Proposed Equation to Estimate the Total Dissolved Salts in Sand

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Abstract:

The major objective of this paper is pediment a new equation which can be used to obtain the total dissolved salts in the sand. This equation enables us to obtain the total dissolved salts by finding density of the watery solution resulting from dissolve any sample in distilled water. This equation shows very good results, so in this paper a new method is proposed to find the total dissolved salts by applying this equation which derived in this research without the need to use usual methods in finding those total dissolved salts. In this study, the proposed method uses the density variation between distilled water and the watery solution which is taken from the sand sample dissolved with distilled water.

- This proposed method will make the test of total dissolved salts more easily and quickly applied.
- The proposed method is equal or exceed in its reliability on other testing methods.

Key Word: Total dissolved salts, Saline density, Soluble, Sand, and Density

الخلاصة:

ان الهدف الرئيسي من هذه البحث هو اشتقاق معادلة جديدة والتي يمكن استخدامها للحصول على الأملاح الكلية الذائبة في الرمل. هذه المعادلة تمكننا من الحصول على الأملاح الذائبة الكلية من خلال إيجاد كثافة المحلول المائي الناتج عن حل اي نموذج في الماء المقطر. هذه المعادلة تظهر نتائج جيدة جدا، لذلك تم اقتراح طريقة جديدة في هذا البحثلايجاد الأملاح الذائبة الكلية من خلال تطبيق هذه المعادلة التي تم اشتقاقها في هذا البحث دون الحاجة إلى استخدام الأساليب المعتادة لايجاد تلك الأملاح الذائبة.

في هذه الدراسة يستخدم الأسلوب المقترح اختلاف الكثافة بين الماء المقطر والمحلول المائي الذي يتم الحصول عليه من حل نموذج الرمل بالماء المقطر.

- الطريقة المقترحة هذه جعلت اختبار الأملاح الذائبة أكثر سهولة وسرعة عند تطبيقها.
- الطريقة المقترحة تساوي أو تتجاوز في دقتها طرق الاختبار الأخرى.

الكلمات المفتاحية: – الأملاح الذائبة الكلية، كثافة المالحة، الذوبان، الرمل والكثافة.

Introduction:

Since ancient time's man had noticed that, there are soils that contain excessive amounts of salts. The salinity is a measurement of the intensity of soluble salts. Cations (sodium, potassium, calcium, and magnesium) and anions (sulfates and chlorides) are the general solutes which responsible on salinity. (Winfield and Lee, 1999)

In many regions of the world, large areas are covered with soils containing water-soluble salts. These saline soil conditions tend to prevail in many regions of the Middle East countries (Al-Amoudi and Abduljauwad, 1995; Bilsel, 2004). Construction on these soils is quite problematic especially in regions of dry and hot climates due to the severe effect of salt corrosion on structural elements (Rongzhen et al., 2006) and due to its high collapse potential and low-bearing strength (Al-Amoudi, 2001).

All natural waters contain soluble salts (El-Swaify, 2000).

The salts contain of positive charge ions mention as cations and negatively charged ions mention anions. They could be resolved in water (soluble salts) or could be found as solids. (Horneck *et.al.*, 2007)

However, it is worth remembering that various types of salts might be present within the soil, but the most frequent and significantly soluble types are listed in Table (1). These salts have high solubility relative to the carbonates.

Table (1): Salts encountered in soils with their densities and solubility, (Weast 1974). (After *Osama et.al.*, 2008) .

Salt formula	Salt name	Molecular weight,M,g/mol	Specific gravity	Solubility at 20◦ C,as A%	Solubility at 25 ◦ C,A%
$CaCl_2.2H_2O$	…	147.02	0.84	42.7	52.1
$CaCl_2.6H_2O$	…	219.08	1.71	…	…
$CaSO_4$	Anhydrite	136.14	2.96	…	…
$CaSO_4.0.5H_2O$	Bassanite	145.15	2.74	…	…
$CaSO_4.2H_2O$	Gypsum	172.16	2.32	0.2014	0.2082
$MgCl_2$	…	95.22	2.32		
$MgCl_2.6H_2O$	Bischofite	203.31	1.57	35.3	35.5
$MgSO_4$	…	120.37	2.66	…	…
$MgSO_4.H_2O$	Kieserite	138.39	2.45	…	…
$MgSO_4.4H_2O$	Leonhardtite	202.45	2.01	…	…
$MgSO_4.6H_2O$	…	238.47	1.72	…	…
$MgSO_4.7H_2O$	Epsomite	246.48	1.68	25.2	26.7
KCl	Sylvite	74.55	1.99	25.5	26.4
K_2SO_4	Arcanite	174.27	2.66	10.0	10.75
$NaCl$	Halite	58.44	2.16	26.38	26.43
Na_2SO_4	Thenardite	142.04	2.67	…	…
$Na_2SO_4..10H_2O$	Mirabilite	322.14	1.46	15.97	21.88

