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### Suitability Evaluation of Mudstone of Injana Formation for Dam Filling Materials in TaqTaq area/Erbil/Iraq

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#### Introduction

Iraq is rich of mudstone rocks which distributed in different parts of it, and through the work of numerous geological surveys and mineral exploration projects carried out by the Iraq geological survey and for many decades of the last century and the beginning of the century has been identified large source of deposits of these mudstone with in of sedimentary rocks mudstone is found in the world ranging from( 45% to 55%). Which uses in different purposes, including the manufacture of bricks, filling materials in dams, and is used in the ceramic industries{1} in order to determine the suitability of its uses as filling materials in the dams.

#### ABSTRACT

The research aims to study some geotechnical properties for mudstone of Injana Formation in the eastern part of Erbil city, to determine their suitability as filling materials in the dams. Nine samples representing the study area were sampled. From the results of petrophysical tests, the liquid limit and the plasticity index were found to be within the limits of the Iraqi standard, the values of the liquid limit range between (39.26-44.2)%. The plasticity index ranges between (14.96-19.82). The grain size distribution analysis shows the applicability of the zone C for Nine samples. Total soluble salts (T.S.S). Ranging from (1.04 -4.81) The gypsum contains between (0.02-0.09)%. It conforms to the Iraqi standard specification where the results of the samples (1)(2)(4)(5) suitable for the filling materials in the dams but the (3)(6)(7) (8)(9) samples unsuitable.

**Location of the Study Area:** The study area is located in the area in Taq Taq area with in longitude (43 ° 20 ') and (45 °20 ') east and to latitudes (35 ° 10' 05 ") and (37 °00 ' 17 ") north .The locations of the station were selected and the field information was recorded at each station. The mudstone was sampled from three sections, with three samples of each section,, as show in Table (1) and Figure (1).

Table 1: Show coordinates of the studied stations .

Stations	East (Longitude)	North (latitude)
Bustana	44° 23' 01"	36° 10' 04"
Taq taq 1	44° 25' 09"	36° 08' 07"
Taq taq 2	44° 37' 07"	35° 58'

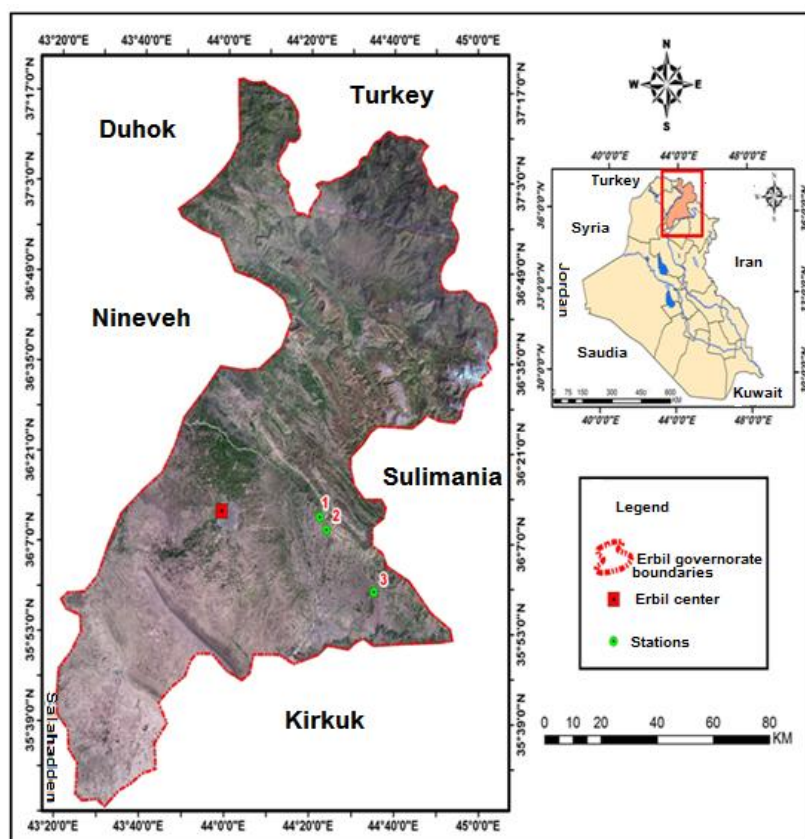


Fig. 1: Location map of the study area.

