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Optimization of the Time Required for Determination of the Total Dissolved Salts in Soil

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ABSTRACT

The purpose of this paper is to determine the shorter time required for proper determination of the total dissolved salts in soil. The usual test takes 3 to 4 days to measure the total dissolved salts in the sample. Eighteen samples were gathered from different sites in Baghdad city. The physical properties were determined experimentally. The testing program was done by two stages; the first stage included measurement of ordinary T.D.S (series A) while the other stages included measurement of the magnitude of total dissolved salts at different times.

It was found that after 24 hours of soaking the soil in distilled water, the total dissolved salts will reach about 95 % of the actual amount (after 3 days). The usual procedure takes at lest three to four days which is very long time if there is no time or conductivity device. Therefore, a proposed procedure is submitted to estimate the T.D.S. after 24 hours which revealed very good agreement with the actual values. The results of T.D.S. measured after 24 hour give a suitable compatibility with those measured by the ordinary method after 3 days where the coefficient of determination R^2 equals (0.918). An expression was determined which can be used to estimate the T.D.S. from values measured after 24 hours only.

Keywords: Total dissolved salts, soil, measuring time, estimation.

أتمتة الزمن المطلوب لايجاد الأملاح الذائبة الكلية في التربة

الخلاصة

إنّ هدفَ هذا البحثِ هو إيجاد أقصر زمن لتحديد مقدار الأملاحَ الذائبة الكلية في التربةِ بصورة صحيحة من خلال اقتراح وقت أقصر من الوقت المطلوب لإيجادها بالطريقة الاعتيادية المعتمدة، حيث يَستغرق الفحص التقليديُ الاعتيادي 3 إلى 4 أيامِ لقياس مقدار تلك الأملاح في العينة. و قد جمع ثمانية عشر نموذجا من مناطق متفرقة في مدينة بغداد، و تم ايجاد الخصائص الفيزيائية لها مختبريا. و قد تضمن

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برنامج الفحص مرحلتين: المرحلة الاولى تضمنت قياس الأملاح الكلية الذائبة بالطريقة الاعتيادية (سلسلة أ) في حين تضمنت بقية المراحل ايجاد مقدار الأملاح الذائبة في أزمان مختلفة.

و قد وجد أنه بعد مرور 24 ساعة من غمر التربة في الماء المقطر، تصل نسبة الأملاح الذائبة الى حوالي 95% من النسبة الكلية (بعد مرور 3 أيام). الطريقة الاعتيادية تستغرق حوالي 3 الى 4 أيام و هذه المدة تعتبر طويلة نسبيا لا سيما اذا لم تتوفر الأجهزة بشكل كاف. و لذلك تم تقديم طريقة مقترحة لتخمين الأملاح الذائبة الكلية بعد مرور 24 ساعة فقط اذ أعطت تقاربا جيدا مع القيم الحقيقية، حيث كانت قيمة معامل الارتباط R^2 تساوي 0.918. و قد تم تقديم معادلة يمكن استعمالها لتخمين نسبة الأملاح الذائبة الكلية من القيم المقاسة بعد 24 ساعة فقط.

INTRODUCTION

Soil soluble salts can originate from very diverse marine, petro graphic or eruptive sources. In sedimentary mediums, they are mainly in the form of crystalline mediums. As well as these major anions, nitrates, borates or even arsenic salts are also found in certain systems, sometimes in quite high proportions. Among the factors which influence the solubility of each salt, the presence of other salts should not be neglected. For example, gypsum solubility increases considerably in the presence of sodium chloride, but decreases in the presence of sodium sulphate due to the effect of common ions (Harvie et al. 1984).

The total soluble salts refer to the total amount of salt dissolved in the soil extract. The salts include substances that form common table salt (sodium and chloride) as well as calcium, magnesium, potassium, nitrate, sulfate and carbonates (Oklahoma State University, 2011).

All common gravels, subgrade soil and water used for road, runway or any construction should be tested for soluble salt content.

The quantity of total dissolved solids (TDS) in the aqueous extracts (dry residue of the extract) is determined by weighing the evaporation residue of the extract previously filtered on a 0.45 μm membrane. This measurement is normally closely linked with that of electric conductivity and the summation of measurements of extractable cations and anions, and possibly of the extractable organic matter. It is thus not necessary to carry out TDS measurements systematically if reliable measurements of electric conductivity are available. Measurement of TDS is useful for precise calibration of enabling a site to be surveyed by measurement of conductivity (Pansu and Gautheyrou, 2006).

