Chemistry and Materials Research
ISSN 2224- 3224 (Print) ISSN 2225- 0956 (Online)
Vol.6 No.1, 2014

Estimate and Classify the Hardness of Different Water Sources by Using Prepared Soap Solution

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Abstract:
This research includes available techniques and simplified methods to estimate and classify the quality of hardness for different water supply sources like sea water, various wells (Fayda, khabyar, jumbyar) and tap water of Basrah ,Mosul, Duhok and Baghdad, by using prepared soap solution from different commercial liquid soap with different concentration ($SS_{1,2,3}$, $SS_{4,5,6}$, $SS_{7,8,9}$). The hardness of water is relative to the formation of foam (suds) when soap solution is added to water samples until a foam layer of a certain height (2cm) formed. We determine the volume (in drops, milliliter) of soap solution. If there is a lot of foam formed quickly with little soap solution, the water is rather soft. If you need to add a lot of soap solution to produce a certain height of foam, the water is rather hard. Many factor that establish during experiments, the quality of water supply, measuring degree of hardness, concentration of water samples. Compared with the results of laboratory tests for water stations of Mosul gave our method of encouraging and positive results to continue in the future, so liquid soap bubbles (foam) are a good indicator of classifying types of water.
Key words: Estimate and classify the hardness of different water sources, New and simple calculations

Introduction:

We review in this introduction the definition of hardness and its relationship with the structure of soap in addition to the formation of soap foam.

Water hardness is caused mainly by soluble ions of calcium and magnesium, but can also be from Al, Fe, Sr, Mn, or Zn. These are usually insignificant(WHO, 1999). If these minerals are present in your drinking water in high concentrations, the water is considered hard.
Hard water is difficulty making lather or suds with soap and detergent , liquid soap bubbles are a good indicator because the minerals in the water react with the liquid soap when they are present. The degree of hardness in drinking water is commonly classified in terms of its concentration of calcium carbonate table (1).(WHO, 1996)(Standards specifications, 1996)(APHA, 2003).

Table(1) Water hardness classification

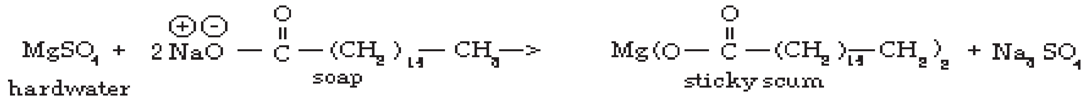
Hardness description	Concentration of Calcium Carbonate (mg/L) (ppm)
Soft	0 --------75
Medium hard	75 ------150
Hard	150 -----300
Very hard	300 -----500
Need treatment	500 and greater

Soap is the common name for sodium stearate (more properly, sodium octadecanoate). The soluble calcium ions and magnesium ions combine with stearate ions in the soap to form *insoluble* calcium and magnesium stearates. These compounds are the insoluble scum that floats on the water. For example, with calcium ions (Brown 1997) .

$$\underset{\text{(in solution)}}{\text{calcium ions}} + \underset{\text{(in solution)}}{\text{stearate ions}} \longrightarrow \underset{\text{(insoluble solid)}}{\text{scum}}$$

$$Ca^{2+}_{(aq)} + 2C_{17}H_{35}CO_2^-{}_{(aq)} \longrightarrow Ca\ (C_{17}H_{35}CO_2)_{2(s)}$$

magnesium ions are similar



Ions in water combine with soap to form insoluble precipitates; prevents sudsing until the combination is complete then the amount of soap that is required to make a lather can therefore be used to estimate the hardness of water.

figure(2) liquid soap bubbles

figure(1) structure of one bubble

The liquid soap bubble is actually made of three very thin layers: soap, water, and another layer of soap. This "sandwich" that is on the outside of a bubble is called a soap film. A bubble pops when the water that is trapped between the layers of soap evaporates. figure (1)

Thousands of bubbles mixed, in this case there seems to be a chaos of angles, levels, curves and reflections. However, the shapes continue to arrange themselves out in an organizer shape. figure (2) . Photo taken near (Nevada, Missouri on February 9, 2012) .

Aim of the research:

1. Using simple and easy experiments to estimate and classify the hardness from different water sources.

2. Find a quick and initial way to classify water hardness.

3. Find a new method to estimate the total hardness in many different units . mg CaCO3/ L, ppm , d ^{0}TH (degree of total hardness).