### Methodology

The drawing stratigraphic sections of the study area by using ( ROCK WORK.6.6.7).

The mudstone as well as using (GIS) (Global Mapper.v12) program. Laboratory tests were done for the (9)samples the mudstone

1- Petrophysic tests: These tests were conducted at which included Applied Geology Department/College of Science/Tikrit University.

-Specific gravity .

-Grain size analysis.

-Atterberge limits ..

-Chemical tests: These tests were conducted at the University of Tikrit / College of Engineering / Department of Chemical Engineering ,and include:

-Gypsum ratio test.

-Percent of organic materials.

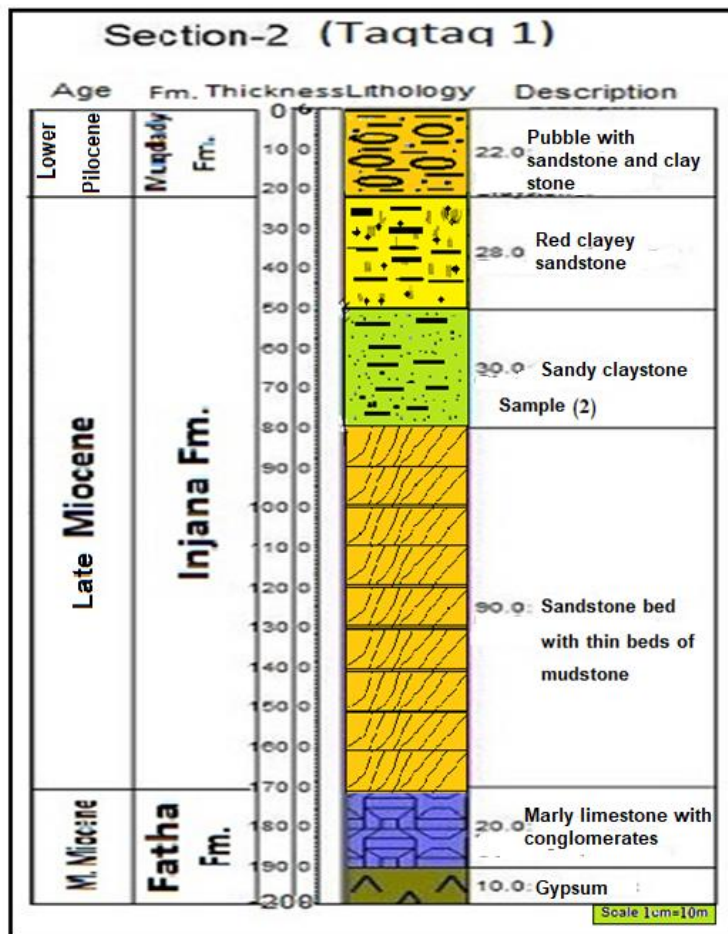
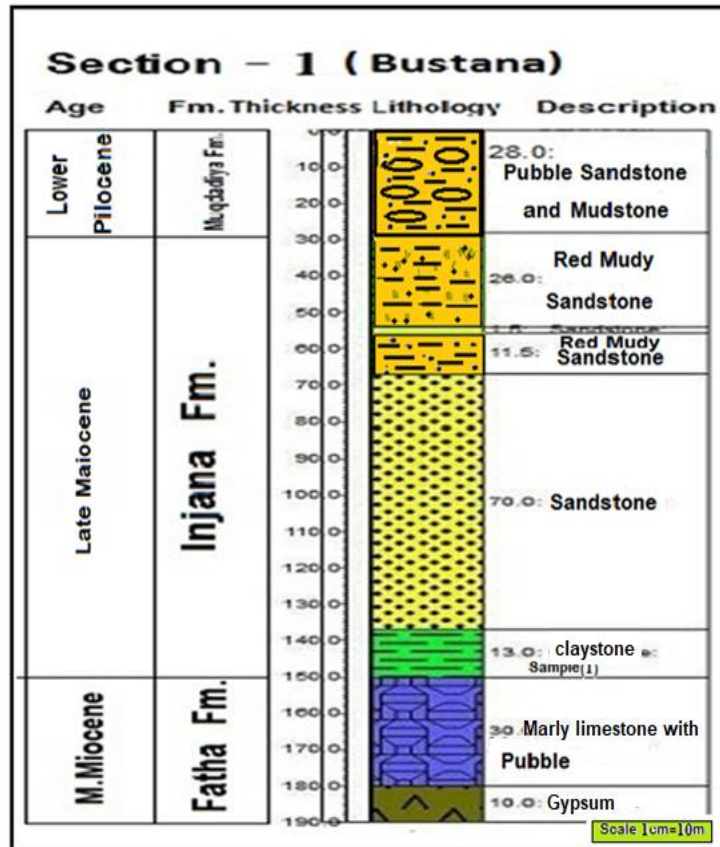
-Total Soluble Salts (T.S.S).