Salt (Chemistry)

In chemistry, salts are ionic compounds result from the neutralization of an acid and a base. This means that these salts are composed of cations and anions, so the product is electrically neutral. These component ions are inorganic such as chloride or organic such as acetate.

Acidic salts that are salts which are hydrolyze to produce hydronium ions in water. Neutral salts are those that are not acid or minimal salts.

An electrolyte is the salt that is able to conduct electricity such as sodium chloride in water. Mixtures of many ions in solution usually do not define salts after evaporation of the water (Kurlansky, 2002).

Salinity is one of the most soil degradation processes. In Asia, Australia and South America, the salinity occurs in the arid-semiarid regions. Salt affecting soil can be divided into five main groups (European Communities, 2010):

- Saline soil is the soil with a high amount of water soluble soils.
- Alkaline soil, high alkalinity and high exchangeable sodium percentage.
- Magnesium soil: is the soil of high magnesium content in the soil solution.
- Gypsiferous soil: is the soil with high gypsum or calcium sulphate cumulative.
- Acid sulphate soil: is the soil with highly acidic iron or aluminum sulphate cumulative.

Solubility

Soluble salts for soils are defined as those salts that are soluble more than gypsum. The most common soluble salts in soils are the calcium (Ca), magnesium (Mg), sodium (N) and the chloride (Cl), sulfate (SO_4), and bicarbonate. Smaller quantities potassium (K), ammonium (NH_4), nitrate (NO) and carbonate (CO_3) also found in most soils. Sources of soluble salts in soils include fertilizers, sewage sludges, organic material, runoff from areas where salt or ice melt used and irrigation water that is high in dissolved salts (Rhoades, 1982).

There are many ionic compounds which can be dissolved in water. The perfect combination of ions makes each compound has a remarkable solubility in any solvent. The solubility is dependent on the ability of each ion to interact with the solvent, so there are certain patterns. However, ions that link tightly to each other would be less soluble because it would be more difficult for these structures to break apart for the compounds to dissolve (Kurlansky, 2002).

Salinity measurement:

There are two principal methods to specify the salt amplitude of water: Total dissolved salts and electrical conductivity. The total dissolved salts are measured by evaporating a known volume of water to aridity, then weighing the solid remaining. Electrical conductivity measured by running an electric current between two metal plates in the water sample and recalling how rapidity current flows between that two plates. The more dissolved salt in the water, the stronger the current gush and the paramount the electrical conductivity measurements can be used to establish an assessment of TDS (Anderson and Cummings, 1999).

The objective of the present work is to determine correlation values between the T.D.S. measured at 3 days with those measured at shorter times.

Experimental work:

Experiments were carried out on soil specimens of 18 samples of Baghdad soil taken from 18 different locations. The index properties of these soils were determined following the ASTM specifications as presented in Table 1.

The testing program was done by two stages; the first stage included measurement of ordinary T.D.S test following the B.S. 1377 (1990) (series A) while the second stage included measurement of the magnitude of total salts with time as illustrated below.

I. First stage (Series A):

The first stage of testing was done by measuring the T.D.S by preparing one cylinder for each sample. The sample was prepared following the B.S. 1377 (1990) procedure by adding 5 gm from soil to 250 cm^3 of distilled water and shaking for 3 days, and after these 3 days, the T.D.S was found in 50 cm^3 from this cylinder.

II. Second stage (Series B, C, D, E and F):

The second stage requires studying the effect of testing time on the values of T.D.S. Five cylinders were prepared for each ordinary sample as recommended by B.S. 1377 (1990) procedure. Each cylinder was tested after different times, not after 3 days as the standard requires and the testing time was designated with a name as different series as described below:

1. Series B was done by measuring the T.D.S. after 1 hour only after preparing the sample, and the test was done by taking 50 cm3 from the cylinder and putting it in the oven at 110o C.
2. Series C was done by measuring the T.D.S. after 2 hours only after preparing the sample and tested as usual.
3. Series D was done by measuring the T.D.S. after 3 hours only after preparing the sample and tested.
4. Series E was done by measuring the T.D.S. after 4 hours only after preparing the sample and the total dissolved salts are measured as usual.
5. Series F was done by measuring the T.D.S. after 24 hours only after preparing the sample and tested.
6. All the tests were carried out at the same temperature, which ranged between 26o C and 28o C, besides, the samples were stored in the refrigerator before testing in order to keep the water content of the samples constant as much as possible. Figure 1 shows the cylinders of experimental tests for some samples.