The Dilution Effect:

One of requisite characteristic of ionic compounds is the solubility. It is understood theoretically that ions crystals in a saturated solution are in equilibrium with the hydrated ions (Gualbert, 2001, (B)).

So when we add water to soil the soluble salts will dissolve if they are found (Reitemeier, 1946).

In this research , the distilled water will be added to sand to check the efficiency of the proposed equation derived for finding the dissolved salts ratio in fine aggregate.

Particular minerals that exist widely in soils resolve when exposed to salt solutions but normally these minerals are not plentiful sufficiently (Chapman and Kelley, 1930). It may be summarized that mixing water with soil will dissolve more and more salts, the concentrations of dissolved substances tend to diverge more and more from those common in the real field conditions. So it has been found that desirable limiting the addition of water to soil samples to the minimum amount compatible with the extraction of sufficient soil solution for analysis. This has led to great popularity of the saturated paste extractions suggested by workers at the U. S. Salinity Laboratory (United States Salinity Laboratory Staff, 1954).after (Kenneth, 1967)

Solution Density

The density of any solution is the summation of intensity of the components of that solution as appear in equation 1. The intensity of a given component in a solution can be called fractional density of that component. (Nuclear Size and Density, 2009)

$$\rho = \sum_i \rho_i \qquad \dots (1)$$

Where:

ρ is the density of solution

Table 2 presents the solution densities corresponding to a wide range of concentration for these salts but only at 20 °C. For other temperatures, the value may be corrected by multiplying it with the ratio $\rho_{W_T} / \rho_{W_{20^\circ C}}$ as a good approximation. Values for other salts may be found in (Weast, 1974). It should be noted that the concentration in Table (2) is referred to as the percentage of the anhydrous phase of the salt in solution, denoted by A (Osama *et.al.*, 2008).

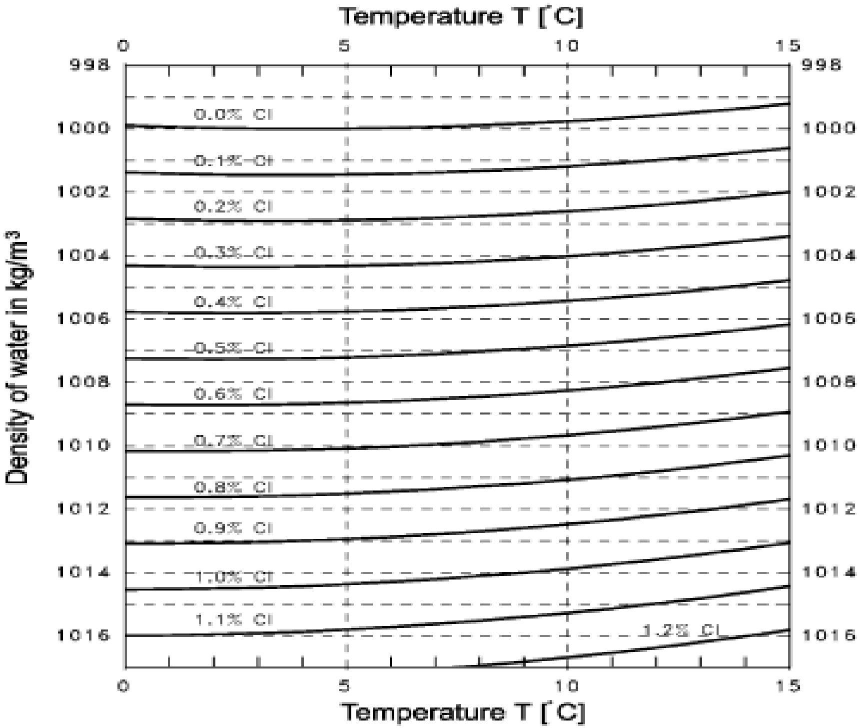
Table (2): Density of solution of different salts for various concentrations, data collected from (Weast,1974) after *(Osama et.al.,* 2008). The numbers in the shaded cells are interpolated.

