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Some Physical Properties Treatment of Expansive Soil Using Marble Waste Powder

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Abstract

This research is an attempt to investigate the effect of marble waste powder on the stabilization of swelling soils. The two areas within the Erbil ,(Bastora and Erbil Airport) , to investigate the swelling characteristics of soil samples and their treatment with marble waste powder taken from (Penjwen, Said Sadiq and Pirmam)areas. Index properties of the soils were determined according to unified soil classification system. The Bastora soil classified as CH group , whereas Airport soil classified as CL group.The evaluation involves the determination of the swelling potential of expansive soil in its natural state. The marble waste powders were added at percentages (10%, 20% and 30%) by weight of soil.The results show that the addition of marble dust decreases liquid limit, plasticity index and plastic limit. With increasing percentage of marble dust in expansive soils, swelling percentage decreases. Data of swelling index revealed that the swelling in Bastora soil is more than the Erbil Airport soil. While Penjwen marble waste powder is more effective to avoid the swelling problems. The Pirmam marble waste powder showed least effect. Further, the mineral composition of soil samples was studied by XRD analysis, which is also confirmed the presence of swelling minerals (Montmorillonite). The bulk mineralogy of the marble waste powder of Penjwen, Said Sadiq, and Pirmam areas include calcite, dolomite and quartz.

Keywords: Soil swelling, wastes ,XRD , plastic limit , marble dust.

"1. Introduction"

Swelling soils are soils that experience significant volume change associated with changes in water contents. These volume changes can either be in the form of swell or in the form of shrinkage. Many soils that exhibit swelling and shrinking behavior contain expansive clay minerals, such as smectite (montmorilonite) that absorb water. The abundance of this mineral (smectite) in the soil led to increase its swell potential, because when it absorbs water its volume increases and swells [9,12] . In Erbil Governorate, some of the soils are essentially of the expansive variety, though these soils are considered only moderately expansive there have been different types of damages caused the structures founded on these soil. Soil stabilization is a well- known technique used to improve the physical properties of soil , the effects of mixing local sand with expansive soils on their swelling potentials also studied [5]. Numerous studies on evaluation the effectiveness of lime, cement, and combinations of lime and cement stabilization on swell potential of expansive soils[3,13,14, 8].
Mixtures of Kaolinite-Bentonite were mixed with waste marble dust for design of landfill liner explained by [15]. The potential of marble dust (by-productof marble industry) as stabilizing additive to expansive soil studied and evaluated [1] and the potential of limestone dust (LSD) and coal fly ash (CFA) to stabilize some soils problem in southeastern Pennsylvania studied[7].

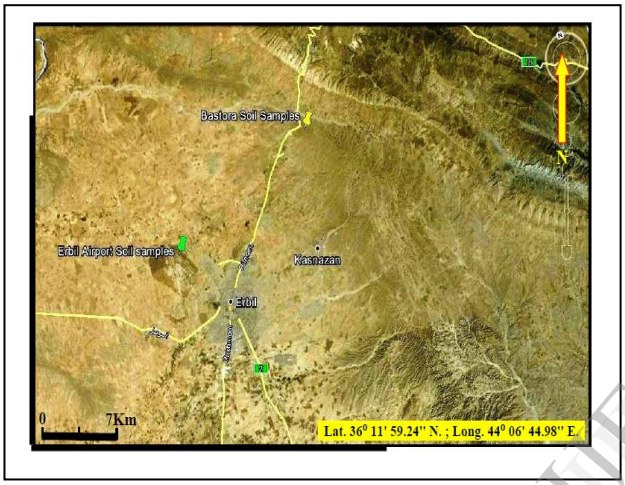
"2. Geology"

At Bastora location good exposure of lower Bakhtiari (Mukdadiya) formation and upper Fars (Injana) formation is noticed. In addition of river terraces is occurred in Bastora valley, and good soil profile as a result of weathering of the underlying rocks characterizes the area. On the other hand Erbil Airport section belongs to Erbil plane ,during field survey no geologic formations are seen to crops out in this area. The area is covered with a thick (nearly 100-150m.) of

unconsolidated sediments, which is regarded to quaternary sediments, consisting of clay, fine silt with pebbly sands, and gravel of different grain sizes (Jassim and Goff, 2006).

