

Water treatment of selected water wells of Al- Muqdadiyah town- Iraq using burned initiated bentonite as a granulated Natural ion-exchanger via columnar method.

Mohammed H. Abdul Latif [*a], Ibrahim M. A.AL- Salman [b], and Thaer M. Ibrahim [c].
[a], Department of Chemistry, Ibn Al Haitham College of Education, University of Baghdad , Adhamiya, Al- Dilal Square, Baghdad, Iraq.
[b, c], Department of Biology, Ibn Al Haitham College of Education, University of Baghdad , Adhamiya, Al- Dilal Square, Baghdad, Iraq.
Email: mohammed21latif@yahoo.com

Abstract

The aim of this study was to find a general method, cheap and easy to deal with water wells. Treatment of selected water wells of Al – Muqdadiyah town was carried out at (25± 0.1) ºC, using natural granulated Iraqi Na – montmorillonite clay (initiated burned bentonite), in known flow packed columns. The Na – montmorillonite clay mineral was characterized by FT – IR spectroscopy. [Total dissolved solids (TDS), Electrical conductivity (EC), Total hardness (T.H.$CaCo_3$), Ca^{+2}, Mg^{+2}, Na^{+}, and pH] quantification was done before and after treatment of water samples using (MI – 180 Multi – Bench meter MARTINI – Instruments). Calcium Ca^{+2}, Magnesium Mg^{+2}, and Sodium Na^{+} were measured using flame photometer [PFP7 flame photo meter from (JENWAY)], Total Hardness was measured using titration method using UniVer1 hardness reagent. The results indicated that the values of these parameters are within or lower than the international drinking water supplies average, , and Iraq drinking water standards.

Keywords: natural ion exchanger, wells water treatment, burned Na – montmorillonite clay, packed column.

1. Introduction

In many developing countries over the years, ground water remains one of the dependable sources of usable water in fast growing towns and villages where the supply of the potable water is not consistent due to urbanization, industrialization and population increase. The demand for water has been at a maximum increase with critical stress on ground water most especially in the dry season when water from other sources is not ready available [1]. In Iraq all rivers especially Euphrates and Tigris are drying up, strangled by the water policies of Iraqi neighbors, the rivers are significantly smaller than it were just a few years ago. These rivers so crucial to the birth of civilization that the Book of Revelation prophesied its drying up as a sign of the end time. Well water is one of the main sources of drinking water in IRAQ, therefore it is necessary to obtain a suitable, and local method of well water treatment to improve the quality of these water sources compared with the international and Iraq drinking water standards. Clean drinking water is an extremely step in infrastructure development. Drinking water quality has become a critical issue in many countries, especially due to concern that fresh water will be a scarce resource in the future. The importance of water supply with sufficient quantity and acceptable quality has been emphasized in the Millennium Development Goals articulated by the General Assembly of the United Nations (2000) [2].The objective of this study is to design a cheap, easy, and perfect method of well water treatment of selected locations in Al-Muqdadiyah town – Diyala Governorate of IRAQ, using burned initiated Traifawi- Iraq bentonite clay mineral as a natural granulated cationic ion-exchanger via columnar method. Al- Muqdadiyah town is located at about 80 km northeast of Baghdad, and 30km northeast of Baquba, the capital of Diyala, it has a population of about 298,000 inhabitants. The alternative name of the town is Shareban [3]. Al Muqdadiyah area is to reach ($1033km^2$) and it's divided to three areas, center of Governorate, Aboseada and AL –Wajeheia, from the center of Governorate we took samples of nine different locations of wells signed on the map shown in (Figure 1).