Figure(1): Experimental cylinders used for soil samples through determination of T.D.S.

Experimental test results:

The total dissolved salts variation with time for the tested samples is shown in Figure (2).

The results of total dissolved salts measured experimentally at different times are summarized in Table 2 for all samples.

The results obtained from experimental work illustrated in Table 2 and Figure 2 for all the samples show that the values of the total dissolved salts increase with time. In order

to make a correlation between the values of T.D.S. measured after 3 days and T.D.S. measured at any time, Figures 3 to 7 are drawn.

Figure 3 shows the relation between the total dissolved salts after 3 days obtained by the usual method and after one hour. The figure reveals the following relation:

$$\text{T.D.S.})_{3\,\text{days}} = 0.977 \text{x} \text{T.D.S.})_{1\,\text{hour}} + 0.908 \qquad \text{……..(2)}$$

The relation of Figure 3 maintains a correlation factor R equals (0.887) and a coefficient of determination R^2 equals (0.787).

Table (1) Physical properties and description of the soil samples.

Sample No.	Depth (m)	Location	Specific Gravity	Organic matter (%)	SO_3	Cl	LL	PL	Soil Description
1	18.75 - 19.75	Al-Jadiriya	2.67	0.2	1.25	40	-	-	Green to brown clayey sandy silt
2	14.5-15	Al-Jadiriya	2.62	0.3	0.67	40	-	-	Brown sandy silt
3	2	Al-Jadiriya	2.79	2.1	1.02	90	-	-	Brown clayey silt
4	12	Sahat Al-Wathek	2.76	0.9	0.82	90	-	-	Brown silty clay
5	15	Sahat Al-Wathek	2.79	0.9	1.24	135	-	-	Dark brown silty clay
6	6.5	Sahat Al-Wathek	2.80	1.9	1.46	40	-	-	Brown clay
7	2-2.5	Al-Orfaly	2.77	1.9	3.00	250	44	22	Brown silty clay
8	9.5-10	Al-Orfaly	2.73	1.7	1.60	350	56	10	Black clay with silt
9	2-4.5	Al-Orfaly	2.72	0.9	2.23	40	26	NP	Brown clayey silt
10	8-9.5	Al-Orfaly	2.75	1.1	3.99	375	39	22	Brown silty clay to clayey silt
11	0-1.5	Al-Orfaly	2.77	1.9	5.06	200	43	21	Silty clay with fill material
12	9.5-10	Al-Orfaly	2.78	1.5	3.61	500	50	26	Dark gray to black silty clay with fill materials
13	0-1.5	Palestine Street	2.78	0.8	1.53	4000	50	24	Brown silty clay with fill material
14	5.5-7.5	Palestine Street	2.81	1.1	2.57	550	74	29	Brown clay
15	11.5-14.5	Palestine Street	2.77	1.1	1.06	550	52	23	Brown clayey silt
16	2-2.5	Palestine Street	2.79	0.5	1.58	450	54	24	Brown silty clay with salts
17	5-5.5	Palestine Street	2.79	1.2	4.30	700	46	26	Brown silt clay
18	11-11.5	Palestine Street	2.74	0.6	0.88	450	22	NP	Brown clayey silt