### The geological setting

This formation was first described by (Busk and Mayo ,1918) in

{2} in Iran and he explained that it represents continental crumbs and its continental counterpart. The composition of Injana in the south of Iraq is equivalent to the formation of Dabdaba and the

formation of a zahra in southwestern Iraq . The surface of the lower seam is formed with the Fatha gradually and it defined with the last clay layer in the formation of Fatha. The top surface of the formation is compatible and gradual with the formation of Almqdadiya and it is defined by the emergence of the first layer of sandstone pebble (pebbly sandstone) {3}. Injana Formation in northern Iraq consists of the succession of sedimentary cycles which are very soft at the upper end of the sand clay {4} in Figure (5). However, the sedimentation environment of this formation represented delta and coastal deposits below, to sedimentary deposits at the top of the formation. The typical section of this composition is located in the Injana area within the fold of Hamrin {2}, but the basic units are largely composed of silica marl or red clay stone, as well as layers of sandstone with medium to coarse grain sizes {6}. The thickness of the formation varies from place to place, either because of erosion in the highlands or originally due to differences in origin {7} and {3}. The thickness of the sandstone layers ranges from (1\_2) m while the thickness of the layers of mud stone (7\_8) m. There are also some thin layers of fine gravel .Figure (2).



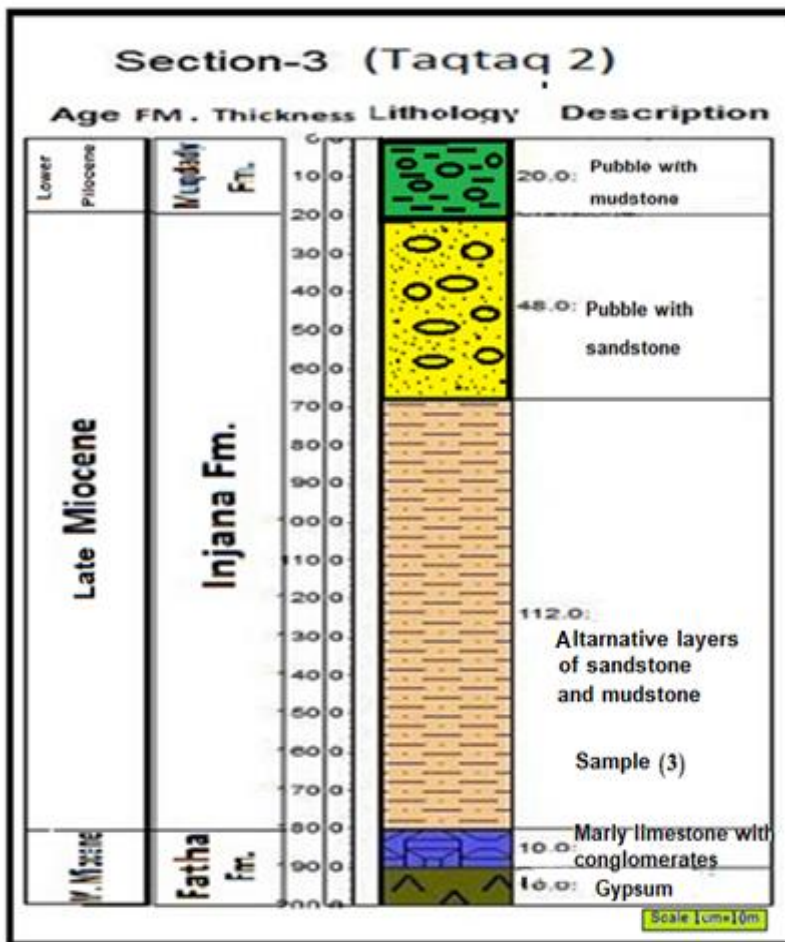


Fig. 2: Stratigraphy of the study area.

**The result of Laboratory test**

Laboratory tests were carried out as follows:

**1- Specific gravity:**

The values for the specific gravity of each type of the soil, as in Table (2). The average specific gravity values the samples are between 2.65 and 2.82 and classified as according to in Table (2)(8) .

This test was carried out on the mudstone of Injana according to the American Standard {8}. The test was conducted at the University of Tikrit/College of Science / Applied Geology Department.

Table 2: The values of specific gravity for the studied samples.

Sample number	Specific gravity
1	2.71
2	2.79
3	2.68
4	2.69
5	2.82
6	2.65
7	2.76
8	2.68
9	2.79

**2-Grain size Analysis**

Grain size analysis is the basis for soil classification, the Unified Classification System. Figure (3),(4).(5) and Table (4).(9)

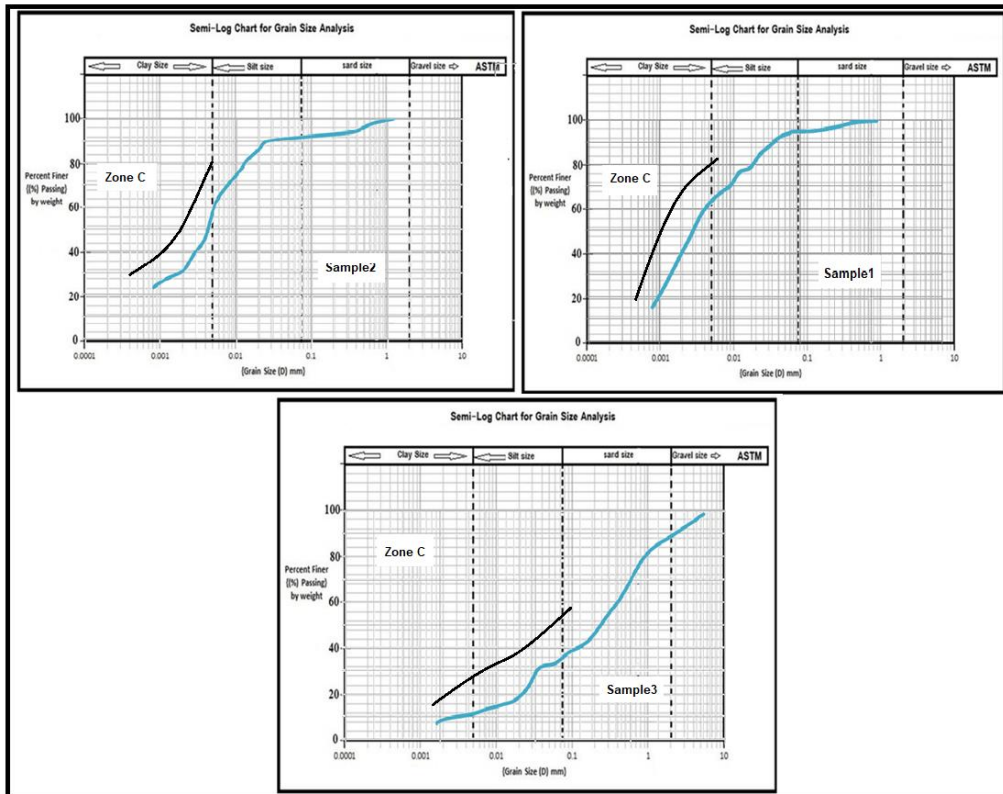


Fig. 3: Grain size analysis to determine the Injana Formation samples (1,2,3).