Practical Part:

Apparatus and equipment:

Measuring cylinder, Burette and burette stand, Test tubes, Stoppers for the test tubes, Beakers with different size, Stirring rod, Centimeter scale, Dropping pipet, Hot plate or Bunsen burner and ring stand, Eye dropper.

Chemicals:

Distilled water, Liquid hand soap(three different type (A,B,C), Soap solution(SS1-9), Sea water, Tap water from various locations of (Duhok ,Mosul ,Baghdad and Basrah.), Wells water from various locations(Fayda , jmbyar , khabyar).

Part 1 Prepare soap solutions(SS) :

Test 1:

1. Mix 0.5 g of the commercial liquid soap(type A) with 200 mL of warm distillate water. rotate the solution (quietly with a stirring rod to mix it well Without shaking for no loss of suds). Label this solution as (SS1).

2 .Repeat the first step by using (types B,C) of commercial liquid soaps to produce (SS2, SS3).

Test 2:

1.Mix 1g of the commercial liquid soap(type A) with 200 mL of warm distillate water. rotate the solution quietly with a stirring rod to mix it well (Without shaking for no loss of suds). Label this solution as (SS4).

2. Repeat the procedure by using (types B,C) of commercial liquid soaps to produce (SS5, SS6).

Test 3:

1. Mix 2g of the commercial liquid soap(type A) with 200 mL of warm distillate water. rotate the solution quietly with a stirring rod to mix it well (Without shaking for no loss of suds). Label this solution as (SS7).

2. Repeat the procedure by using (types B,C) of commercial liquid soaps to produce (SS8, SS9).

Part 2: Determination of hardness in water samples

Experiments :

Test 1:

1. Pour 5 ml of water sample (sea water) into test tube.
2. Using dropper add SS1 to the test tube start with 0.1ml (two drops) . then go on to add SS1 drop by drop .after each addition put the plug on the test tube and shake it for 15 second.
3. Continue adding SS1 until suds layer is formed in height 2cm.
4. Record all volume of the added SS1.

Test 2- 8:

1. Repeat the same procedures with other (7) samples(tap and wells)water.
2. Determine the hardness of the samples in d^0TH and mg/l (ppm).

Test 9:

1. Pour 5 ml of water sample (sea water) into test tube.
2. Using dropper add SS2 to the test tube start with 0.1ml (two drops) . then go on to add SS2 drop by drop .after each addition put the plug on the test tube and shake it for 15 second.
3. Continue adding SS2 until suds layer is formed in height 2cm.
4. Record all volume of the added SS2.

Test 10- 16:

1. Repeat the same procedures with other (7) samples(tap and wells)water.
2. Determine the hardness of the samples in d^0TH and mg/l(ppm).

Tests :

1. Repeat the previous steps by using (SS3 – SS9) with all water samples**.**
2. Determine the hardness of the samples in d^0TH and mg/l(ppm) .

Result and discussion:

For the purpose of discussing and clarify work steps and connect the obtained results which has been put the following classification that shows the major samples in conducting present study

The used materials can be classified into three types.

First : water samples(types of water samples To be analyzed)

1- Sea water.

2- Tap water from (Basrah , Mosul , Duhok , Baghdad).

3- Wells water from (fayda , khabyar , jumbyar).

Second: liquid hand soap (commercial soap).

1- Type A.

2- Type B.

3- Type C.

Third : soap solution (prepared solutions from commercial soap with different types and different concentrations)

SS1 , SS2 , SS3 , SS4 , SS5 , SS6 , SS7 , SS8 , SS9

In this practical activity liquid soap bubbles are a good indicator of water hardness because the minerals in the water react with the liquid soap when they are present. water hardness can be measured by finding out the volume of soap solution required to form a lather (foam) with a known volume of water samples (5mL) . Record the volume of soap solution added by two ways.
a –Number of drops.
b – Number of milliliter.
Two drops of soap solution equal 0.1 mL .

Determine the hardness of different water samples in d^0TH and ppm after calculate overall volume of soap solution added. Compare the results with the values of laboratory water station of Mosul, table (2-9).