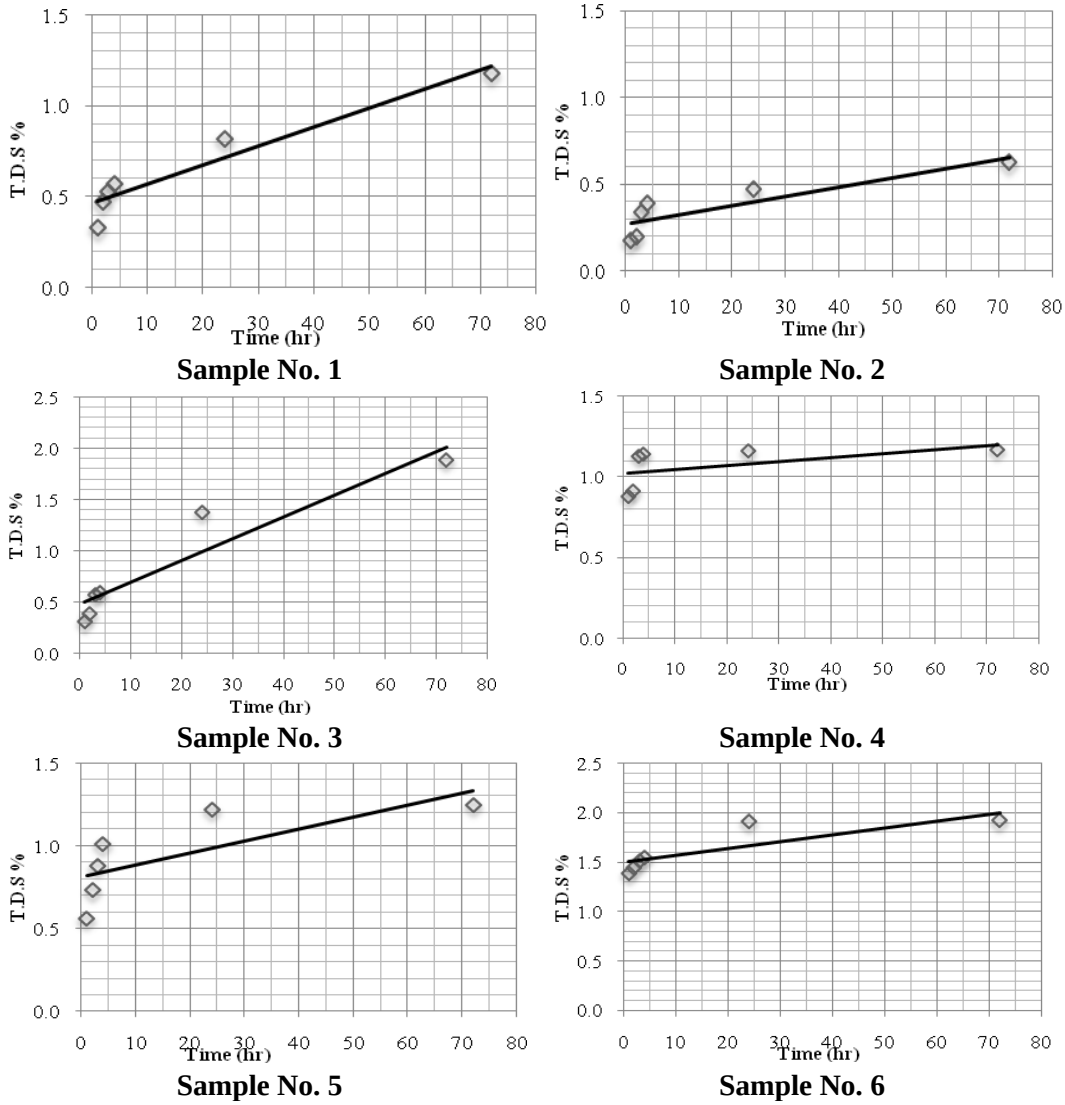
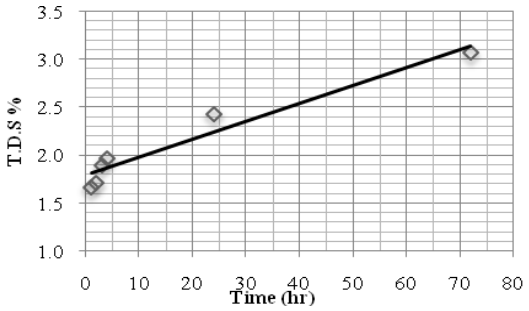


Figure (2): Experimental results of variation of T.D.S. with time for all samples tested.