"3. Materials and Methods"

In this study, three different types of marble waste were taken from Erbil marble factory that includes marble waste of (Penjwen, Said Sadiq, and Pirmam) which has been added to expansive soil samples was taken from two studied sections, these are Bastora area and Erbil Airport area, which were located around the Erbil city (fig 1) .



"**Figure 1**. Satellite image from Google Earth of the Bastora and Erbil Airport areas"

3-1 Preparation of Samples

The studied soil samples were divided into ten parts. The first part was left in its natural state, while the other nine parts were mixed with marble waste powder of (Penjwen, Said Sadiq, and Pirmam) at different percentages (10 % , 20 %, and 30%).

3-2 Test Program

Grain size analysis, hydrometer tests, Atterberg limits, specific gravity and x-ray differaction analysis were carried out on each specimen in both studied areas for natural soils and soils mixed with three different types of marble waste powders with three different percentages (10%, 20%, and 30%).
The following laboratory tests have been carried out both on natural soil and stabilized soil with marble waste .

3-2-1-Particle Size Distribution

Particle size distribution of the investigated samples was determined by sieve analysis and hydrometer methods, this test is performed to determine the percentage of different grain sizes present in the soil ,accordance to American Society Test Method per standard ASTM D 422- 63.

3-2-2- Liquid Limit

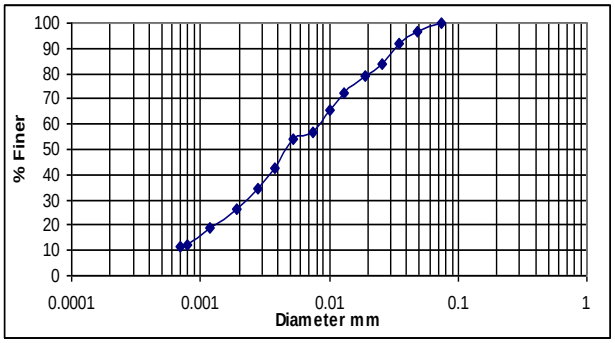
The test procedures of liquid limit is performed by cone penetration method (BS 1377: 1990, test, No 2 A).

3-2-3- Plastic limit

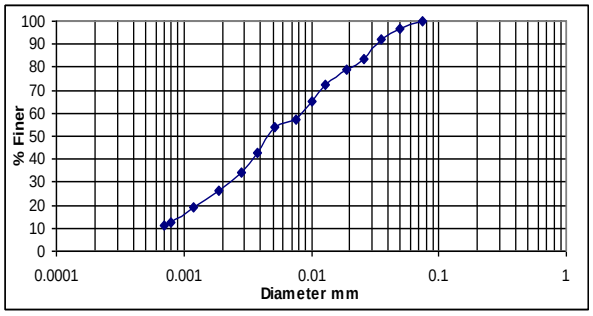
The plastic limit procedure according to B.S 1377: 1990, test No.3

"4. Results and Discussion"

The grain size analysis revealed that size of the particles in a certain soil represented in Fig (2) indicates the percentage of the particles in Bastora and Airport soil are the clay percent is about (27%,27%) whereas the silt percent is (68.58% ,69.76%) and sand percent is (4.42% , 3.24) respectively.

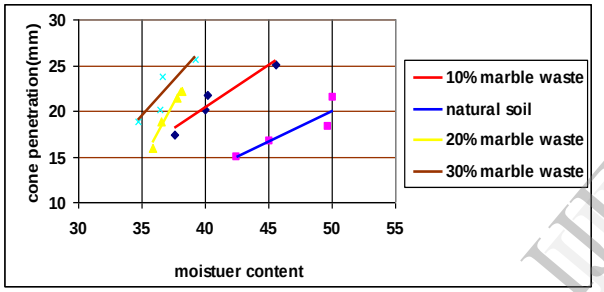


"Figure (2): Grain size analysis of Bastora natural soil"



"Figure 3.Grain size analysis of Airport natural soil"