Table(2) Analysis results of sea water samples by using prepared soap solutions

sea water					
SS	V1(drop)	V1(ml)	d^{0TH}	Ppm	(lab.Mosul)
1	150	7.5	37.5	8550	5700
2	167	8.35	41.75	9519	5700
3	150	7.5	37.5	8550	5700
4	67	3.35	16.75	3819	5700
5	100	5	25	5700	5700
6	110	5.5	27.5	6270	5700
7	40	2	10	2280	5700
8	67	3.35	16.75	3819	5700
9	70	3.5	17.5	3990	5700

Calculation :
Sea water samples:
From the table above we note :
After 150 drops (7.5mL) of prepared soap solution(type1)were added , a foam layer of a certain height (2cm) is formed .
d^0 TH= V(mL)of SS1 × V of sample

$$= 7.5 \times 5 = 37.5$$

To estimate the value of one degree of hardness take the arithmetic average to sum total degree of hardness for samples.
For example from the above table .

$$37.5+41.75+37.5+16.75+25+27.5+10+16.75+17.5=230.25$$

Total summation / no of SS samples =

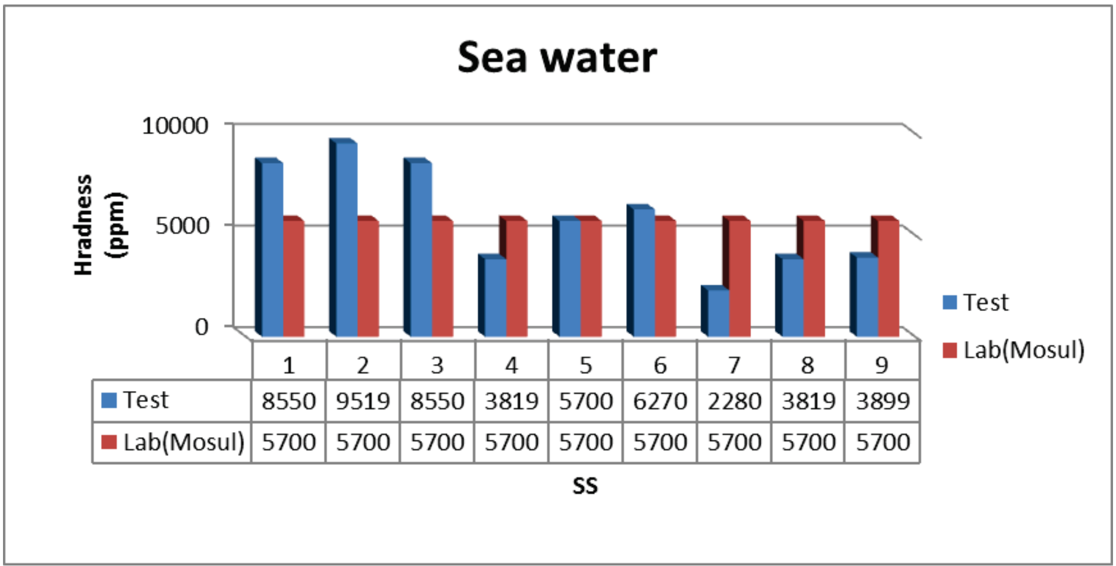
$$230.25 \div 9 = 25.58$$

The nearest number from the table above =25

We suggested that the number 25 is equivalent to the value of the measured hardness in Mosul water station (5700 ppm)
To find 1 d^0 TH =

$$5700 \div 25 = 228 \text{ mgCaCO}_3\text{/L H}_2\text{O(ppm)}$$

That mean 1d^0TH of each SS is defined as 228 mg calcium carbonate per liter of sea water (reporting water hardness in calcium carbonate doesn't mean that $CaCO_3$ is present in water , but signifies how much (Ca^{+2}, Mg^{+2})would be present.
Hardness of sea water by using SS1 = 37.5 × 228 =8550 ppm
Hardness of sea water by using SS2 = 41.75×228 =9519 ppm
Repeat method of calculation with other prepared SS and for all samples.



	1	2	3	4	5	6	7	8	9
Test	8550	9519	8550	3819	5700	6270	2280	3819	3899
Lab(Mosul)	5700	5700	5700	5700	5700	5700	5700	5700	5700

Figure (3) Relationship between hardness values of sea water between research tests and lab(Mosul) test with prepared soap solution

After drawing a relationship between hardness values of tests and lab. With prepared soap solution(SS) figure(3) , table(2). by comparing the results of tests .Notes the similarity hardness value of sample 5 between laboratory test for water station of Mosul (5700ppm) and the search test (5700ppm) in addition to Convergent results for sample 6 (6270ppm).

Tap water samples:
Samples of tap water (Basrah , Mosul , Duhok , Baghdad) evaluate on the same principle of sea water samples and through the tests results that are installed in the following tables and figures .