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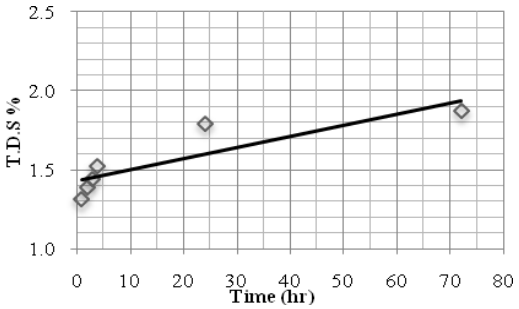

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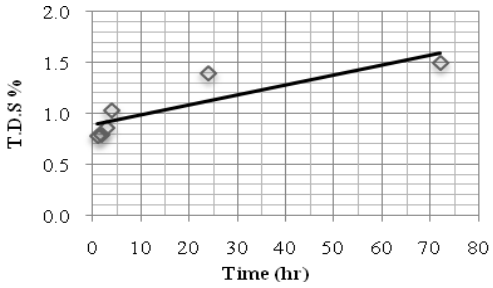

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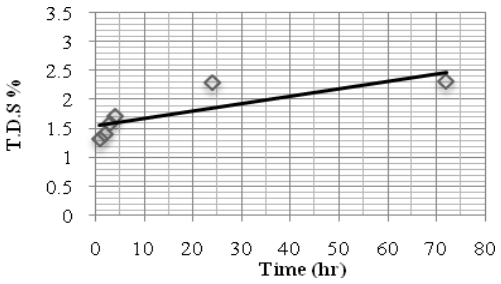

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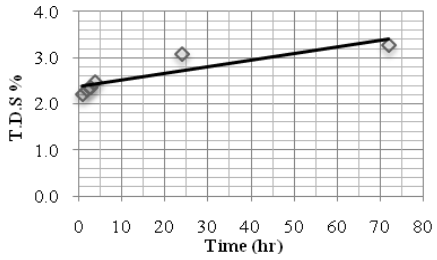

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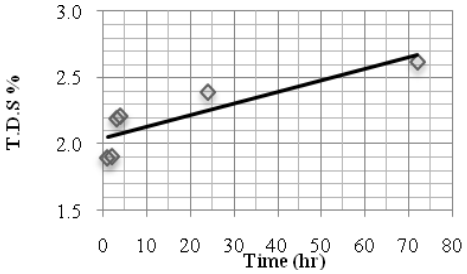
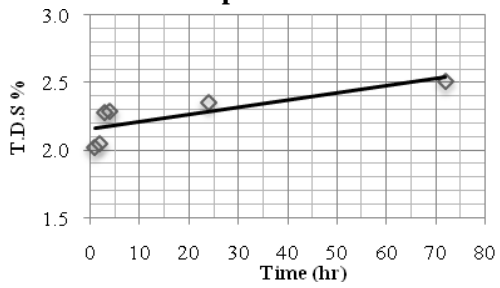


Sample No. 12



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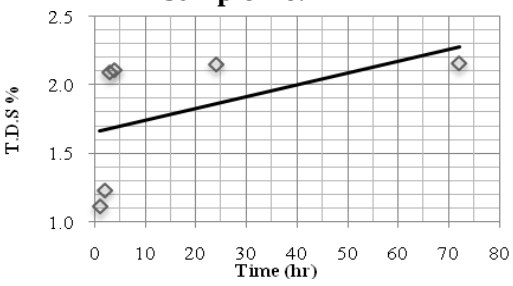
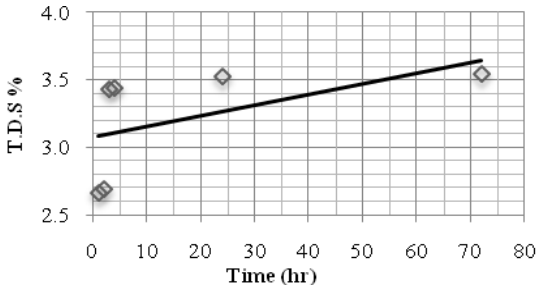
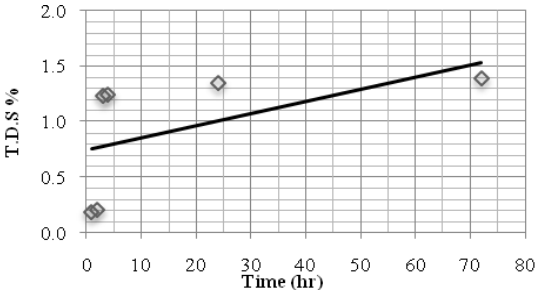


Sample No. 14

Figure (2): (Continued).