Salt formula and name	***$CaCl_2.2H_2O$***	***$MgCl_2$ .6H_2O Bischofite***	***$MgSO_4$.7 H_2O Epsomite***	***KCl Sylvite***	***K_2SO_4 Arcanite***	***NaCl Halite***	***Na_2SO_4. . Na_2SO_4. .10H $_2O$ Mirabilite***
A%	Density of solution at 20 °C, g/cm^3						
0.1	1.0005	1.0004	1.0007	1.0003	1.0004	0.9989	1.0005
0.2	1.0010	1.0009	1.0013	1.0006	1.0009	0.9997	1.0011
0.3	1.0014	1.0013	1.0020	1.0008	1.0013	1.0004	1.0016
0.4	1.0019	1.0018	1.0026	1.0011	1.0018	1.0011	1.0022
0.5	1.0024	1.0022	1.0033	1.0014	1.0022	1.0018	1.0027
1.0	1.0065	1.0062	1.0084	1.0046	1.0062	1.0053	1.0071
1.5	1.0106	1.0103	1.0135	1.0078	1.0102	1.0089	1.0116
2.0	1.0148	1.0144	1.0186	1.0110	1.0143	1.0125	1.0161
2.5	1.0190	1.0185	1.0238	1.0142	1.0183	1.0160	1.0206
3.0	1.0232	1.0226	1.0289	1.0174	1.0224	1.0196	1.0252
3.5	1.0274	1.0268	1.0341	1.0207	1.0265	1.0232	1.0298
4.0	1.0316	1.0309	1.0392	1.0239	1.0306	1.0268	1.0343
4.5	1.0358	1.0343	1.0445	1.0271	1.0347	1.0304	1.0389
5.0	1.0401	1.0394	1.0497	1.0304	1.0388	1.0340	1.0436
5.5	1.0443	1.0447	1.0545	1.0336	1.0429	1.0377	1.0481
6.0	1.0486	1.0479	1.0602	1.0369	1.0470	1.0413	1.0526
6.5	1.0529	1.0522	1.0655	1.0402	1.0512	1.0450	1.0572
7.0	1.0572	1.0564	1.0708	1.0434	1.0553	1.0486	1.0619
7.5	1.0615	1.0608	1.0762	1.0467	1.0595	1.0523	1.0666
8.0	1.0659	1.0651	1.0816	1.0500	1.0637	1.0559	1.0713
8.5	1.0703	1.0695	1.0870	1.0533	1.0679	1.0596	1.0760
9.0	1.0747	1.0738	1.0924	1.0566	1.0721	1.0633	1.0808
9.5	1.0791	1.0782	1.0979	1.0600	1.0763	1.0670	1.0856
10.0	1.0835	1.0826	1.1034	1.0633	1.0806	1.0707	1.0905
11.0	1.0923	1.0916	1.1146	1.0700	…	1.0781	1.1002
12.0	1.1014	1.1005	1.1257	1.0768	…	1.0857	1.1101
13.0	1.1105	1.1097	1.1371	1.0836	…	1.0932	1.1201
14.0	1.1198	1.1189	1.1484	1.0905	…	1.1008	1.1301
15.0	1.1292	1.1281	1.1601	1.0974	…	1.1085	1.1402
16.0	1.1386	1.1372	1.1717	1.1043	…	1.1162	1.1503
17.0	1.1482	1.1463	1.1836	1.1114	…	1.1240	1.1604
18.0	1.1579	1.1553	1.1955	1.1185	…	1.1319	1.1705
19.0	1.1677	1.1648	1.2077	1.1256	…	1.1398	1.1806
20.0	1.1775	1.1742	1.2198	1.1328	…	1.1478	1.1907

The Density of Solution:

Usually the Density is a function of pressure, temperature of the fluid and dissolved solids. (Gualbert, 2001, (A))