Table(3) Analysis results of Basrah water samples by using prepared soap solutions

Basrah tap water					
SS	V2(drop)	V2(ml)	d^0 TH	Ppm	(lab. Mosul)
1	35	1.75	8.75	1948	1948
2	40	2	10	2226	1948
3	75	3.75	18.75	4174	1948
4	25	1.25	6.25	1391	1948
5	25	1.25	6.25	1391	1948
6	40	2	10	2226	1948
7	15	0.75	3.75	835	1948
8	20	1	5	1113	1948
9	25	1.25	6.25	1391	1948

Tap water samples: (Basrah samples)

From the table above we note:

After 75drops (3.75mL) of prepared soap solution(type3)were added , a foam layer of a certain height (2cm) is formed .

d^0 TH= V(mL)of $SS_3 \times$ V of sample =

$$3.75 \times 5 = 18.75$$

To estimate the value of one degree of hardness take the arithmetic average to sum total degree of hardness for samples .

For example from the above table .

$$8.75+10+18.75+6.25+6.25+10+3.75+5+6.25= 75$$

Total summation / no of SS samples

$$75 \div 9 = 8.33$$

The nearest number from the table above =8.75

We suggested that the number 8.75 is equivalent to the value of the measured hardness in Mosul water station (1948 ppm)

To find 1 d^0 TH =

$$1948 \div 8.75 = 222.63 \text{ mgCaCO}_3\text{/L H}_2\text{O(ppm)}$$

That mean 1d^0TH of each SS is defined as 222.62 mg calcium carbonate per liter water of Basrah samples

For example :

Hardness of Basrah water by using SS1 = 8.75×222.63 = 1948

Hardness of Basrah water by using SS6 = 10×222.63 =2226

Repeat method of calculation with other prepared SS and for all tap samples.

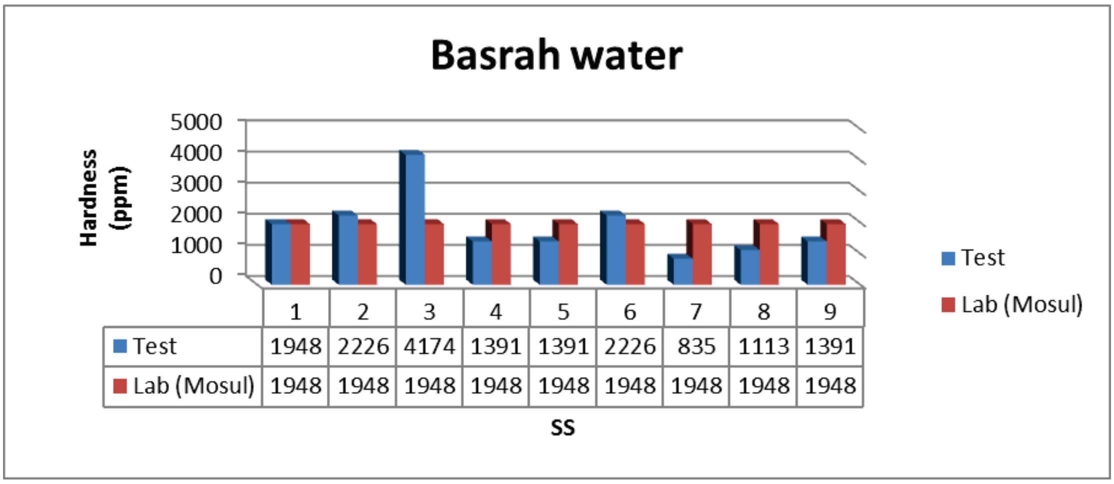


Figure (4) Relationship between hardness values of Basrah water between research tests and lab(Mosul) test with prepared soap solution

After drawing a relationship between hardness values of tests and lab. With prepared soap solution(SS) figure(4) , table(3). by comparing the results of tests for Basrah tap water:

Notes the similarity hardness value of sample 1 between laboratory test for water station of Mosul (1948 ppm) and the search test (1948 ppm) in addition to convergent results for sample 2 (2226ppm) and sample6(2226ppm).

