



Iron determination of drinking water wells in Benghazi City

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ABSTRACT:- Several colorimetric reagents have been employed for the determination of iron. In this work the characteristic design and operational features of spectrophotometry instruments that suitable for absorption in the visible and ultraviolet regions were studied. Sodium acetate was used to control the pH around 3.5 ± 1.0 to achieve formation of the orange-red as iron (II)-phenanthroline complex. The molar absorptivity is as high as $1.1 \times 10^4 \text{ L mole}^{-1} \text{ cm}^{-1}$ of the product which is highest than the complex with other reagents. In this work a commonly used method for the determination of trace amounts of iron in some drink water wells involves the complexation of Fe^{2+} with 1,10-phenanthroline to produce an intensely red orange colored complex: the Beer's law was obeyed, a linear calibration plot was, at 510 nm the maximum absorbance of iron complex.

Iron is a naturally occurring mineral found around the world. It dissolves in ground water when water filters through surrounding rock. The safety of drinking water is a very important public health issue. The United States and World Health Organization have established well-defined standards for drinking water purity. For example, U.S. Federal regulations limit the amount of iron to less than 0.3 ppm (mg/l) in municipal drinking water. Although iron is only toxic at very high concentrations, it acts as a useful surrogate for other heavy metals, whose presence in drinking water is a real danger to public health, a flow of rusty-red water from taps. It can create scale, deposits of iron in the pipes, which can block water flow or damage hot water tanks. In the laundry, iron deposits on clothes, staining fabric yellow, orange or brown. Depending on the concentration of iron, more than one removal option may be necessary (<http://www.livestrong.com/article/271642>).

Keywords: Water quality, Iron, water wells, Spectrophotometry, Environment.

• INTRODUCTION

Pure water has no taste, but water is a natural solvent. Most minerals from groundwater, including iron, will be absorbed by water. Large amounts of iron in drinking water can give it an unpleasant metallic taste. Iron is an essential element in human nutrition, and the health effects of iron in drinking water may include warding off fatigue and anemia.

1.1 Iron in Drinking Water

The water may be discolored and appear brownish, and it may even contain sediment. Iron will leave red or orange rust stains in the sink, toilet and bathtub or shower. It can build up in your dishwasher and discolor ceramic dishes. It can also enter into the water heater and can get into the laundry equipment and cause stains on clothing. The EPA cautions that although iron in drinking water is safe to ingest, the iron sediments may contain trace impurities or harbor bacteria that can be harmful. Iron bacteria are naturally occurring organisms that can dissolve iron and some other minerals. These bacteria also form a brown slime that can build up in water pipes. Iron bacteria are most commonly problematic in wells, where water has not been chlorinated (EPA, 2010).

1.2 Iron Levels in Water

It's recommended that tap water have no more than 0.3 mg/l, the Penn State College of Agricultural Sciences reports. However, if you have well water or if your water comes from a private source, it may not be subject to local or federal mandates, which means your water could have more iron. If your water has higher levels of iron, it probably won't be clear and could have a metallic taste.

1.3 Types of Iron in Water

If you pour yourself a glass of tap water and it turns brown or red after it sits for a few minutes, you likely have ferrous iron in your water. However, if your water comes out of the tap with a red or yellow tone, your water probably contains ferric iron. While your body can process both types of iron, ferrous iron is easier

for your body to absorb. Because it absorbs efficiently at rates as high as 33 percent, according to the Office of Dietary Supplements, ferrous iron might be more likely to make you sick if you have it in your drinking water [3].

1.4 Iron in Human Body

People often care down the level of iron in the blood, because it leads to a type of anemia (anemia), on the one hand, and because the iron, means strength and good health. It is striking that people do not pay any attention to the high level of iron from the normal level, but on the contrary, they may rejoice if the level of iron (especially when their children) is higher than the normal level, and did not know that this rise complications may be fatal in some cases. The iron is a mineral needed blood hemoglobin (the protein is present inside red blood cells, is to carry oxygen). It is known scientifically that 70 percent of the body's iron be united with the hemoglobin in red blood cells, while the rest of it iso- with other proteins, such as: "transferrin" Transferrin in the blood and Ferritin in the bone marrow (pure) Bone Marrow or be stocks in various tissues and organs of the body. When die of red blood cells (red cell ranges between 100 and 120 days) the iron within it, and the transferrin transferred to the bone marrow and to other organs such as the liver and spleen, where stores. It uses iron in the bone marrow to make new red cells.