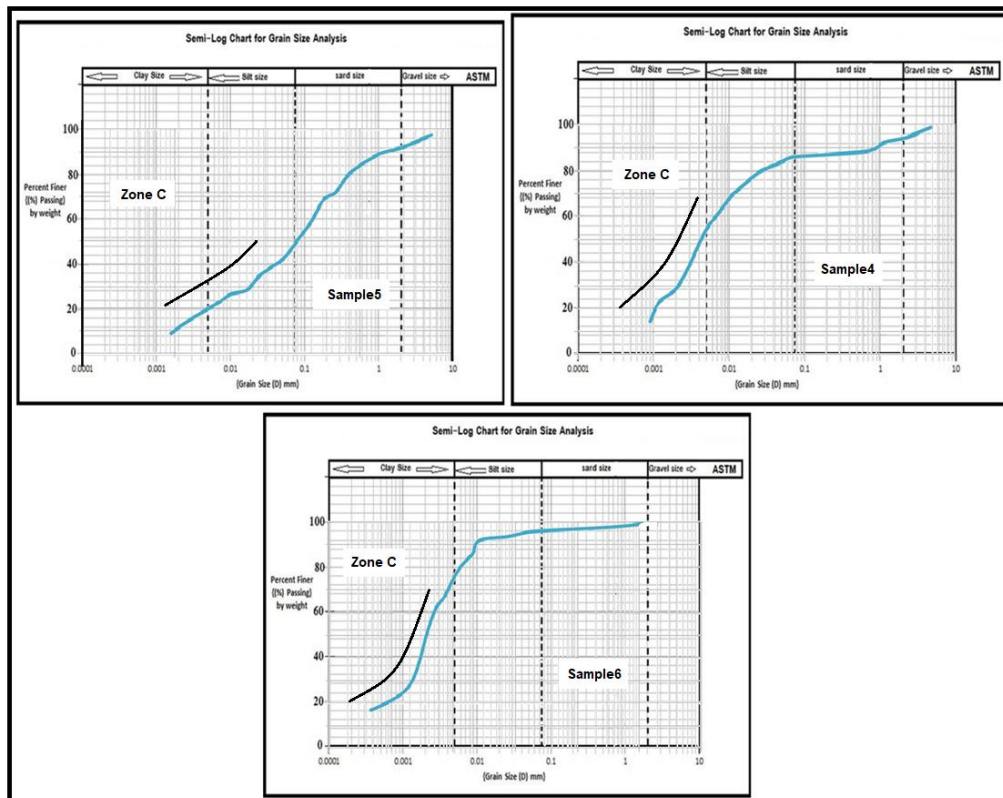


Fig. 4: Grain size analysis of the Injana Formation samples (4,5,6).