Figures 4 & 5 together with the expansive soil classification system , which was compiled from Holtz and Gibbs (1956), the present study show that the liquid limit of selected soil sample of Bastora natural soil is about 51.5, which classified as High potential of volume change, this indicates high swelling, while airport natural soil liquid limit is 44.4, which regarded as Medium potential of volume change, indicating medium swelling. By adding the (10%, 20%, 30%) marble waste powder of Penjwen , Said Sadiq, Pirmam to the Bastora and Airport natural soil, the liquid limit of Bastora and Airport areas decreases as the stabilizer percentage increases. The maximum reduction of liquid limit in Bastora soil is from 51.5 to 35.2 by adding 30% of the marble waste powder of penjwen and the maximum reduction of liquid limit in Airport soil is from 44.4 to 30.78 by adding 30% of the marble waste powder of penjwen. The liquid limit is more affected by addition of the marble waste powder with the soils, as shown in (table 1).



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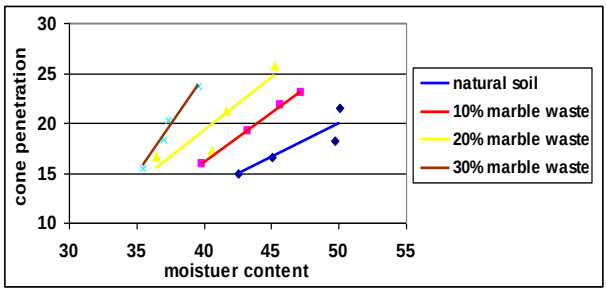

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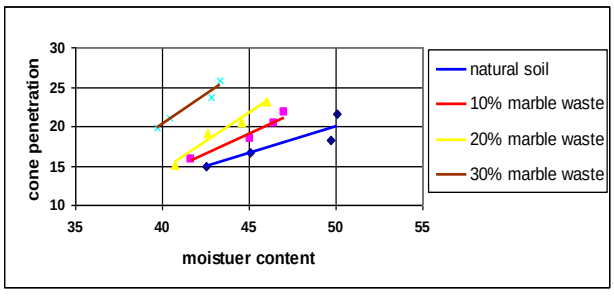
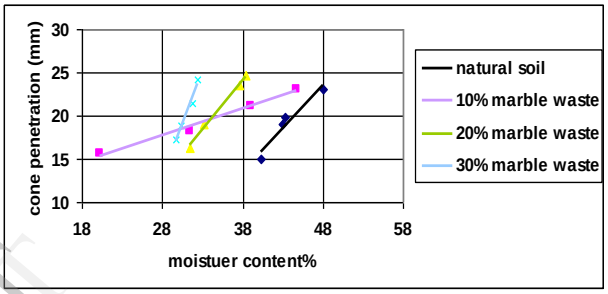


(c)

"Figure (4): Relation between moisture content% and cone penetration of Bastora soil with adding marble waste powder of (a) Penjwen (b) Said Sadiq (c)Pirmam"

"**Table 1.** Liquid limit of Bastora natural and treated soils by addition three different percentages of different marble waste powder

Position	Liquid Limit (LL)			
	Natural	Natural soil with adding marble waste powder		
Bastora natural soil	51.5	10%	20%	30%
Penjwen		39.9	37.2	35.2
Said Sadiq		44	40.55	37.6
Pirmam		45.8	43.78	40



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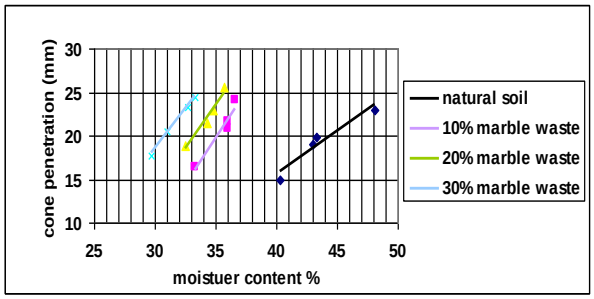

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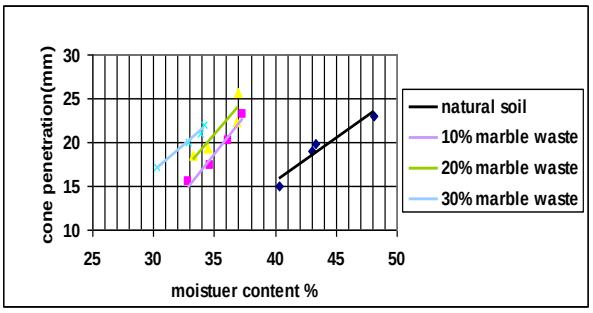