And ranges normal level of iron in the blood between 37 and 165 micrograms per deciliter, while the body has 3-4 grams of iron (Water Quality, 2012).

It is noted that the level of iron in men is higher than in women, because women lose a certain amount of iron per month as a result of bleeding (menses) associated with the monthly cycle. However, this picture changed after the age of menopause (menopause) that the iron level begins to rise slowly to nearly its level in men. However, it must examine the level of iron and ferritin to make sure that women need to iron after this age. Ranges and the level of iron in the blood of women between 31 and 126 mcg/dl, while this level varies in men between 55 and 161 mcg/dl. And the ferritin level at women between 11 and 200 mcg/l, while in men of between 15 and 400 mg /l. This is the total quantity of natural iron in the human body the way the following mechanism control: the body loses daily milligrams and one of the iron through sweating and loss of skin cells and the mucous membrane lining of the intestines, and in return the intestines absorb milligram and one of iron (located in the food) lost for compensation. In this way it is to maintain the normal level of iron in the body. The body cannot take out the excess amount of iron in the blood. But if the amount of blood entering more than the natural amount (whether it be through the intestine or by receiving blood-will be explained later), the body cannot get rid of this additional quantity, who shall have stored in the liver and the heart muscle and endocrine glands (especially thyroid, pancreas, testes). Therefore prefer, if possible, that does not exceed the amount of iron intake of 45 milligrams a day, while children should not exceed 39 mg. Note that women need 15 milligrams of iron a day, and the man setting calls to 10 milligrams (Health wise, 2014).

- **Applications for spectrophotometer**

For analytical purpose,-one of the most, important types of absorption by inorganic species is *charge-transfer* absorption, because the molar absorptivity of the band peaks Very large ($\epsilon > 10,000$). Thus, a highly sensitive means for detecting and determining the absorbing species is provided. Many inorganic and complexes exhibit charge-transfer absorption and therefore called charge-transfer complexes. Common examples include the thiocyanate and phenolic complex of iron (III), the o-phenanthroline (1,10 - phenanthroline) complex: iron (II). In order for a complex to exhibit a charge transfer spectrum, it is necessary that one of its components have electron-donor characteristic and the other electron acceptor properties. Absorption of radiation then involves transition of an electron of the donor group to orbital that is largely associated with the acceptor (Skoog et al, 1988, Abdollahi, 2001 and Douglas et al, 1976).

- **Determination of Iron with 1,10-Phenanthroline**

This complex absorbs light in the visible region rather strongly with a maximum absorbance occurring at 510 nm. The absorption of light by this complex follows the Beer-Lambert law. In this experiment the iron content of an unknown will be determined by comparing the absorbance at a specific wavelength of an unknown solution to that of standards. The reaction between ferrous ion and 1,10-phenanthroline to form a reddish-orange complex:



Iron (III) does not form the complex, for this analysis to be successful, all of the iron must be reduced from Fe (III) to Fe (II). In this experiment, the reduction is carried out with hydroxylamine hydrochloride, while the solution is buffered with sodium acetate or ammonia.



The complex is very stable and the color intensity does not change appreciably over long period of time. The visit absorption spectrum of the complex will be measured, using the UV/VIS Spectrophotometer. A calibration curve (absorbance versus concentration) is constructed for Fe (II) and the concentration of the unknown Fe sample is determined (Charistian, 1994).

II. EXPERIMENTAL

2.1 Samples Collection

Collected samples in the September 2015 has been collected 15 samples, collected water samples in the bottles of polyethylene liter capacity and transferred to the laboratory. Random samples collected from some different residential areas of the city of Benghazi as Al-Maraj, Sedi-Khalif, Hai-Alsalam, Shabna, Boatnay and Ard-Alahlam. The measure directly and most of the tests have been completed within 24 hours of samples collection.

2.2. Materials and Reagents

- All the chemical used was analytical grade include. All glassware pyrex washed several times with soap, distilled water and diluted nitric acid to remove any impurities. The standard solution of iron, 0.3% 1,10 phenanthroline as liquid and solid , hydroxylamine hydrochloride which is used to reduce any Fe^{+3} to Fe^{+2} , the sodium acetate which is used to maintain the pH, controlled within certain limits to obtain optimum, reproducible color formation. The adjusting of the pH were used the standard solution into beaker, and add drops of bromophenol blue indicator. Introduce sodium acetate solution from burette until the intermediate color of the indicator is achieved. Sodium acetate was to control the pH around 3.5 ± 1.0 to achieve formation of the orange-red as iron (II)-phenanthroline complex. Once a colored complex is formed, the wavelength of the light, which is most strongly absorbed, is found by scan measuring the absorbance at various wavelengths between 400-600 nm and choose the maximum wave at this wavelength and a calibration plot of absorbance visible concentration is prepared. The absorbance of unknown sample in the calibration curve is used to calculate the concentration of iron sample (Standard Methods for the Examination of Water and Wastewater, 1999).