Sample No. 15



Sample No. 16

Figure (2): (Continued).

Table (2): - Variation of the total dissolved salts with time for the samples.

Sample number	Depth (m)	T.D.S. (%)					
		1 hr	2 hrs	3 hrs	4 hrs	1 day	3 days
1	18.75-19.75	0.33	0.47	0.53	0.57	0.82	1.18
2	14.5-15	0.18	0.2	0.34	0.39	0.47	0.63
3	2	0.31	0.39	0.57	0.59	1.38	1.89
4	12	0.88	0.91	1.13	1.14	1.16	1.17
5	15	0.56	0.73	0.88	1.01	1.22	1.25
6	6.5	1.39	1.45	1.51	1.55	1.91	1.92
7	2-2.5	1.66	1.71	1.89	1.97	2.43	3.07
8	9.5-10	1.31	1.39	1.44	1.52	1.79	1.87
9	2-4.5	0.78	0.79	0.86	1.03	1.39	1.5
10	8-9.5	1.32	1.41	1.59	1.71	2.29	2.32
11	0-1.5	2.21	2.29	2.36	2.47	3.08	3.28
12	9.5-10	1.89	1.9	2.19	2.21	2.39	2.62
13	0-1.5	2.02	2.05	2.28	2.29	2.35	2.51
14	5.5-7.5	1.21	1.25	2.2	2.33	2.6	2.68
15	11.5-14.5	1.04	1.11	1.83	1.84	1.89	1.93
16	2-2.5	1.11	1.23	2.09	2.11	2.15	2.16
17	5-5.5	2.66	2.69	3.43	3.44	3.52	3.54
18	11-11.5	0.18	0.21	1.23	1.24	1.35	1.39

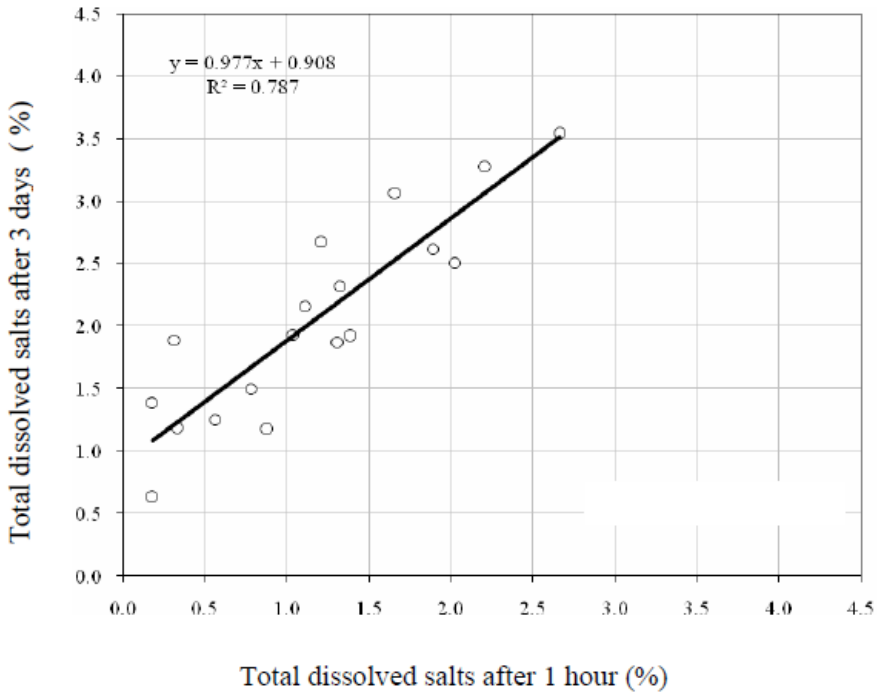


Figure (3): Relation between the total dissolved salts measured after 3 days and 1 hour.