(c)

"Figure 5. Relation between moisture content% and cone penetration of Airport soil with adding marble waste powder of (a) Penjwen (b) Said Sadiq (c)Pirmam"

"**Table 2.** Liquid limit of Airport natural and treated soil by addition of three different percentages of different marble waste powder"

Position	Liquid Limit (LL)			
Airport natural soil	Natural	Natural soil with adding marble waste powder		
	44.2	10%	20%	30%
Penjwen		35	34.25	30.78
Said Sadiq		35.16	33.2	30.8
Pirmam		36.15	34.35	32.9

Addition of marble waste powder to the expansive soil, plastic limit of Bastora and Airport decreases as the stabilizer percentage increases. The maximum reduction of Plastic limit in Bastora soil is from 28.44 to 22.8 (table 3) by addition 30% of the marble waste powder of penjwen and the maximum reduction of plastic limit in Airport soil is from 24.20 to 17.25 (table 4) by addition 30% of the marble waste powder of Said Sadiq.

"**Table 3.** Plastic limit of Bastora natural soil treated soil by addition of three different percentages % of marble waste powder"

Position	Plastic Limit (PL)			
Bastora natural soil	Natural	Natural soil with adding marble waste powder		
	28.44	10%	20%	30%
Penjwen		25.23	23.58	22.8
Said Sadiq		27.33	26.7	25.11
Pirmam		28.16	27.39	24.17

"**Table 4.** Plastic limit of Airport natural soil treated soil by addition of three different percentages % of marble waste powder"

Position	Plastic Limit (PL)			
Airport natural soil	Natural	Natural soil with adding marble waste powder		
	24.2	10%	20%	30%
Penjwen		23.96	23.68	20.63
Said Sadiq		19.33	18.7	17.25
Pirmam		20.86	20.51	19.97

Addition of marble waste powder to the expansive soil of Bastora and Airport areas, demonstrate that the plasticity index of both areas decreases as the stabilizer percentage increases

The maximum reduction of plasticity index in Bastora soil is from 23.06 to 12.40 (table 5) by addition 30% of the marble waste powder of penjwen and the maximum reduction of plasticity index in Airport soil is from 20 to10.15 (table 6) by addition 30% of the marble waste powder of penjwen. These indicate that the Plasticity index (PI) decreases when the stabilizer percentages increases.

"**Table 5.** Plasticity index of Bastora natural and treated soil by addition of three different percentages% of marble waste powder"

Position	Plasticity Index (PI)			
Bastora natural soil	Natural	Natural soil with adding marble waste powder		
	23.06	10%	20%	30%
Penjwen		14.67	13.62	12.4
Said Sadiq		16.67	13.83	12.49
Pirmam		17.64	16.39	15.83

"**Table 6.** Plasticity index of Airport natural and treated soil by addition of three different percentages% of marble waste powder"

Position	Plasticity Index (PI)			
Airport natural soil	Natural	Natural soil with adding marble waste powder		
	20	10%	20%	30%
Penjwen		11.04	10.57	10.15
Said Sadiq		15.83	14.5	13.55
Pirmam		15.29	13.84	12.93

According to unified soil classification system Al-Asho(1991) the Bastora natural soil classified as (CH), and high plasticity clayey soil. Whereas Airport natural soil classified as (CL), low plasticity clayey soil .

The specific gravity in Bastora natural soil is about 2.72 gm/cm3, and for Airport natural soil is about 2.70 gm/cm3 .

XRD analysis were done for Bastora ,Erbil Airport areas and marble waste powder of Penjwen, Said Sadiq, and Pirmam areas, to identify the clay mineralogy and bulk mineral components.The existing clay minerals in studied soil samples were identified according to first

reflection (001) and other reflections. XRD-analysis revealed the presence of (Montmorillonite, palygorskite, illite, kaolinite, and chlorite (clay minerals) Fig(6)associated with quartz, carbonate and feldspars minerals (non-clay minerals) Fig(7) and (Table 7). XRD analysis for bulk samples of waste marble powder for Penjwen area shows that the abundant non-clay mineral is calcite , dolomite and quartz figure (8).