Under the normal conditions, the influence of pressure and temperature on the density can be ignored compared with the effect of dissolved solids concentration. Therefore, the density of water is often only related to the concentration of the Total Dissolved Solids TDS in the water as shown in Figure 1. ((Gualbert, 2001, (A)),(Gualbert, 2001,(B)))



Accurate for T<15 °C and for Cl <1.1 %

Fig.1.Density of water varied with tempreture and chloride (Cl$^-$), (After Gualbert, 2001, (B))

The Methods of Salinity Measuring:

The salinity of any sample solution may be obtained in the laboratory by means of: Displacement, Compaction, and Centrifugation, Molecular adsorption, Vacuum- or pressure extraction methods.

The latter methods are described by Richards (1941); displacement methods by Adams (1974); combination displacement/centrifugation methods by Gillman (1976), Elkhatib *et.al.*,1986; a combinationvacuum/displacement method by Wolt and Graveel (1986); a simple field-pressure filtrationmethod by Ross and Bartlett (1990); adsorption techniques by Davies and Davies , 1963; Kinniburgh and Miles, 1983; and Elkhatib *et.al.*, 1987; After Rhoades *et.al.*, 1999)

So the intensity of total dissolved salts may be determined by applying many methods, but it is usually done either by separating and weighing the salts or by measuring the conductivity of the solution sample .So in first method which named as (direct gravimetric method) ,a particular amount of a watery solution is dried, and the salts contained in it are found and explained as milligrams per liter, where in the second method which named (Electrical conductivity)the watery solution of any samples could contain electrolytes which have capable of conducting an electric current . So when the sample contains high concentration of salts the electrical conductivity will be also high. This test needs specially register and sensors. (El-Swaify *et.al.,* 1983)

Previous Studies:

- In 1983 Romanklw and Choumeasured the Density of (NaCl) solutions in a temperature between (25 to 45) $^{\circ}C$ and concentration between (0-26.2) weight % and the following equation was found. (Akridge, 2008).

$$D=\left(\frac{25}{T_{sol}}\right)^{0.012}\left(2.754\times10^{-5}S^{2}+6.872\times10^{-3}S+0.99704\right) \quad \dots (2)$$

Where D is the solution density in (g/cm^3), S is the NaCl concentrationinweight%, and T_{sol} is the temperature of the solution in ($^{\circ}C$).

- The density of slushysalts could be calculated using device based on the Archimedes' principle for buoyancy for immersed bodies. In the Archimedes' theory the density of a liquid could be calculated from the buoyancy force exerted on a sinker of known mass and volume submerged in the liquid. In this device the submerged sinker was suspended by a wire attached to a balance, which allows the buoyancy force to be determined by a differential measurement between the immersed mass and the baseline state of the sinker in air at ambient temperature. The density of a liquid sample is calculated according to Equation below:

$$\rho=-\left(M_i-M_o\right)/V_S\{1+3C\left(T-T_O\right)\} \quad \dots (3)$$

Where $M_i$and $M_o$are the masses of the sinker immersed and at ambient temperature (T_o), respectively, $V_s$is the volume of the sinker at the ambient temperature, and C is linear thermal expansion coefficient of the sinker material.T in Celsius units(Bradshaw,2009) after (Wang and Wang, 2006)

- Stuyfzand in (1989) produce a proximate formula in terms of total dissolved solids (TDS) in mass fraction sampled as (cm), and temperature $^{\circ}C$ .after(Kue-Young *et.al.,* 2007):

$$\rho=1000\times\left[1+0.805\times c_m-6.5\times10^{-6}\times\left(T-4+220\times c_m\right)^{2}\right] \quad ... (4)$$

Stuyfzand found (TDS) by The EC.

- Kue-Young *et.al.,* 2007 presented a study to assessment the depth of the (fresh water/salt water) moderator in aquifers using two groups of data obtained from the pure and saline zones within a single borehole. In this research the method uses the density difference between pure and saline water. The EC was almost 250 $\mu S/cm$ in the pure water part and between (25,000 - 31,000) $\mu S/cm$ in the salt water part.

$$c_m(kg/kg) = 0.69778\times10^{-6}\times c(\mu S/cm) \qquad \ldots (5)$$

The derive procedure:

All the standards agree on using the avoirdupois of dislodged water to determine the volume of the solids. Such approach is well discussed in many well-known references (Lamb, 1951).