1 d^0TH =222.63 $\text{mgCaCO}_3\text{/L H}_2\text{O(ppm)}$

Table(4) Analysis results of Mosul water samples by using prepared soap solutions

Mosul tap water					
SS	V3(drop)	V3(ml)	d ^{0TH}	Ppm	(lab.Mosul)
1	30	1.5	7.5	276	276
2	40	2	10	368	276
3	60	3	15	552	276
4	18	0.9	4.5	166	276
5	25	1.25	6.25	230	276
6	35	1.75	8.75	322	276
7	12	0.6	3	110	276
8	15	0.75	3.75	138	276
9	20	1	5	184	276

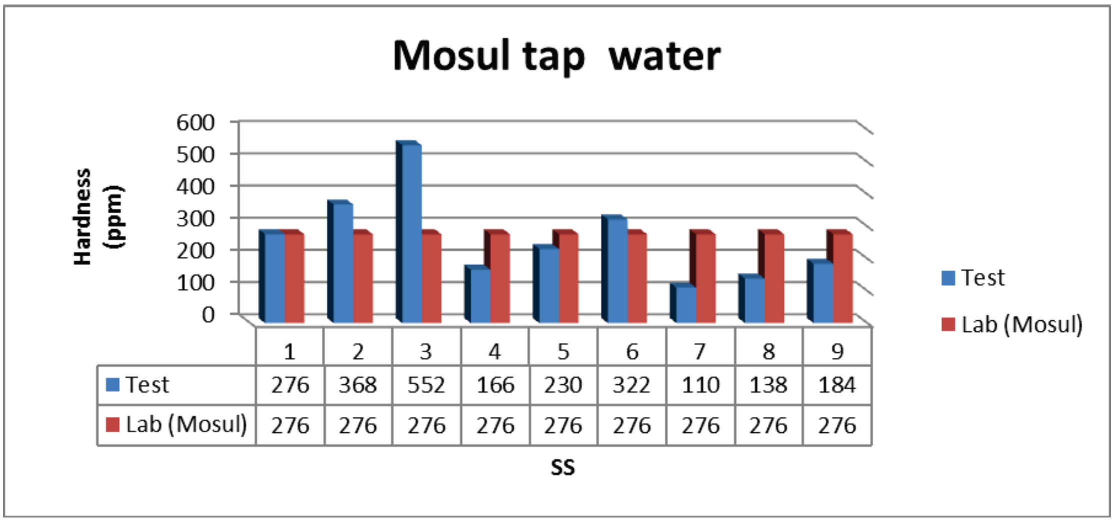
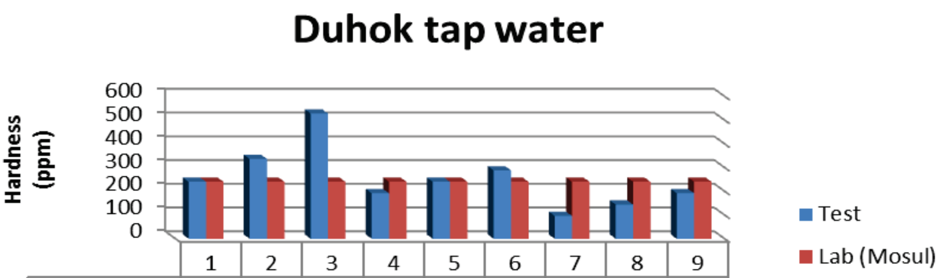


Figure (5) Relationship between hardness values of Mosul water between research tests and lab(Mosul) test with prepared soap solution

After drawing a relationship between hardness values of tests and lab. With prepared soap solution(SS) figure(5) , table(4). by comparing the results of tests for Mosul tap water:
Notes the similarity hardness value of sample 1 between laboratory test for water station of Mosul (276 ppm) and the search test (276 ppm) in addition to convergent results for sample 5 (230ppm) .
1 d ^{0}TH =36.8 mg$CaCO_3$/L H_2O(ppm) .

Table(5) Analysis results of Duhok water samples by using prepared soap solutions

Duhok tap water					
SS	V4(drop)	V4(ml)	d ^{0TH}	Ppm	(lab.Mosul)
1	25	1.25	6.25	240	240
2	35	1.75	8.75	336	240
3	55	2.75	13.75	528	240
4	20	1	5	192	240
5	25	1.25	6.25	240	240
6	30	1.5	7.5	288	240
7	10	0.5	2.5	96	240
8	15	0.75	3.75	144	240
9	20	1	5	192	240