"**Table 7.** Mineralogical composition of the studied natural soils and Waste Marbles in Bastora and Erbil Airports areas."

Soil types and Marbles	Arrangement of the Minerals	
	Clay Minerals	Non-Clay Minerals
Bastora normal soil	Smectite, Chlorite, Palygorskite, Iillite, Kaolinite	Quartz, Calcite, Feldspar
Erbil Airport normal soil	Smectite, Chlorite, Palygorskite, Iillite, Kaolinite	Quartz, Calcite, Feldspar
Marble Waste powder of Penjwen		Calcite, Dolomite, Quartz
Marble Waste powder of Said Sadiq		Calcite, Quartz
Marble Waste powder of Pirmam		Calcite, Dolomite, Quartz

"**5. Conclusion**"

The grain size analysis of Bastora and Erbil Airport natural soil, demonstrate that the clay percent is (27%),(27%) silt percent is (68.58%),(69.76%) and sand percent is (4.42%),(3.24%) respectively.

According to Unified Soil Classification System (USCS), the Bastora soil classified as CH group and the Erbil Airport soil as CL group .

Addition of 10 %, 20 % and 30 % of the marble waste powder of Penjwen, Said Sadiq and Pirmam areas to the (natural soil) of Bastora and Airport area led to decrease in the Liquid limits ,Plastic limits and Plasticity index .

XRD analysis for soil samples revealed that the presence of swelling mineral such as Smectite in both studied areas. Other present clay minerals include were , palygorskite, illite, kaolinite and chlorite. In addition to mixed layer, illite-palygorskite and smectite-chlorite. Non-Clay minerals include calcite, quartz and feldspars. The bulk mineralogy for Marble waste powder of Penjwen, Said Sadiq and Pirmam areas, include; calcite, dolomite, with few quartz minerals.