In this research attempt made to derive an equation to find the total dissolved salts in soil as shown in equation 6 to equation 23 and as below:

This principle is true for all solutions as well: the more dissolved solutes, the denser the solution. Any volume taken from the soluble represent dissolved salts and distilled water. The relative density difference of the dissolved salt could find in eq.6

$$\alpha = {(\rho_{total}-\rho_{water})}\Big/{\rho_{water}} \qquad \ldots\ldots (6)$$

$$v_{taken} = v_{salt} + v_{water} \qquad \ldots\ldots(7)$$

$$v_{taken} = \frac{w_{salt}}{\alpha\times\rho_{water}} + \frac{w_{water}}{\rho_{water}} \qquad \ldots\ldots\ldots(8)$$

$$w_{water} = w_{of\ taken\ volume} - w_{salt} \qquad \ldots\ldots (9)$$

$$w_{salt} = T.D.S_{\text{soluble}}\times v_{water} \qquad \ldots (10)$$

$$v_{taken} = \frac{T.D.S_{\text{soluble}}\times v_{water}}{\alpha\times\rho_{water}} + \frac{\left(w_{of\ taken\ volume} - T.D.S_{\text{soluble}}\times v_{water}\right)}{\rho_{water}} \qquad \ldots (11)$$

$$v_{taken} = T.D.S_{\text{soluble}}\times v_{water}\left(\frac{1}{(\alpha\times\rho_{water})} - \frac{1}{\rho_{water}}\right) + \frac{\left(w_{of\ taken\ volume}\right)}{\rho_{water}} \qquad \ldots (12)$$

$$v_{taken} - \frac{\left(w_{of\ taken\ volume}\right)}{\rho_{water}} = T.D.S_{\text{soluble}}\times v_{water}\left(\frac{1}{(\alpha\times\rho_{water})} - \frac{1}{\rho_{water}}\right) \qquad \ldots (13)$$

$$T.D.S_{\text{soluble}} \times v_{water} = \frac{v_{taken} - \dfrac{\left(w_{of\ taken\ volume}\right)}{\rho_{water}}}{\left(\dfrac{1}{\left(\alpha \times \rho_{water}\right)} - \dfrac{1}{\rho_{water}}\right)} \qquad \dots (14)$$

$$T.D.S_{\text{soluble}} = \frac{\left|\dfrac{v_{taken} - \dfrac{\left(w_{of\ taken\ volume}\right)}{\rho_{water}}}{\left(\dfrac{1}{\left(\alpha \times \rho_{water}\right)} - \dfrac{1}{\rho_{water}}\right)}\right|}{v_{water}} \qquad \dots (15)$$

$$v_{water} = v_{taken} - v_{salt} \qquad \dots (16)$$

$$v_{water} = v_{taken} - \left(T.D.S_{\text{soluble}} \times v_{Ttaken}\right) \qquad \dots (17)$$

$$T.D.S_{\text{soluble}} = \frac{\left[\dfrac{\left(v_{taken} - \dfrac{\left(w_{of\ taken\ volume}\right)}{\rho_{water}}\right)}{\left(\dfrac{1}{\left(\alpha \times \rho_{water}\right)} - \dfrac{1}{\rho_{water}}\right)}\right]}{v_{taken} - \left(T.D.S \times v_{taken}\right)} \qquad \dots (18)$$

$$T.D.S_{\text{soluble}} \times v_{taken}\left(1 - T.D.S_{\text{soluble}}\right) = \frac{\left(v_{taken} - \dfrac{\left(w_{of\ taken\ volume}\right)}{\rho_{water}}\right)}{\left(\dfrac{1}{\left(\alpha \times \rho_{water}\right)} - \dfrac{1}{\rho_{water}}\right)} \qquad \dots (19)$$

And rearranging, the following is obtained:

$$\left(T.D.S_{\text{soluble}}\right)^2 - T.D.S_{\text{soluble}} - \frac{\dfrac{\left(v_{taken} - \dfrac{\left(w_{of\ taken\ volume}\right)}{\rho_{water}}\right)}{\left(\dfrac{1}{\left(\alpha \times \rho_{water}\right)} - \dfrac{1}{\rho_{water}}\right)}}{v_{taken}} = 0 \qquad \dots (20)$$