2.3 Statistical Analysis

In this study, statistical calculation were performed by using the statistical analysis.

III. RESULTS AND DISCUSSION

3.1 Acidity of water samples

PH is a scale of acidity and alkalinity of water, and it is expressed by measuring the concentration of hydrogen ions. Generally, the pH of groundwater is influenced by geology of catchment area and buffering capacity of water. Most biochemical reactions and biological processes are pH dependent of water. Higher pH reduce the germicidal potentially of chlorine and induces the formation of toxic trihalomethane. The pH values of the groundwater samples for study region vary between 6.92- 7.23. Table (3.1), the minimum pH value was 6.92 in sample 2, while the highest pH value is 7.32 was recorded at sample 4.

Table 3.2: pH values of waters samples

No	pH	No	pH
1	6.96	9	7.01
2	6.92	10	7.09
3	7.01	11	6.94
4	7.23	12	6.96
5	6.98	13	6.92
6	6.97	14	7.01
7	7.08	15	7.32
8	6.92		

3.2. Effect of reducing agent

The relation between the different concentrations of standard iron (0.1,0.2,0.3 and 0.4 ppm) and the absorbance at 510 nm in the presence of 1.0 mL and 4.0 mL hydroxylamine hydrochloride (as the hydrochloride salt to increase solubility). It is seen that at 4.0 mL reduction agent the absorbance was 0.408 ± 0.003 at 0.2ppm standard solution for $n=3$ (where n =number of experiments). The value of the slope of this line which pass through the original is found to be 2.097 ± 0.009 and R^2 are found to be 0.999946 while the absorbance is small amount as in the presence of 1.0 mL ($A=0.128 \pm 0.01$). So from the data and the graph it is clear that an excess of reducing agent is added to the solution to keep the iron in the Fe (II) state and to reduce Fe^{+3} to Fe^{+2} .

3.3 Choose the λ_{max} for Iron Complex

The chosen for a quantitative determination is the wavelength of maximum absorbance. In the table and graph below is shown the relation between the wavelength (nm) in the range from 390 to 550 nm and the absorbance, for close region see table 3.2 and fig.3.1. It's found the wavelength of maximum absorbance at 510 nm for $n= 3$.

Table 3.2: The absorbance of 0.4 ppm standard iron at different wavelength for $n=3$

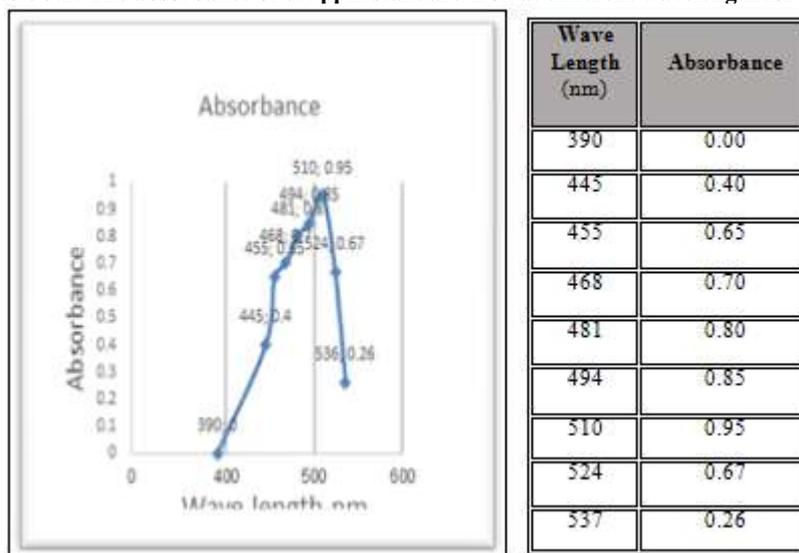


Fig. 3.1: The scanning of the maximum wave length

3.4. Standard curve for 1, 10-phenanthroline

Using the optimum conditions, the reaction was examined in order to evaluate its usefulness as a sensitive spectrophotometric method for determination of trace amount of iron in drink water wells of Benghazi city. See fig.2. The calibration curve shown at wavelength 510 nm, this wavelength is referred to as λ_{max} . The value of the slope of the line is found to be 2.097 ± 0.009 the value of the correlation coefficient and R^2 are found to be 0.999946 and 0.9998 respectively. P Value < 0.0001 (two tailed test). The slope is very significantly different than zero. So that, Beer's law is obeyed, a liner calibration plot we get. If there are any deviations from Beer's law.