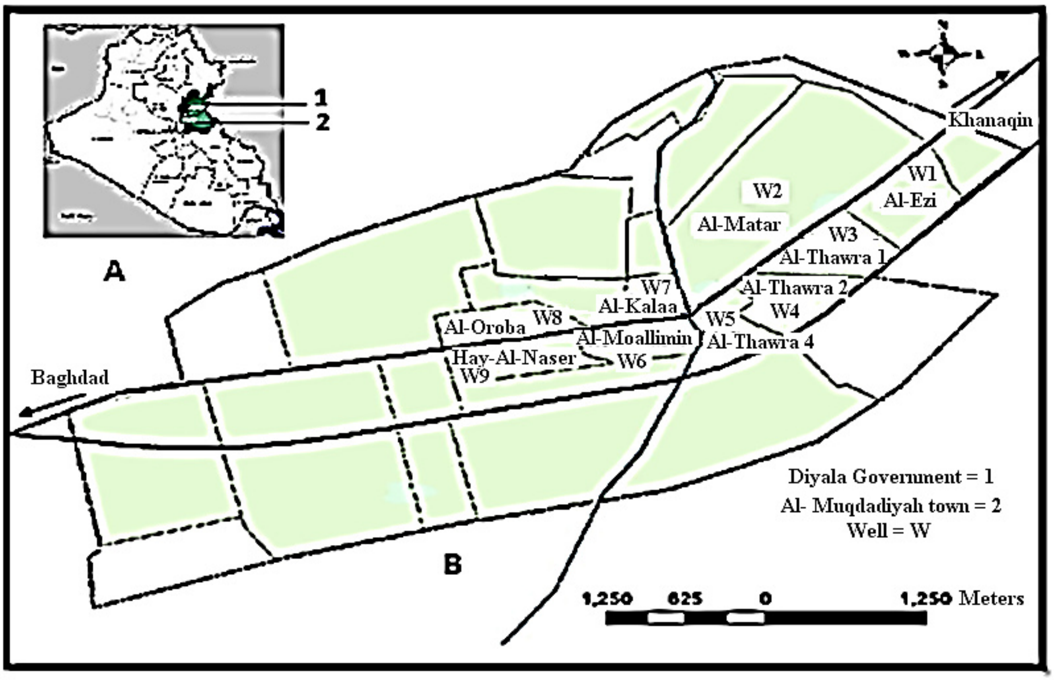

Figure 1: A. IRAQ map showed Al- Muqdadiyah region, B. Al- Muqdadiyah map showed the location of selected water wells.

Clays are hydrous aluminosilicates composed of mixture of fine-grained by minerals, crystals of other minerals and oxides. Natural mineral clays possess specific compounds, which have led to investigations on the potential use of clays as adsorbents for treating heavy metals surface chemical properties, e.g., cation exchange capacity, and adsorptive affinity for some organic and inorganic and organic pollutants, or as coagulant aids for improving the settling performance in coagulating low particle content water. Bentonite is characterized mainly by an Al octahedral sheet placed between two Si tetrahedral sheets. The isomorphous substitution of Al^{+3} for Si^{+4} in the tetrahedral layer and Mg^{+2} for Al^{+3} in the octahedral layer results in a net negative surface charge on the clay. This charge imbalance is offset by exchangeable cations, typically Na^{+} and Ca^{+2} at the clay surface. Bentonite is a clay mineral with high cation- exchange capacity (CEC) [4]. The CEC of west Iraqi (Traifawi) bentonite for instant is approximately (80 meq./100 g.) as given in(table-1), it was determined using an ethylenediamine complex of Cu [Cu (EDA) $_2{}^{+2}$] method proposed by Bergaya and Vayer [5]. The CEC of bentonite sample was obtained by the difference in Cu content in initial and final solutions as determined by atomic adsorption spectrometry [Thermo S1(UK)] and the CEC calculated from the quantity of [Cu $(EDA)_2{}^{+2}$] absorbed (amount initially added to the clay minus amounts remains) [6]. The surface area of west Iraqi (Traifawi) bentonite was estimated using methylene blue (MB) adsorption method [7] and it was (123 m^2 /g) as given in(Table 1). This method is simple, rapid, economical, and has advantages over BET gas adsorption measurements in being readily applicable to a wide range of areas especially to minerals under aqueous conditions [6, 7].

Table 1
Some bentonite characteristics.

analysis	Bentonite
CEC (meq. /100g)	80
Surface area (m^2/g)	123

West Iraqi (Traifawi) bentonite mostly consists of calcium – montmorillonite. Montmorillonite percent is between (60 – 65 %) of crude bentonite, (Table 2) show the chemical analysis of West Iraqi

(Traifawi) bentonite. Therefore it is necessary to remove impurities before the bentonite is ready for use [9].

Table 2
Chemical analysis of West Iraqi (Traifawi) bentonite.