Figures 4 to 7 show a comparison among the total dissolved salts measured after 3 days with values measured after two, three, four and 24 hours, respectively. The figures reveal the following relations:

$$\mathbf{T.D.S.)_{3\,days} = 0.993\ x\ T.D.S.)_{2\,hours} + 0.826} \quad \text{……..(3)}$$

with R^2 equals (0.90).

$$\mathbf{T.D.S.)_{3\,days} = 0.893\ x\ T.D.S.)_{3\,hours} + 0.643} \quad \text{……..(4)}$$

with R^2 equals (0.791).

$$\mathbf{T.D.S.)_{3\,days} = 0.91\ x\ T.D.S.)_{4\,hours} + 0.562} \quad \text{……..(5)}$$

with R^2 equals (0.808).

$$\mathbf{T.D.S.)_{3\,days} = 0.871\ x\ T.D.S.)_{24\,hours} + 0.175} \quad \text{……..(6)}$$

with R^2 equals (0.918).

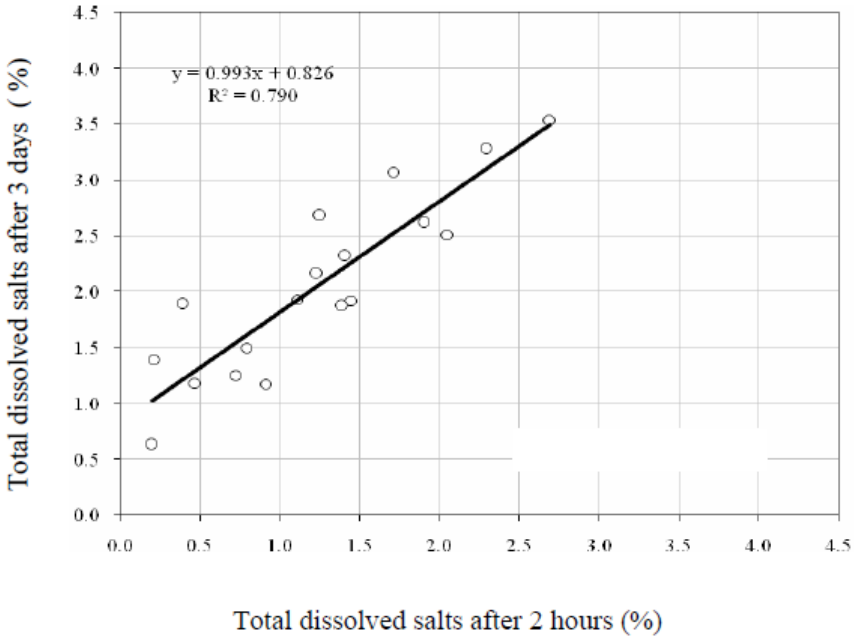


Figure (4): Relation between the total dissolved salts measured after 3 days and 2 hours.

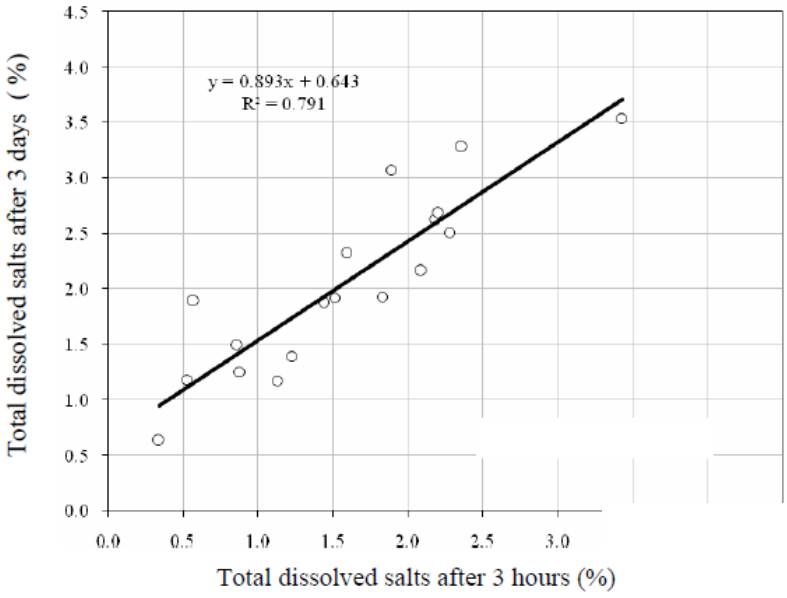


Figure (5): Relation between the total dissolved salts measured after 3 days and 3 hours.