If we assume

$$z=\frac{\dfrac{\left(v_{taken}-\dfrac{\left(w_{of\ taken\ volume}\right)}{\rho_{water}}\right)}{\left(\dfrac{1}{\left(\alpha\times\rho_{water}\right)}-\dfrac{1}{\rho_{water}}\right)}}{v_{taken}} \qquad \dots (21)$$

Sub equation. (21) In equation. (20) And solve to find the total dissolved salt in solution of the volume taken from the cylinder of the dissolved soil as follow.

$$T.D.S_{\text{soluble}}=\left|\frac{1-\sqrt{1+4(Z)}}{2}\right|\times 1000 \qquad \dots (22)$$

To find the total dissolved salts in soil the following equation will apply:

$$T.D.S=\frac{T.D.S_{\text{soluble}}\times De}{W_{SOIL}} \qquad \dots (23)$$

Where:

$T.D.S=$ Total dissolved salts in soil in %.

$T.D.S_{\text{soluble}}$= total dissolved salts in the soluble of soil.

$De=$ Dissolution percent (example-if the percent of the soil to water equal to 1:50, then De = 50)

$W_{SOIL}=$ The Weight of the soil used, in gm.

Samples Properties

The samples, which used in this study, have various chemical characteristics and the general properties of the samples shown in Table (3).

Table 3- The properties and the description of the samples.

Sample no.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Specific Gravity	2.71	2.59	2.70	2.61	2.61	2.65	2.67	2.62	2.66	2.57	2.67	2.62	2.58	2.62	2.60
OR %	0.95	0.10	1.70	4.80	0.72	0.34	0.85	1.78	1.32	1.80	0.20	1.10	2.30	0.30	1.85
SO_3 %	1.10	0.30	1.08	1.53	1.11	0.50	0.90	0.90	0.35	0.55	1.24	0.90	1.30	0.67	1.05
Cl mg/l	120	25	50	250	142	40	100	190	20	68	40	30	140	40	95

Experimental procedure:

The proposed equation (23) was previosly checked with soil samples, in this research the proposed equation will check the vilidity with sand samples by experiment done according to the following program**:**

For each sample, the following tests are done;

1- The total dissolved salts were tested as described in (Earth Manual (E2), 1974). by evaporation method, which consists of preparing soil solution with 1:50 dilution, by adding 5 gm of soil to 250 cm^3 distilled water in the cylinder and shaking the cylinder for three day.

2- From this cylinder, two samples of 30 cm^3 are taken, one putting in the oven to find the total dissolved salt as usual and the second sample, its weight found by using a balance with four digits.

3-The total dissolved salts then found by applying equations 21, 22 and 23.These results have shown in Table 4 as below:

Figure (2) shows the steps of the proposed test by finding the density of the soil soluble. after (Ali, 2016)

Fig (2): Sample Prepration and Testing Pictures

Table 4: The results of the total dissolved salts for the samples by the derived equation.

Sample no.	$W_{\text{of taken volume}}$ gm	W_{water} gm	V_{water} cm^3	ρ_{water} gm/cm^3	V_{taken} cm^3	ρ_{total} gm/cm^3	Z	$T.D.S_{solubl}$	TDS by density %
1	30.3324	29.9785	30	0.99928	30	1.01108	-0.000141	0.1409049	1.409
2	30.2019	29.9785	30	0.99928	30	1.00673	-5.59E-05	0.0559061	0.559
3	30.3775	29.9785	30	0.99928	30	1.012583	-0.000179	0.1793725	1.794
4	30.5101	29.9785	30	0.99928	30	1.017003	-0.00032	0.3197940	3.198
5	30.2993	29.9785	30	0.99928	30	1.009977	-0.000116	0.1156538	1.157
6	30.4861	29.9785	30	0.99928	30	1.016203	-0.000291	0.2913413	2.913
7	30.2809	29.9785	30	0.99928	30	1.009363	-0.000103	0.1027048	1.027
8	30.3727	29.9785	30	0.99928	30	1.012423	-0.000175	0.1750551	1.751
9	30.4363	29.9785	30	0.99928	30	1.014543	-0.000237	0.2365925	2.366
10	30.3573	29.9785	30	0.99928	30	1.01191	-0.000162	0.1615627	1.616
11	30.4333	29.9785	30	0.99928	30	1.014443	-0.000234	0.2334788	2.335
12	30.2829	29.9785	30	0.99928	30	1.00943	-0.000104	0.1040747	1.041
13	30.4178	29.9785	30	0.99928	30	1.013927	-0.000218	0.2177248	2.177
14	30.4551	29.9785	30	0.99928	30	1.01517	-0.000257	0.2565815	2.566
15	30.3612	29.9785	30	0.99928	30	1.01204	-0.000165	0.1649278	1.649