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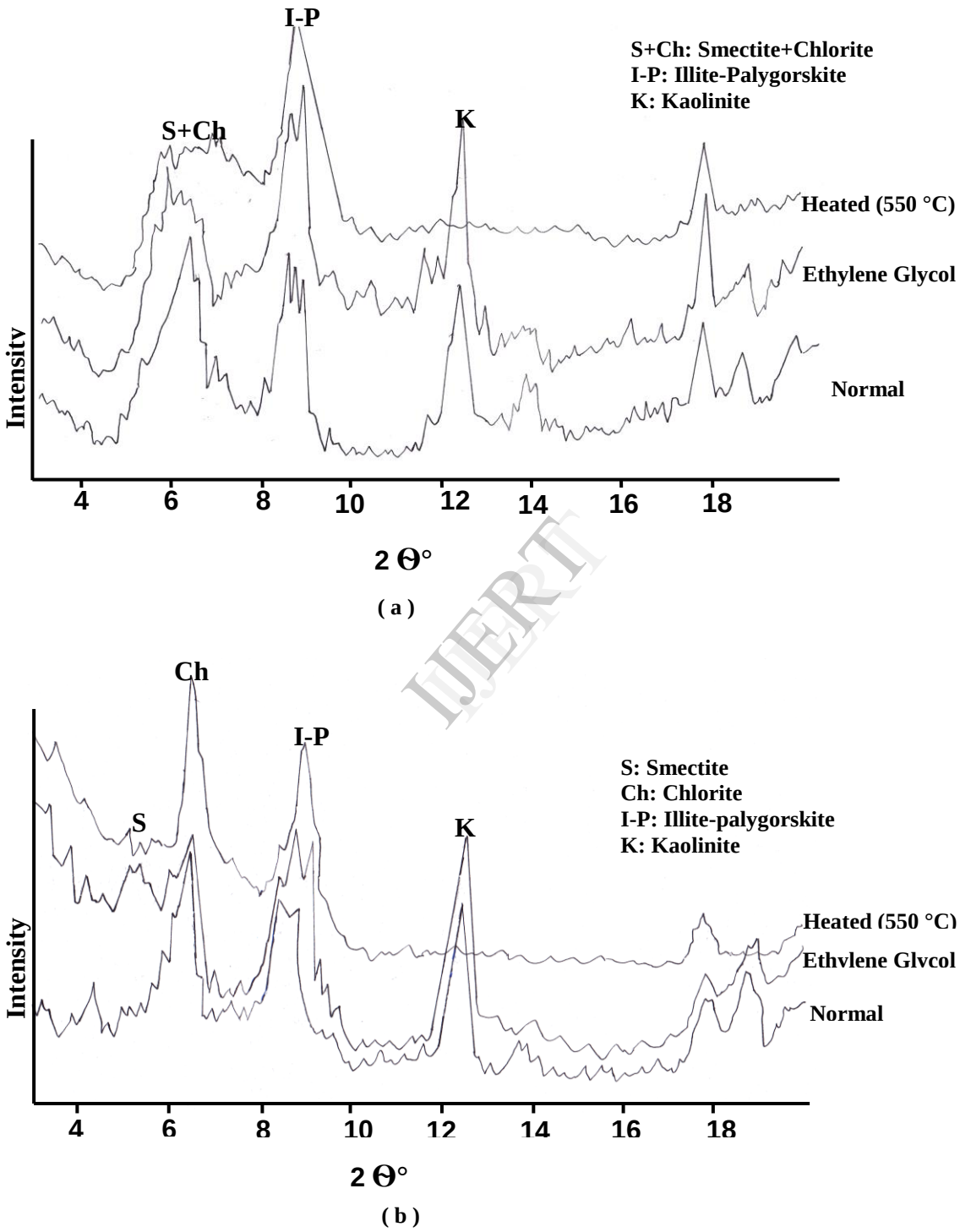
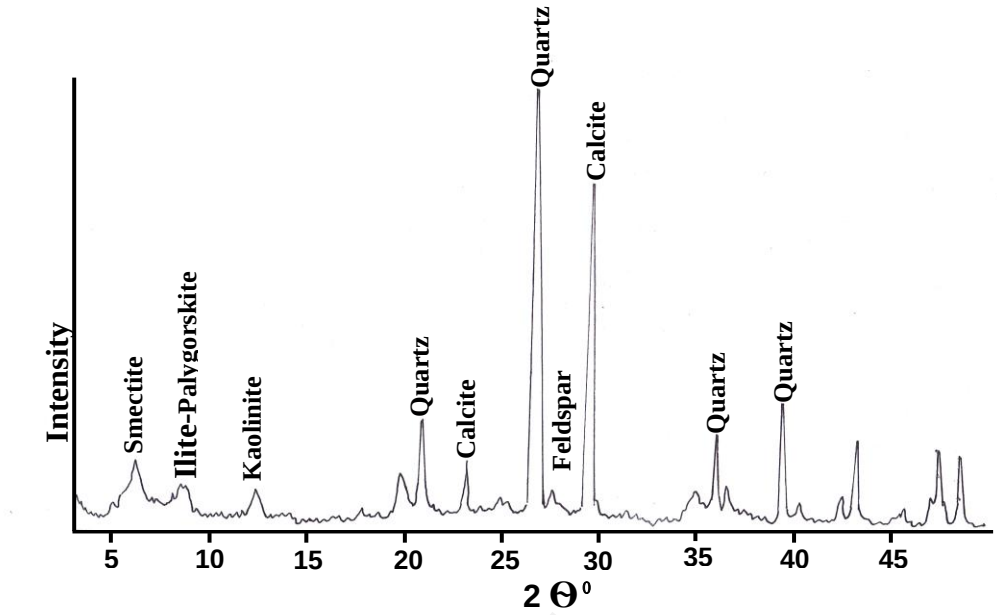


" **Figure 6** XRD pattern of the clay fraction of natural soil of
(a) Bastora area (b) Erbil Airport area"