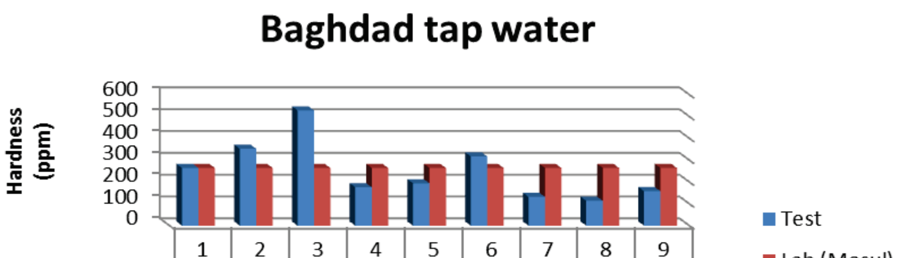
	1	2	3	4	5	6	7	8	9
Test	240	336	528	192	240	288	96	144	192
Lab (Mosul)	240	240	240	240	240	240	240	240	240

Figure (6) Relationship between hardness values of Duhok water between research tests and lab(Mosul) test with prepared soap solution

After drawing a relationship between hardness values of tests and lab. With prepared soap solution(SS) figure(6) , table(5). by comparing the results of tests. for Duhok tap water:
Notes the similarity hardness value of sample (1 and 5) between laboratory test for water station of Mosul (240 ppm) and the search test (240 ppm) in addition to convergent results for sample 4 (192ppm) and sample6(288ppm).
1 d ^{0}TH =38.4 mg$CaCO_3$/L H_2O(ppm)

Table(6) analysis results of Baghdad water samples by using prepared soap solutions

Baghdad tap water					
SS	V5(drop)	V5(ml)	d ^{0TH}	Ppm	(lab.Mosul)
1	30	1.5	7.5	264	264
2	40	2	10	352	264
3	60	3	15	528	264
4	20	1	5	176	264
5	22	1.1	5.5	194	264
6	36	1.8	9	317	264
7	15	0.75	3.75	132	264
8	13	0.65	3.25	114	264
9	18	0.9	4.5	158	264



	1	2	3	4	5	6	7	8	9
Test	264	352	528	176	194	317	132	114	158
Lab (Mosul)	264	264	264	264	264	264	264	264	264

Figure (7) Relationship between hardness values of Baghdad water between research tests and lab(Mosul) test with prepared soap solution

After drawing a relationship between hardness values of tests and lab. With prepared soap solution(SS) figure(7) , table(6). by comparing the results of tests for Baghdad tap water:
Notes the similarity hardness value of sample 1 between laboratory test for water station of Mosul (264ppm) and the search test (264 ppm) in addition to convergent results for sample 6(317ppm).
1 d ^{0}TH =35.2 mg$CaCO_3$/L H_2O(ppm) .

Wells water samples:
Samples of wells water (Fayda , khabyar , jumbyar) evaluate on the same principle of water samples and through the tests results that are installed in the following tables and figures .

Table(7) Analysis results of Fayda water samples by using prepared soap solutions

Fayda well					
SS	V6(drop)	V6(ml)	d ^{0TH}	Ppm	(lab.Mosul)
1	35	1.75	8.75	450	450
2	47	2.35	11.75	605	450
3	70	3.5	17.5	900	450
4	20	1	5	257	450
5	25	1.25	6.25	322	450
6	42	2.1	10.5	540	450
7	15	0.75	3.75	193	450
8	20	1	5	257	450
9	25	1.25	6.25	322	450

Well water samples: (fayda samples)
From the table above we note
After 35drops (1.75mL) of prepared soap solution(type1)were added , a foam layer of a certain height (2cm) is formed .
d^0 TH= V(mL)of SS_1 × V of sample

$$= 1.75 \times 5 = 8.75$$

To estimate the value of one degree of hardness take the arithmetic average to sum total degree of hardness for samples .
For example from the above table .

$$8.75+11.75+17.5+5+6.25+10.5+3.75+5+6.25+ = 74.75$$

Total summation / no of SS samples

$$74.75 \div 9 = 8.30$$

The nearest number from the table above =8.75
We suggested that the number 8.75 is equivalent to the value of the measured hardness in Mosul water station (450ppm).
To find 1 d ^{0} TH =

$$450 \div 8.75 = 51.43 \text{ mgCaCO}_3\text{/L H}_2\text{O(ppm)}$$

That mean 1d^{0}TH of each SS is defined as 51.43 mg calcium carbonate per liter water of fayda samples
For example :
Hardness of fayda water by using SS1 = 8.75 × 51.43 = 450
Hardness of fayda water by using SS8 = 5 × 51.43 = 257
Repeat method of calculation with other prepared SS and for all well samples.