Figure (3) shows the relation between the (actual) dissolved salts and estimated total salts from the solution density found the equation derived in this researchas below.

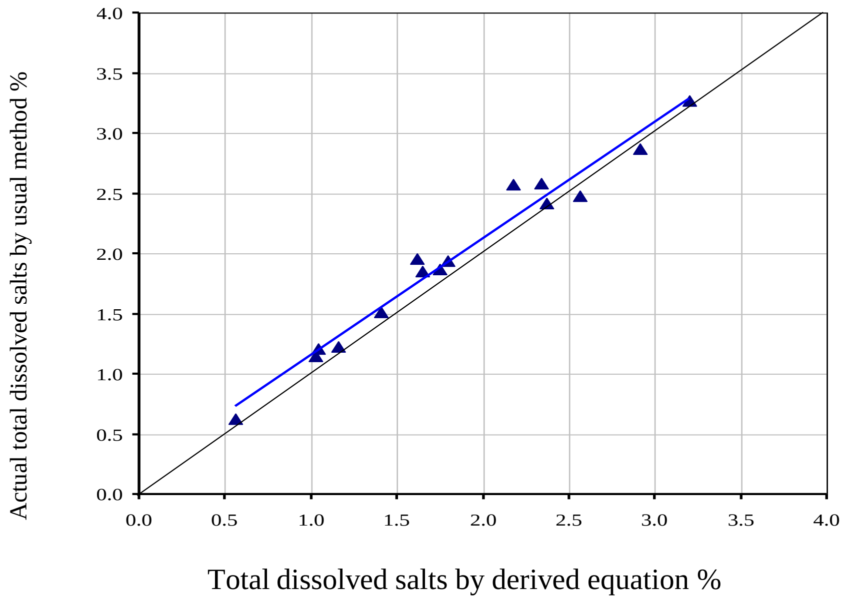


Fig (3) – Relation between total dissolved salts by the derived equation and actual dissolved salts.

Figure 3 shows that's the derived equation in this research gives very good results where the root square equal to (R^2) (0.9708).

Comparison with previous studies:

To study the efficiently of the derived equation, Table (5) shows the results of the experiment by applying the derived equation and the previous equations in this field.

Table 5: - The results of the total dissolved salts for the samples by the derived equation and other previous equations.

Sample no.	T.D.S by traditional method	T.D.S by proposed method and using derived equation	T.D.S by Romanklw & Chou eq.1983	T.D.S by Stuyfzand eq.1989
1	1.510	1.409	1.429	1.545
2	0.625	0.559	0.799	0.964
3	1.940	1.794	1.633	1.734
4	3.272	3.198	2.252	2.313
5	1.230	1.157	1.267	1.395
6	2.870	2.913	2.165	2.231
7	1.145	1.027	1.176	1.311
8	1.870	1.751	1.628	1.730
9	2.420	2.366	1.914	1.996
10	1.960	1.616	1.543	1.650
11	2.580	2.335	1.900	1.984
12	1.210	1.041	1.195	1.329
13	2.570	2.177	1.832	1.920
14	2.480	2.566	2.009	2.085
15	1.850	1.649	1.576	1.682

Figure 4, shows the relation between the (actual) dissolved salts and estimated total salts from the solution density found by previous equations beside the equation derived in this research.

