I,P, K, Ch., and M.	Q,Cal., H, G, and Feld.
Al-Jabbri, 2005	Khor Abdullah	K, P, Ch, M, Ch-M, I, I-M.	Q, Cal., G, and Feld.
Al-Saad, 2006	Qurna	M-Ch, K, M, Ch, P, and I.	Cal., Dol., G, Q, and Feld.

K= Kaolinite, M= Montmorillonite, I= Illite, P=Palygorskite, Ch=Chlorite.
Cal=Calcite, Dol.= Dolomite, G= Gypsum. H= Halite, Q= Quartz, Feld.= Feldspar.

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