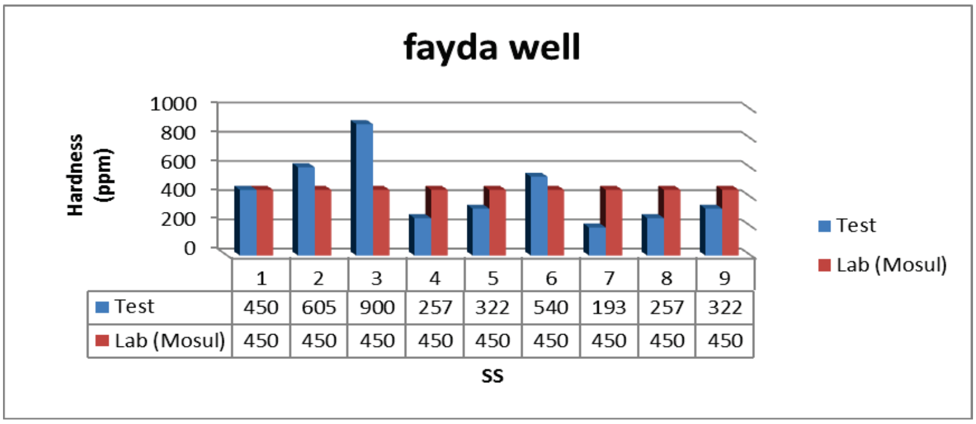


Figure (8) Relationship between hardness values of fayda water between research tests and lab(Mosul) test with prepared soap solution

After drawing a relationship between hardness values of tests and lab. With prepared soap solution(SS) figure(8) , table(7). by comparing the results of tests for fayda well water:
Notes the similarity hardness value of sample 1 between laboratory test for water station of Mosul (450ppm) and the search test (450 ppm) in addition to convergent results for sample 6(540ppm).
1 d ^{0}TH =51.43 mg$CaCO_3$/L H_2O(ppm)

Table(8) Analysis results of khabyar water samples by using prepared soap solutions

khabyar well					
SS	V7(drop)	V7(ml)	d ^{0TH}	Ppm	(lab.Mosul)
1	30	1.5	7.5	330	220
2	40	2	10	440	220
3	50	2.5	12.5	550	220
4	15	0.75	3.75	165	220
5	20	1	5	220	220
6	30	1.5	7.5	330	220
7	8	0.4	2	88	220
8	12	0.6	3	132	220
9	20	1	5	220	220

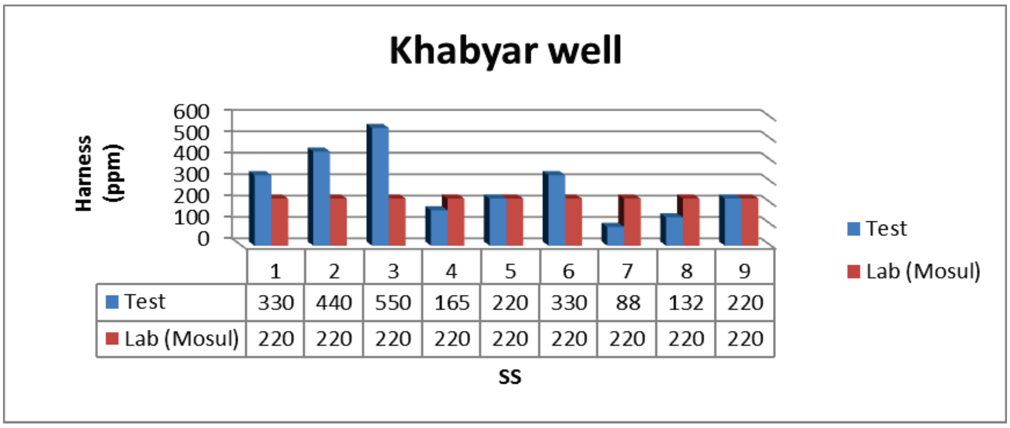


Figure (9) Relationship between hardness values of khabyar water between research tests and lab(Mosul) test with prepared soap solution

After drawing a relationship between hardness values of tests and lab. With prepared soap solution(SS) figure(9) , table(8). by comparing the results of tests for khabyar well water:

Chemistry and Materials Research
ISSN 2224- 3224 (Print) ISSN 2225- 0956 (Online)
Vol.6 No.1, 2014