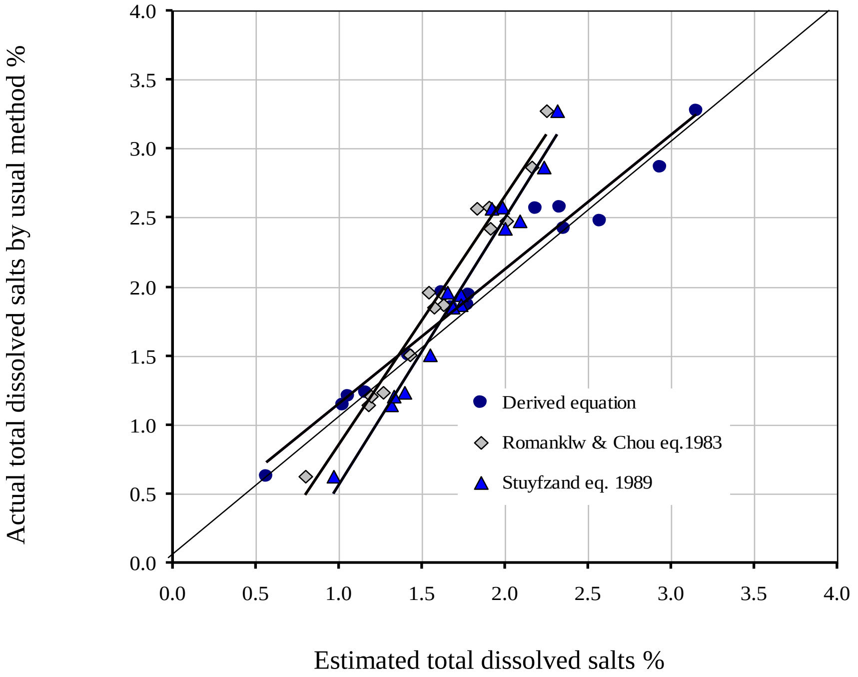


Fig (4) – Relation between actual total dissolved salts and estimated total dissolved salts by the derived equation and in different previous equation.

It is obvious in Figure 3 that the derived equation's results show better results than the other equations, that's because that the proposed equation is derive from the principles, were the other equations are empirical relationship found from statistical analyses of a tests. The correlation factor with the derived equation equals to (0.9853), but the correlation factor equals to (0.9858with Romanklw and Chou equation 1983; and its equal to 0.9860with Stuyfzand equation 1989).

Conclusions:

1-Salt water is denser than distills water because of the dissolved salt.

2-When water is added to any sample, it dissolved salt by shattering the salts into ions which attract after that to the water jots. This attraction causes them to link tightly and that increase the amount of matter per volume in other word increasing the density.

3- In this research , a new equation is derived to find the total dissolved salts from the density of the solution of the soil, this equation gives a root square equal to (R^2)(0.9708).

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Sample used:

T.D.S=total dissolved salts in %.

$T.D.S_{\text{soluble}}$= total dissolved salts in the soluble of soil.

$De =$ Dissolution percent (example-if the percent of the soil to water equal to 1:50, then De = 50)

$W_{SOIL} =$ The Weight of the soil used, in gm.

$\rho_{water} = \text{d}ensity \text{ of the water} \qquad in\ gm/cm^3$

$\rho_{salt} = \text{d}ensity \text{ of the salt} \qquad in\ gm/cm^3$

$\rho_{total} = \text{d}ensity \text{ of the soluble} = \frac{w_{of\ taken\ volume}}{v_{taken}} \qquad in\ gm/cm^3$

$w_{of\ taken\ volume}$= weight of soluble in the volume taken, in gm.

v_{taken}= volume of the soluble taken, in cm^3.

v_{salt}= volume of salt in the volume of the taken soluble, in cm^3.

v_{water}=volume of water in the volume of the taken soluble, in cm^3.

w_{salt}= weight of the dissolved salt in the volume of the taken soluble, in gm.

w_{watert}= weight of the water in the volume of the taken soluble, in gm.

D= the solution density in (g/cm^3)

S = the NaCl concentrationinwt%

T_{sol}=the solution temperature in ($°C$).

ρ = density (kg/m3),

p = pressure ($M\,L$−1 T−2),

T = temperature (^oC),

S = salinity1 or total dissolved solids (TDS) (mg/l).

α =The relative density$= {(\rho_{total} - \rho_{water})}/{\rho_{water}}$