3.5. Concentration of Water Samples

Apply the equation of standard curve see fig 3.1, for found concentration of water samples. Table 3.2 is clarifies number of each measured samples against where that sample taken from.

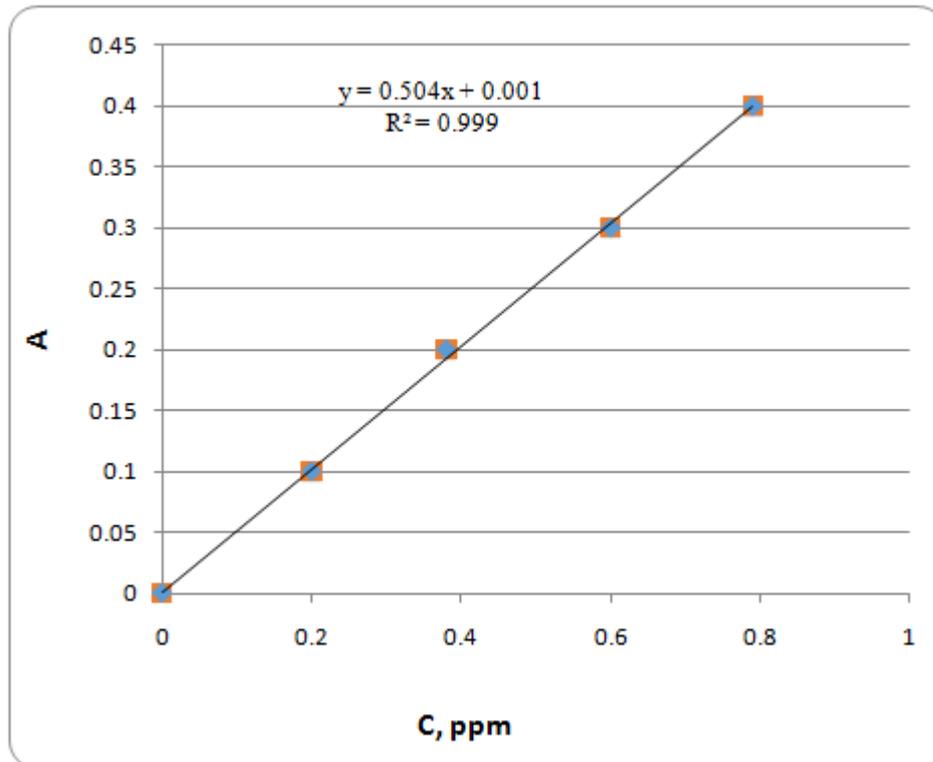


Fig.3.2: Standard curve of iron complex, at 510nm, n=3

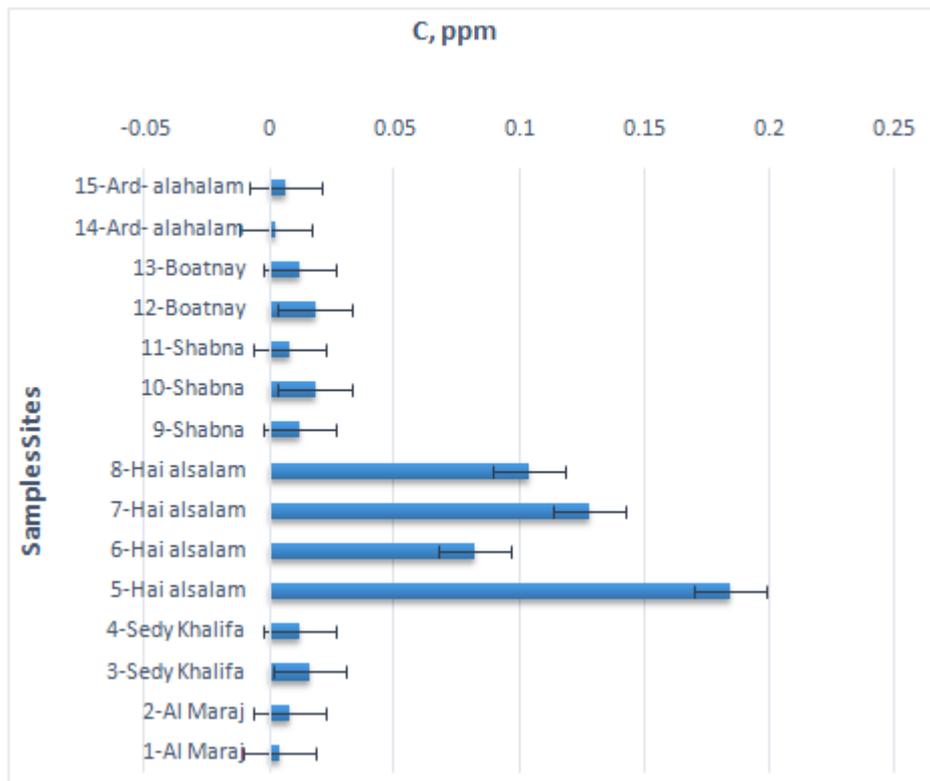


Fig.3.3: Concentration of Iron of water samples by ppm, n=3

Table 3.3: Name of sample site against the concentration of Iron in water samples, n=3

Name of site	N of sample	C, ppm
Al-Maraj	1	0.004±0.00 1
	2	0.008. ±0.001
	3	0.016±0.01 2
Sedi-khalif	4	0.012±0.00 2
	5	0.184±0.03 4
	6	0.082±0.03 5
Hai-alsalam	7	0.128±0.00 6
	8	0.0104 ±0.042
	9	0.012±0.00 5
Shabna	10	0.018±0.00 8
	11	0.008±0.00 3
	12	0.018±0.00 8
Boatnay	13	0.012±0.00 7
	14	0.002±0.00 1
Ard - alahlam	15	0.006±0.00 2

From the results were placed in table 3.3 and shown in fig. 3.3, noted that the all water samples were in normal iron level, it is than 0.3 mg/l (WHO, 2006). The samples of Hai-alsalam have highest concentration of iron but also they are in the range.

IV. CONCLUSION

In Benghazi city, some area depended on the water wells for drinking water and water for personal, domestic and homework). So this source of water must be control and treatment before used. The reason for the high concentration of iron in drinking water to pipe network water supply.

Several colorimetric reagents have been employed for the determination of iron, Depending on the pH. Sodium citrate used was to control the pH around 3.5±1.0 to achieve the formation of the orange-red iron (II)-phenanthroline complex. The plateau region of constant absorbance is the best pH for measuring the absorbance. and the molar absorptivity is as high as $1.1 \times 10^4 \text{ L cm}^{-1}$ of the product which bigger than of the complex with other reagents, also from the data and the graph it is clear that an excess of reducing agent as added to the solution to keep the iron in the +2 state and to reduce Fe^{+3} to Fe^{+2} . The beer's law is obeyed, and we get a linear calibration plot.