Compound	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	LiO_2	SO_3	L.I.O.	Total
Weight %	55.81	14.91	5.78	5.72	3.5	1.29	0.41	0.67	----	10.86	99.67

The origin of WHO Guidelines for Drinking-Water Quality (GDWQ) goes back to the 1950s. International Standards for Drinking-Water were published in 1958. In this instance the term "standards" was used to be applied to the suggested criteria of water quality (WHO 1958) [10]. This study compares the guidelines for Iraqi drinking water with corresponding of some chemical and physical parameters recommended by the World Health Organization (WHO), and (FAO) Food and Agriculture Organization. These parameters are Total dissolved solids (TDS), Electrical conductivity (EC), Total hardness (T.H.CaCo3), Ca+2, Mg+2, Na+, and pH. Hardness is defined as a characteristic of water which represents the total concentration of Ca^{+2}, and Mg^{+2} expressed as their $CaCO_3$ equivalent. Hardness concentrations were originally expressed as grains / gallon, but are now commonly reported as milligrams / liter or ppm. The hardness test is the most frequently performed analysis in water industry. Large amount of hardness are undesirable for aesthetic and economic reasons in many industries and must be removed before the water is suitable for use. Calcium, the fifth most common element, is found in most natural waters at levels ranging from zero to several hundred milligrams per liter. Calcium and other alkali earth metals like Magnesium contribute to the hardness properties of water. Magnesium is found in seawater (about 1300 p pm) and oceans (after the sodium) in big quantity [11].

The 1971 WHO International Standards stated that the maximum permissible level of hardness in drinking-water was 10 meq / liter (500 mg calcium carbonate/liter), based on the acceptability of water for domestic use. TDS comprise inorganic salts (principally calcium, magnesium, potassium, sodium, bicarbonates, chlorides and sulfates) and small amounts of organic matter that are dissolved in water. In the first edition of the Guidelines for Drinking-water Quality, published in 1984, value of 1000 mg/liter was established for TDS, based on taste considerations. However, the presence of high levels of TDS in drinking-water (greater than 1200 mg/liter) may be objectionable to consumers; also a guideline value of 200 mg/liter was established for sodium based on taste considerations. However, concentrations in excess of 200 mg/liter sodium may give rise to unacceptable taste [10].

Materials and methods

1.1. Wells water sampling and analysis.

Samples of nine selected wells were collected in plastic cans of 2.25 liter capacity, and after determining field parameter (temperature), they were kept in the dark at a cool temperature in a cool box before being transported to a laboratory for quantification of other parameters [Total dissolved solids (TDS), Electrical conductivity (EC), Total hardness ($T.H.CaCo_3$), Ca^{+2}, Mg^{+2}, Na^{+}, and pH]. In the laboratory, all the samples were kept in a refrigerator at a temperature below 4◦C to reduce all the activities and metabolism of the organisms in the water. The laboratory analysis of pH, TDS, and EC were carried out using (MI – 180 Multi – Bench meter MARTINI – Instruments). Calcium Ca^{+2}, Magnesium Mg^{+2}, and Sodium Na^{+} were measured using flame photometer [PFP7 flame photo meter from (JENWAY)], Total Hardness was measured using titration method using UniVer1 hardness reagent [11]. All Chemicals used were of analytical reagent grad unless otherwise is mentioned, bentonite mineral clay obtained from the General Company for Geological Survey and Mining in Baghdad – Iraq.

1.2. Procedure for synthesis of granulated Iraqi Burned Initiated Na – montmorillonite clay.

In this study the bentonite was beneficiated to improve its Smectite (Montmorillonite) content by attrition – scrubbing at high solid concentration (50%) and at high impeller speed (2500 r.p.m.) for 1 h, using flotation cell. Convert calcium - montmorillonite to sodium - montmorillonite by process of activation using ion-exchange technique, by mixing the bentonite preconcentrate with Na – form activated amberlight orange ion exchanger followed by agitation for 1 h, at 150 r.p.m. The clay was separated from the mixture by filtration, washed five times with distilled water. Each washing step involved stirring the slurry in distilled water, followed by centrifugation and removal of the supernant, then Na – montmorillonite was treated with 0.5 M NaCl to ensure complete transformation to the Na – form, then the treated clay was washed with distilled water to remove excess NaCl, turned to a granules of (2mm) diameter using granulating machine (GK Dry Granulating Machine) and dried at 110 ºC for 3h, until constant mass, and then burned at 650^{o}C to make an ion – exchange column ready to use.

2.3. Columnar water treatment procedure.

A nine glass columns (50 cm X 15 mm i.d.) filled with known mass (105gm) of natural clay ion - exchanger (Initiated Burned Na - montmorillonite) corresponding to bed heights of (10 cm) (the surface area of 105 gm. mass of natural clay ion - exchanger was calculated physically and its found to be 0.251 m^2) have been prepared for the passage (250ml) of each water sample from the selected nine wells Al -Muqdadiyah town at flow rate of (80 drops/ min. or 4 ml/ min.) i.e. the contact time of 250 ml well water sample and ion exchanger surface is 62.5 min. then we examine the percolated well water samples with the same laboratory analysis mentioned above [Total dissolved solids (TDS), Electrical conductivity (EC), Total hardness ($T.H.CaCo_3$), Ca^{+2}, Mg^{+2}, Na^{+}, and pH], Results were then recorded in (Table 3).