Notes the similarity hardness value of sample (5 and 9) between laboratory test for water station of Mosul (220ppm) and the search test (220 ppm) in addition to convergent results for sample 4(165ppm).
1 d ^{0}TH =44 mg$CaCO_3$/L H_2O(ppm)

Table(9) Analysis results of jumbyar water samples by using prepared soap solutions

jumbyar well					
SS	V8(drop)	V8(ml)	d ^{0TH}	Ppm	(lab.Mosul)
1	25	1.25	6.25	236	236
2	40	2	10	378	236
3	60	3	15	566	236
4	18	0.9	4.5	170	236
5	20	1	5	189	236
6	25	1.25	6.25	236	236
7	10	0.5	2.5	94	236
8	13	0.65	3.25	123	236
9	18	0.9	4.5	170	236

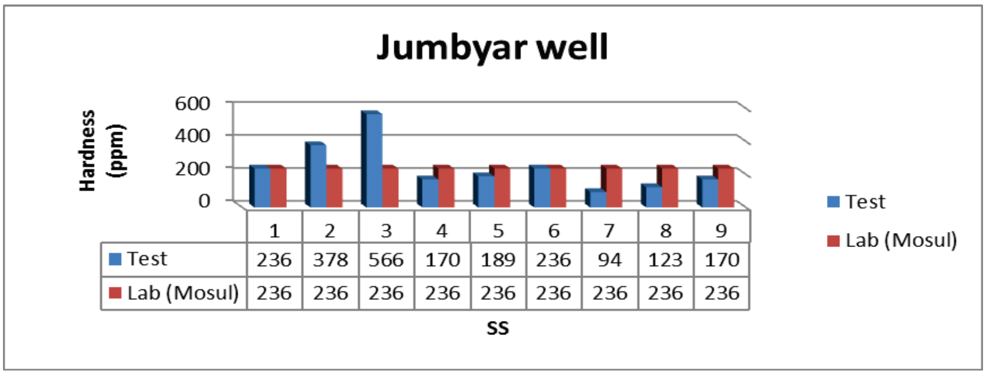


Figure (10) Relationship between hardness values of jumbyar water between research tests and lab(Mosul) test with prepared soap solution

After drawing a relationship between hardness values of tests and lab. With prepared soap solution(SS) figure(10) , table(9). by comparing the results of tests
for jumbyar well water:
Note the similarity hardness value of sample (1 and 6) between laboratory test for water station of Mosul (236ppm) and the search test (236 ppm) in addition to convergent results for sample 5(189ppm).
1 d ^{0}TH =37.76 mg$CaCO_3$/L H_2O(ppm)

Conclusion :

1. In this research available techniques were used, it was applied in some aspects for the first time.

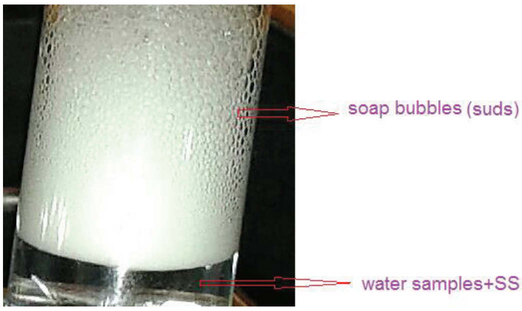
2. Developing fixed practical tests of samples to reach the desired aim.

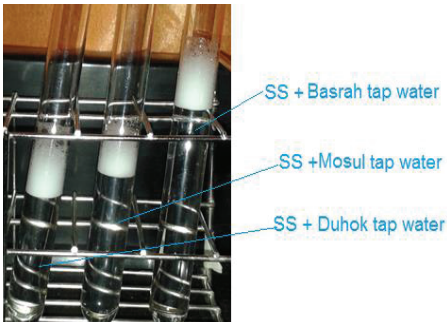
3. We have been able, after many experiments to obtain positive results for most samples.

4. Using a group of practical calculations to reach the correct and stable results.

5. Compared the practical results of the various samples with the results of laboratory tests for some of the specialized water plants Mosul , duhok and standard values of WHO .

Some pictures of samples :





Acknowledgements:

In the name of Allah,

The Most gracious and the most merciful .

Alhamdulillah,

All praises to Allah for the strengths and His blessing in completing this research.

This research represents our efforts in the work, we have been given unique opportunities... and taken advantage of them, and specifically within the Laboratory First and foremost,. we would like to thank our families for their support and patience for the duration of our time. Here I would like to take this opportunity to thank every person who gave any help .

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