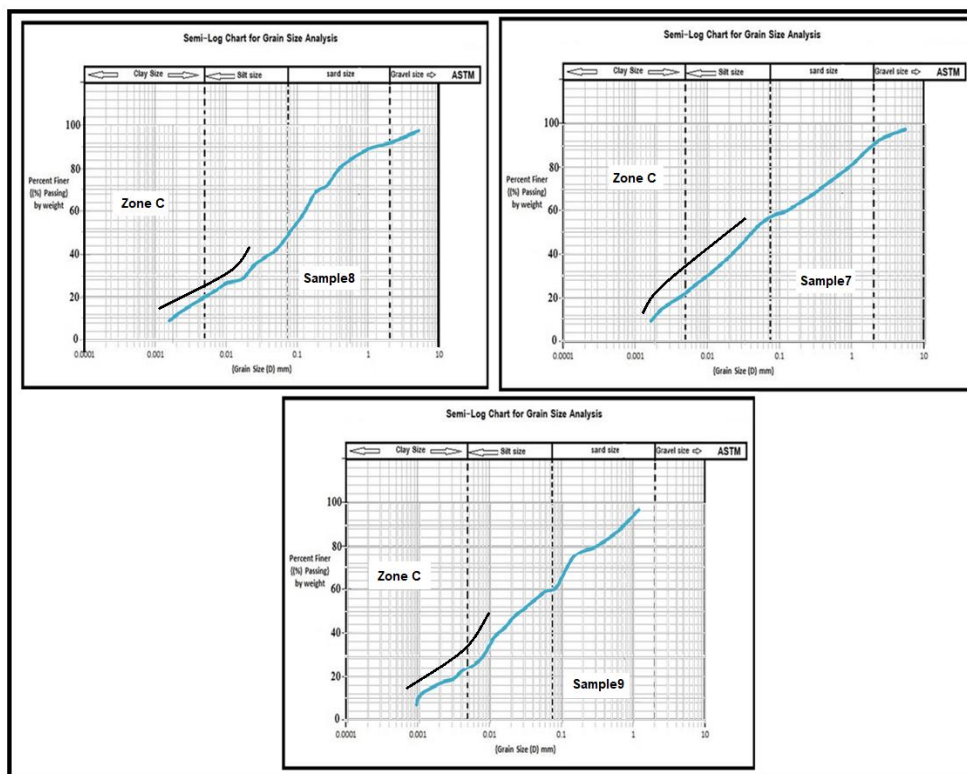


Fig. 5: Grain size analysis determine the Injana Formation samples (7,8,9).

**Atterberg Limits:**

The liquidity and plasticity limits were tested according to US standards {9} and {10}. The results were as shown in Table (3) and the classification of

the rock samples study is based on the plasticity index {10}.

**Table 3: Results of the Atterberg limits of the samples.**

Samples NO.	Liquid Limit L. L%	Plastic Limit P. L%	Plasticity index P. I	Classification according to (Budnikov, 1964)	According to the standard (ASTM- D, 4318- 00., 2004) classification
1	40	22.70	17.30	Plastic	CL
2	42	23.75	18.25	Plastic	CL
4	44.2	24.38	19.82	Plastic	CL
5	39.26	24.3	14.96	Moderately Plastic	CL

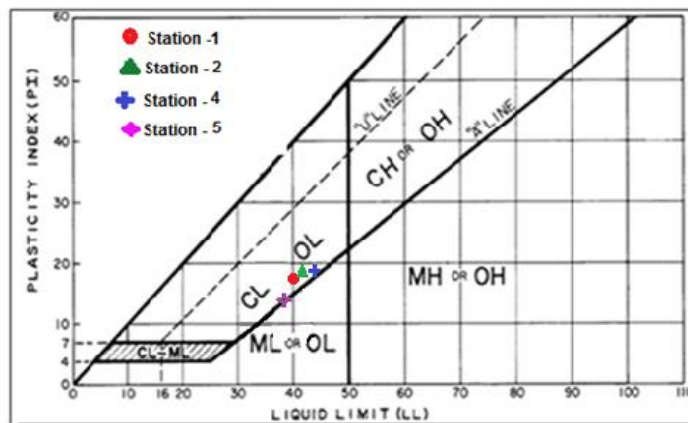


Fig. 6: Atterberg limits Classification of samples (ASTM D-2487, 2004).

**Chemical properties**

The chemical tests were performed according to {11} as in Table (4)

- 1- Gypsum content ratio .
2. Total Soluble Salts (T.S.S).