Table 3
Rates of the values of the properties studied in well water of Al – Muqdadiyah town.

Sample location name	Well NO.	PH		EC m.s/cm		TDS (ppm)		T.H.$CaCO_3$ (ppm)		Ca^{+2} (ppm)		Mg^{+2} (ppm)		Na^{+} (ppm)	
		B	A	B	A	B	A	B	A	B	A	B	A	B	A
Al- Ezi	W1	7.46	7.2	2.457	0.572	1232	287	505	73	91	11.8	190.3	44.28	1200	22.22
Al- Matare	W2	7.35	7.2	5.85	1.365	4070	950	407	58.8	78.1	11.78	112.24	7.14	2250	139.76
Al- Thawra(1)	W3	7.39	7.1	3.920	0.910	1970	459	759.3	109.7	63	12.9	100.7	0	1483	173.91
Al- Thawra(2)	W4	7.34	7.3	2.929	0.684	1472	344	413	59.6	84	11.78	190.3	43.32	3200	134.33
Al- Thawra(4)	W5	7.26	7.9	3.260	0.761	1640	383	582	84	76.7	15.7	133.8	30.46	1620	52.20
Al- Moalimin	W6	7.52	7.6	3.110	0.727	1560	365	418.3	59.8	83.5	23.56	102.1	11.5	2650	68.29
Al- Kalaa	W7	6.92	7.3	5.530	1.290	2730	637	416.3	74.48	84.9	11.78	96.8	10.9	1965	79.00
Al- Orooba	W8	7.5	7.33	1.625	0.532	818	268	426.5	47.04	85.4	23.56	103.3	0	1450	160.98
Hay Al- Naser	W9	7.45	7.1	1.741	0.543	874	273	749	108.2	96	19.6	160.2	52.86	2060	135.76

A. After treatment, B. Before treatment.

2. Results and discussion

Natural Iraqi bentonite was characterized by FT –IR spectroscopic analysis (Shimadzu FTIR Spectrometer – 30 000:1/ IRAff). FT-IR spectrum (Figure 2. A) showed absorption band at 3628.10 cm^{-1}(Al-Al-OH) (Mg-OH-Al) corresponding to starching vibration of structural OH groups coordinating to Al-Al pair or Mg-OH-Al. Adsorbed water gives a broad bands from 4306.29 cm^{-1} to 3533.59cm^{-1} corresponding to H2O- stretching vibration . Al, Mg bound water molecules gives H-O-H stretching vibration bond at 1643cm^{-1}. Also thee bands at 1546.91, 1427.32 and 1384.89 cm^{-1}corresponding to H...O...H weak .The complex broad band around 1033 cm^{-1} belongs to Si-O stretching vibration. Two bands at 914.26 cm^{-1} and 837.11 cm^{-1} are most characteristic for quartz. Finally the bands from 420.00 $cm^{-1}$to 516.93 cm-1 are related to Al-O-Si, Si-O-Si deformations. FT-IR spectrum of initiated bentonite (Figure 2. B) showed the same bands of (Figure 2. A) but with higher transmittance percent and sharper than bands of FT- IR spectrum of natural bentonite. Nevertheless H...O...H weak disappear in this spectrum. Adsorbed water band appear at 4321.72 cm^{-1}, two bands belong to Al, and Mg bound water molecules observed at 1654.92 cm^{-1} and 1641.42 cm^{-1}. The broad complex band becomes single band at 1039 cm^{-1} belongs to Si-O stretching vibration. Also we observe two bands belongs to Al…OH stretching vibration at 937.04 cm^{-1} and 916.19 cm^{-1} with higher transmittance percent .the quartz characteristics band from 694.37 cm^{-1} to 839.03 cm^{-1} become boarder. Finally Al-O-Si, Si-O-Si and Si-O stretching vibration bands from 426.27 cm^{-1} to 522.71 cm^{-1} become sharper and triplet bond [12]. Burned initiated Iraqi bentonite FT- IR spectrum (Figure 2. C) showed the same bands of that in (Figure 2. B) but sharper and with higher transmittance percent , also the band of adsorbed water become a single band at 3421.7 cm^{-1} mostly due to burning process and the same thing happen with band Al, Mg around water molecule stretching vibration also H…O...H weak bands disappear in this spectrum.