If there is any deviation from beer's law, the calibration plot will curve upward. Samples were collected from drinking water, they were collected from water wells. They are found that the on centration of the iron in the samples (0.004 - 0.184 ppm) they were in the range of HOW (Health World Organization [11]) (0.03 - 0.04) ppm.

V. SOLUTIONS AND RECOMMENDATION

To remove Iron from water wells, there is filter used for this aim as illustrated as below.

5.1. Water Filters to Remove Iron

Iron in drinking water is not considered a health hazard but it can impart a bad taste and leave an unsightly residue, according to the Wisconsin Department of Natural Resources. Iron is usually not a problem in

municipal water supplies but if you rely on well water, you may need to install a water filter to remove excess iron.

5.1.1. Filter function

A water filter that removes iron from water supply is usually a whole house filter installed at the water main. This removes iron before the water reaches any of your faucets or plumbing. Iron can leave behind a residue at any point in your home where you use water, including the washing machine or toilet. For that reason, whole house filters are used for removing iron rather than using point-of-use filters under the sink.

5.1.2. Types of filter

Iron can be removed with sediment filters, water softeners and carbon filters but the iron can clog these systems quickly, according to the Minnesota Department of Health. To reduce iron, a manganese greensand filter is commonly used. These filters are sometimes combined with aeration or the addition of chlorine for more thorough water treatment (Healthwise, 2014).

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