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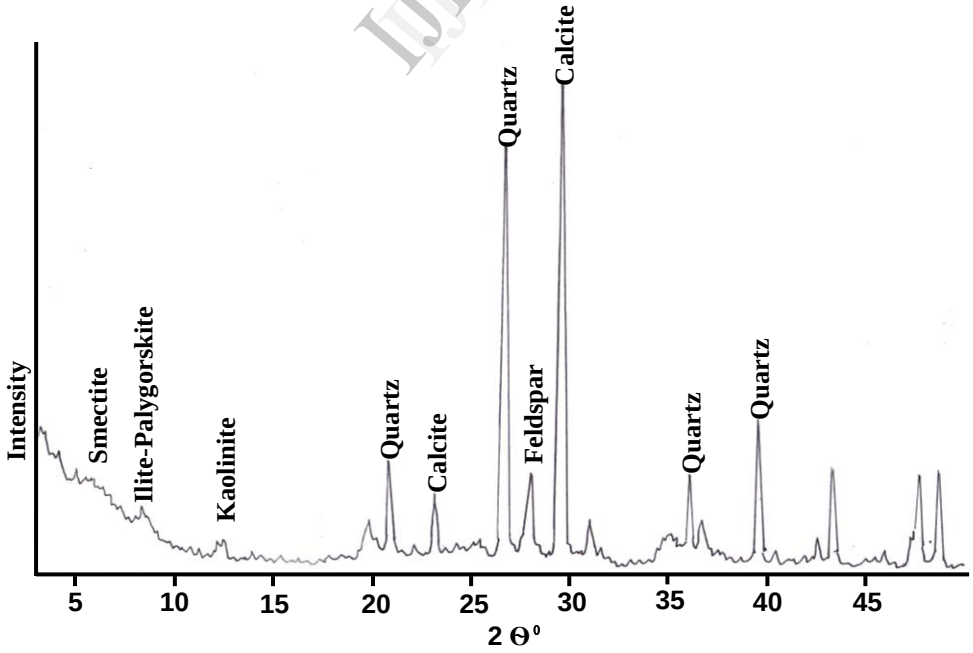
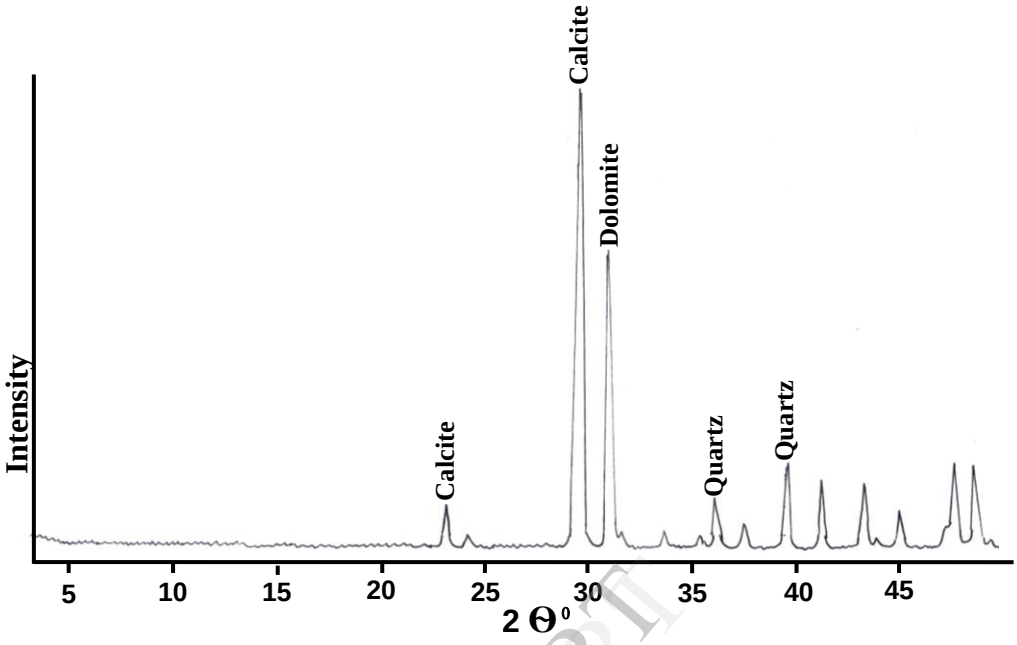


(b)