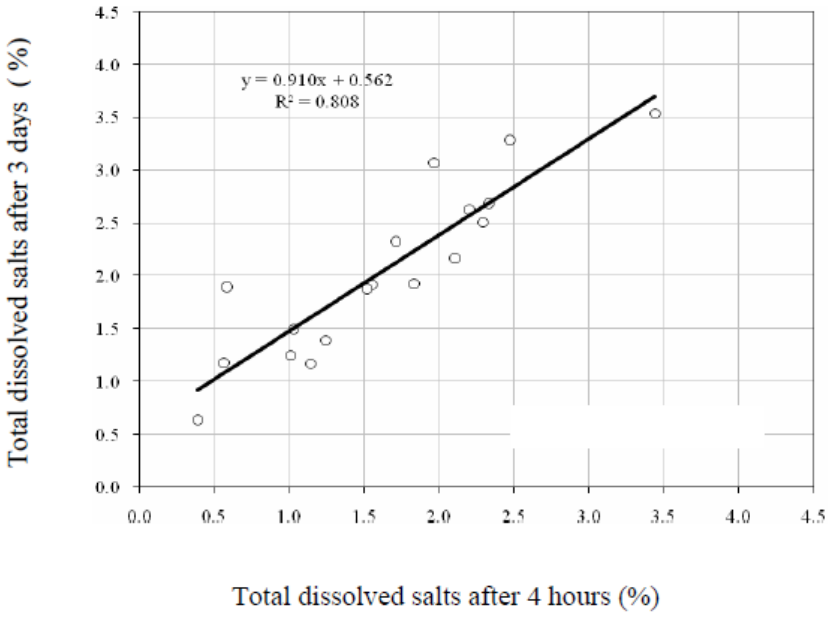


Figure (6): Relation between the total dissolved salts measured after 3 days and 4 hours.

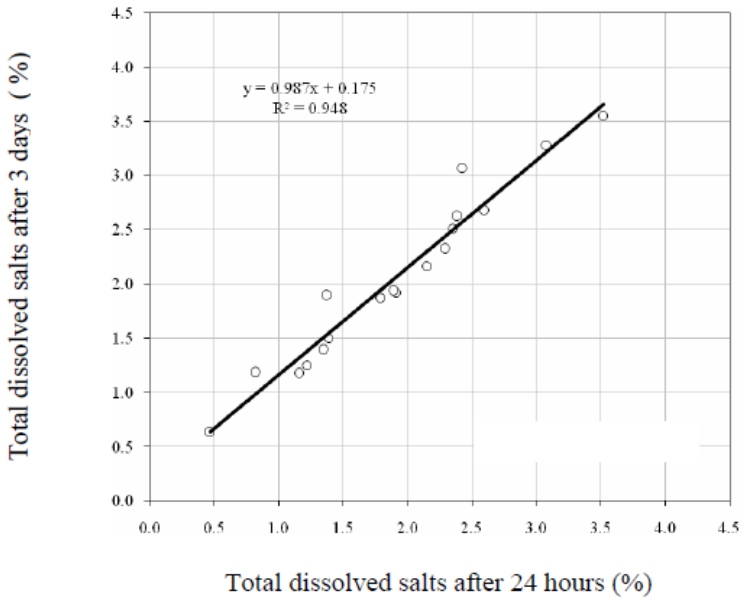


Figure (7): Relation between the total dissolved salts measured after 3 days and 24 hours.

CONCLUSIONS:

The following conclusions can be drawn from the results of this research:

- It was found that after 24 hours of soaking the soil in distilled water, the total dissolved salts will reach about 95 % of the actual amount (after 3 days).
- The usual procedure takes at lest three to four days which is very long time if there is no time or conductivity device. Therefore, a proposed procedure is submitted to estimate the T.D.S. after 24 hours which revealed very good agreement with the actual value.
- The results of T.D.S. measured after 24 hour give a suitable compatibility with those measured by the ordinary method after 3 days where the coefficient of determination R2 equals (0.918).
- The following expression can be used to estimate the T.D.S. from values measured after 24 hours:

$$\text{T.D.S.})_{3\,\text{days}} = 0.871 \text{ x } \text{T.D.S.})_{24\,\text{hours}} + 0.175$$

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