**Table 4: Results of chemical tests.**

No. Samples	Gypsum %	T.S.S %
1	0.06	4.05
2	0.02	4.81
3	0.04	4.68
4	0.08	1.82
5	0.06	1.97
6	0.09	1.63
7	0.07	1.09
8	0.03	1.15
9	0.04	1.04

**5-Geotechnical assessment for mudstone of the study area:**

For the purpose of determining the suitability of the samples for use as filling materials in the construction of the Embankment Dams based on table (5){12} and the results are in table (6)

**Table 5: Physical and chemical specifications of the spelling spindle (National Center for Laboratory and Structural Research, 2003).**

No.	Physical and chemical of soil filling	Permissible ranges
1	(Liquid Limit )	Not more than 55%
2	( Plasticity Index)	Ranging from 10 to 20%
3	(Grains size analysis)	The curve (Zone C)
4	(Gypsum Content)	Not more than 3%
5	( T. S. S. )	Not more than 4.4%

**Table 6: The tests results of physical and chemical.**

Samples NO.	Total soluble salts%	Gypsum content %	Grain Size Analysis	P. I	L. L%
1	4.05	0.06	conform	9.3	36
2	4.81	0.02	conform	15.25	42
3	1.82	0.04	conform	-	-
4	1.82	0.08	conform	10.99	44.2
5	1.97	0.06	conform	32.38	8.88
6	1.63	0.09	conform	-	-
7	1.09	0.07	conform	-	-
8	1.15	0.03	conform	-	-
9	1.04	0.04	conform	-	-

In the final evaluation of the station samples based on the Iraqi Standard (National Center of construction laboratories, 2003) the suitability of the mudstone of the Injana Formation as a raw materials of the dams filling show that same samples conform to the physical specifications set by the above specification, The chemical specifications specified by the standard are found to be within the Iraqi standard. In table (7).

**Table 7: The suitability of the sample of the study area for use in the filling dams, according to (National Center Of Construction laboratories , 2003)**

Final Evaluation	grain size analysis	(T.D.S)	Gypsum content%	Plasticity Index	Liquid Limit	NO.
good	+	+	+	+	+	1
good	+	+	+	+	+	2
failed	+	+	+	-	-	3
good	+	+	+	+	+	4
good	+	+	+	+	+	5
failed	+	+	+	-	-	6
failed	+	+	+	-	-	7
failed	+	+	+	-	-	8
failed	+	+	+	-	-	9

(+) Conform to the specification, (-) not conform to the specifications

**Conclusions**

1-Physical tests, which included (liquid limit, plasticity, grain size analysis curve), found that the Injana formation, suitable in the earth dams.

2 - From the chemical tests, which included (total soluble salts, gypsum content) found that the results

of these tests range within the proportion specified by the Iraqi standard.

3-Grain size analysis tests showed that the samples were low elasticity clay (CL) and sand .

4- The samples (1,2,4,5) were suitability for the filling materials in the dams , but samples(3,6,7,8,9) were unsuitability.

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## تقييم صلاحية الصخور الطينية لتكوين أنجانة لاستخدامها كمواد املائية في السدود في منطقة طق / أربيل

فهد جمال سهيل ، أميرة اسماعيل حسين

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### الملخص

يهدف البحث الى دراسة الخصائص الجيوتكنيكية للصخور الطينية لتكوين أنجانة المنكشفة في شرق محافظة اربيل وذلك لمعرفة صلاحية استخداماتها كمواد املائية في السدود. حيث تمت النمذجة من ثلاث محطات ممثلة لمنطقة الدراسة وقد أظهرت النتائج وجود تطابق للتحليل الحجمي الحبيبي للنماذج مع المنحني (Zone C) لجميع النماذج المدروسة ومن خلال الفحوصات البتروفيزيائية والمتمثلة بحد السيولة ومعامل اللدونة وجد ان جميع النماذج تقع ضمن حدود المواصفة العراقية حيث تتراوح قيم حد السيولة بين (39.26-44.2) كما تتراوح معامل اللدونة بين (14.96-19.82). كذلك وجد بأن الفحوصات الكيميائية لمجموع الاملاح الذائبة الكلية (T.S.S) تتراوح بين (1.04-4.81) ومحتوى الجبس بين (0.02-0.09) وهي تتطابق مع المواصفة. بينت نتائج الفحوصات الفيزيائية والميكانيكية والكيميائية انها صالحة للمواد الاملائية في السدود للنماذج (1)(2)(4)(5) اما النماذج (3)(6)(7)(8)(9) فهي غير صالحة.