" **Figure 7.** XRD of the bulk natural soil of Erbil
(a) Bastora area (b) Airport area"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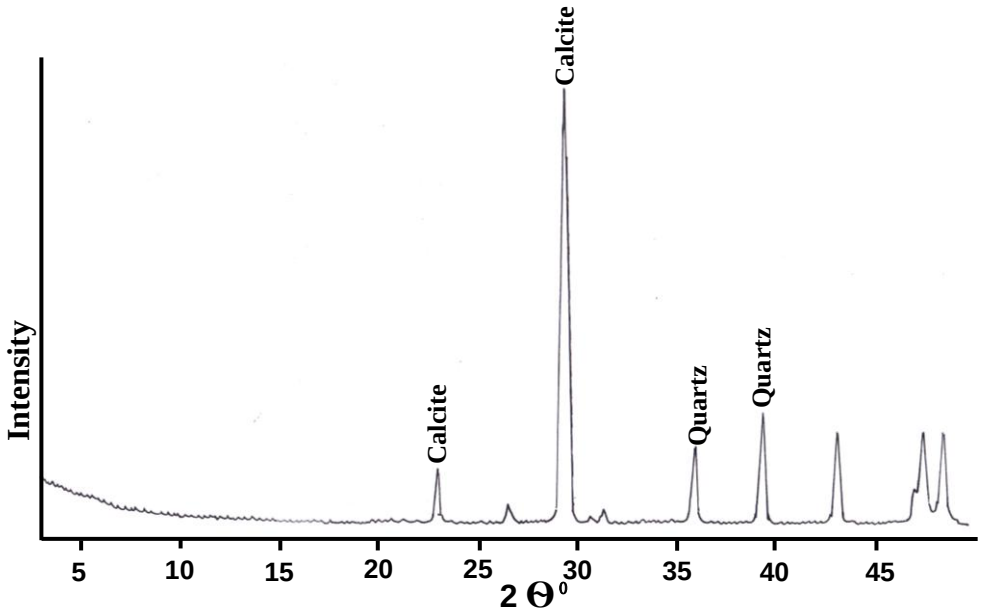
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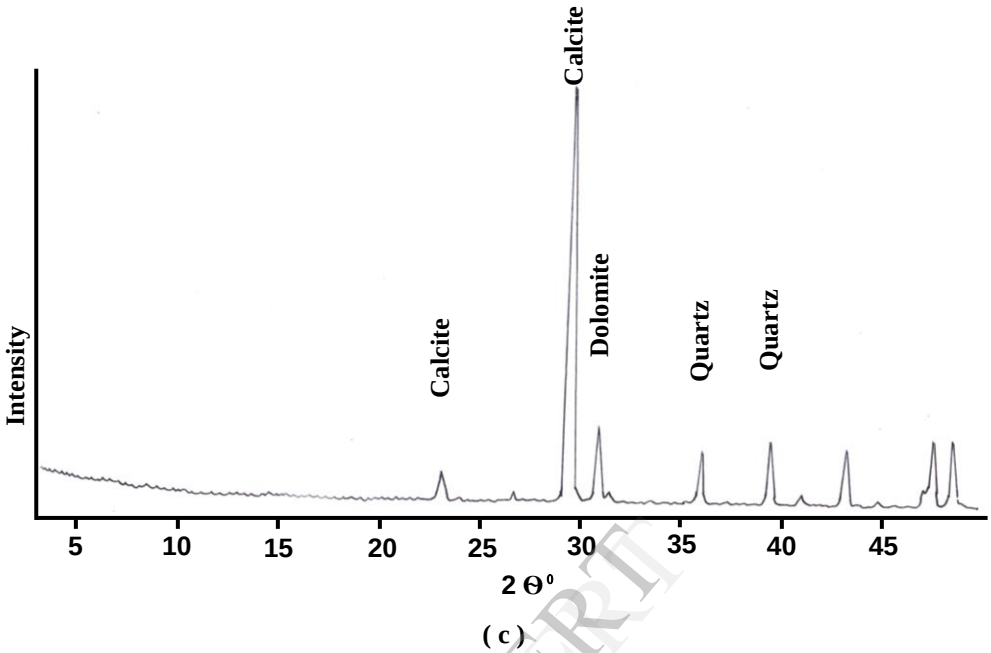

" **Figure 8.** XRD of the bulk Mrable Waste Powder of
(a) Penjwen (b) Said Sadiq (c) Pirmam area"