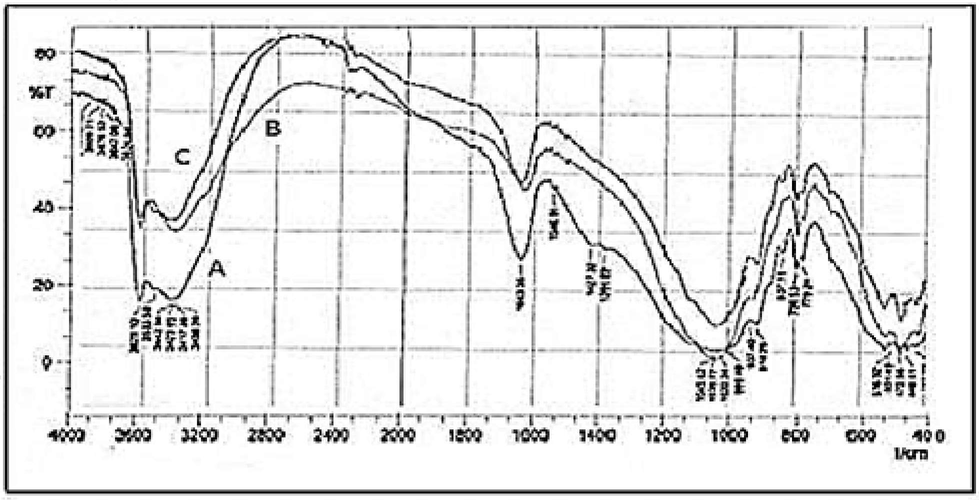

Figure 2. A- FT-IR spectrum for crude Iraqi bentonite (Trifawi), B - FT- IR spectrum for initiated bentonite, C- FT- IR spectrum for burned initiated bentonite.

(Table 3) shows that the hardness concentration of water samples of selected wells of Al – Muqdadiyah town ranged from (407 – 759.3 ppm.), and after treatment by passing these water samples through the natural clay ion exchange columns, the hardness become within the range (47.04 – 109.7 ppm.), pH values of the water samples ranged from (6.92 – 7.52) and after treatment the value of pH become within the range of (7.1 – 7.9), TDS values of the water samples ranged from (818 – 4070 ppm.) and after treatment the value of TDS become within the range of (268 – 950 ppm), Na^{+} concentration values of the water samples ranged from (1450 – 3200 ppm.) and after treatment the value of Na^{+} concentration values become within the range of (22.22 – 173.91 ppm), Ca^{+2} concentration values of the water samples ranged from (63 – 96 ppm.) and after treatment the value of Ca^{+2} concentration values become within the range of (11.78 – 23.56 ppm), and Mg^{+2} concentration values of the water samples ranged from (96.8 – 190.3 ppm.) and after treatment the value of Mg^{+2} concentration values become within the range of (0.0 – 52.86 ppm). All these values are within or lower than the limit of the international, and Iraq drinking water standards as shown in (Table 4).

Table 4
comparison average results with the international and Iraq drinking water standards.

Parameter	Unit	Before treatment	After treatment	WHO	FAO	Iraqi limits
PH	-	7.35	7.34	6.5-8.5	6.5-8.5	6.5-8.5
EC	µS/cm	3380	820	1000	1000	400
TDS	mg/L	1818.44	440.67	1000	1000	1000
T.H.$CaCO_3$	mg/L	519.6	74.96	500	500	500
Ca^{+2}	mg/L	82.51	15.84	200	200	150
Mg^{+2}	mg/L	132.19	22.27	150	150	100
Na^{+}	mg/L	1986.44	107.38	200	200	200

3. Conclusions

The study mentioned above is a process of ion – exchange, as we now the ion exchange processes are used to remove the inorganic contaminations if they cannot be removed adequately by filtration or sedimentation. Our processes depends on preparing a natural, activated, burned, and granulated Iraqi bentonite clay, filled in a glass columns with known mass. All the results indicated that the process succeed in treating well water is clear, and good, and all the parameters examined above [Total dissolved solids (TDS), Electrical conductivity (EC), Total hardness (T.H.$CaCo_3$), Ca^{+2}, Mg^{+2}, Na^{+}, and pH], have values after treatment, within or lower than the international drinking water supplies average, and Iraq drinking water standards as shown in (Table 4). And so we have provided local, good, and cheap way to deal with water wells in Al - Muqdadiyah and Iraq in general.

Acknowledgments

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