A Study of Inorganic Chemical Metals for Raw and Drinking Water of Central Baquba Liquefier Station

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Abstract

This study has achieved to determine the concentrations of inorganic chemical metals for raw and clean water of Baquba liquefier station (the largest unit which provides the city with drinking water) by taking water samples from the station through (April 2009) till (February 2010), these analysis included the estimation of pH, electrical conductivity, total dissolved salts, total hardness, calcium, magnesium, chloride, sulfate, sodium, potassium and aluminum. The clean water results has compared with the world health organization standards to determine any access in these metals concentrations that are anticipated to produce adverse health effects following long-term exposure.

All the final results of water samples reinforce the fact that has accepted chemical and physical properties except turbidity, with simple difference in some chemical concentrations all over the experimental period, as well as, it is observed that there is no any qualitative treatment of total hardness for raw water in the station.

Also, the statistical analysis emphasize no significant differences between raw and clean water except turbidity with the presence of significant differences for most parameters all over months with significant positive relation between water temperature and both turbidity and total dissolved salts and negative relation between total dissolved salts and the raining rates.

Introduction

Water has always been earth's most valuable resource. It can be consider as the main factor to the live, all systems and every field of human activity depend on water. It is the most favorable due to its ability of dissolving materials and cover (¾) of the earth. The validity of water for drinking purposes is based upon two conditions [1] (WHO) (1984):

1 – To be colorless, tasteless and odorless with absence of turbidity.

2 – It must not contain any deleterious materials such as mineral salts, organisms and organic dissolved items.

Then, all efforts looking for the quality of water which can be defined as the acceptability of the water for uses like drinking, cooking, bathing, and laundering, but in the same time it is affected by a wide range of natural and human influences (widespread and varied) [2] (2005). The contaminated water may have off-tastes, odors, or visible particles. However, some dangerous contaminants in water are not easy to detect and need expenditure of a great deal of time and money. Public health officials have been concerned about the presence of these contaminants at trace concentrations in drinking water. Fortunately, several technologies effectively remove these contaminants from drinking water including coagulation followed by filtration, anion exchange, membrane technology and disposable adsorptive media.

All these factors lead to study the quality of drinking water for the main water liquefier station in Baquba and this at least will determine the validity of water consumption and need more focus upon the concentrations of chemicals since both short-term and long-term exposure to these contaminants in drinking water can cause serious health problems.

All countries have their own legal drinking water standards. These recommended which substances can be in drinking water and what the maximum levels of these substances are. WHO's set up the standard for drinking-water quality and make it as guidelines (reference points) for all countries, these standards are published in Geneva, 1993 [3]. The recommended values for the experimental metals are inclusively mentioned in table [1].

Many of researchers insist upon the study of water quality for the famous rivers in Iraq (Tigris and Euphrates). (Al– Shawak and Al– Refaay) [4] (1994) have concluded that there is a distinct difference in chemical compositions for Euphrates all over the year.

Definitely, the concentrations of water metals change when it enters the town, it was clearly observed that the important problem is the pollution from contaminants that are mainly discharged to the environment in industrial residue effluents and finally this will consolidate and stress the decreasing of water quality, this is clearly observed by (Al– Dulemy and his follows) [5] (1992), who have concluded that the concentrations of hardness, calcium and sulfate increase while Tigris flows into Baghdad, so, naturally the concentrations of metals for Dayala River will change since it passes through farms with many of citizens omission and industrial residue effluents.

The aim of this study is to investigate the concentrations of the inorganic dissolved chemicals in Baquba water and make a simple comparison with the world health organization standard specifications to determine the high levels of these metals (if it was present). This investigation included both chemical and physical tests carried out in the national laboratory of Baquba municipal and sewerage bureau.

Materials and methods

water samples (raw and clean water) have been collected from Baquba drinking water liquefier station about two samples per each month through (4,5,9,10,11,12) of 2009 and (1,2) of 2010, and then taken to special water lab to determine the chemical and physical properties in Baquba municipal water and sewerage bureau. The examination procedures were performed by using the standard methods for the examination of water and waste water [6] (1998), and included: Turbidity, pH, total dissolved salts, electrical conductivity, total hardness, calcium, magnesium, chloride, sulfate, sodium, potassium and aluminum.

The water temperature has been determined by using graduated thermometer. pH has been registered by using pH meter manufactured by Hanna (Romania origin). The electrical conductivity for water samples has been determined by Orchidis device (French origin) with (ms/cm) units. The calculation by analysis and summation used to determine total dissolved salts. Turbidity is a term called for water that is not transparent which can be measured by an instrument called as nephelometer (turbid meter) made by Hach Company (USA origin), while total hardness and calcium have been calculated by the calibration with standard solutions by EDTA Titrimetric method. Product of the subtraction of calcium from total hardness used to calculate magnesium concentration. Gravimetric method used to indicate sulfates concentrations in water samples. Argentometric method used to estimate chlorides. Erichrome cyanine R method used to determine aluminum, while sodium and potassium have been determined by using flame photometer made by Jenway Company (U.K. origin).

Statistical analysis

The statistical analysis system–SAS [7] (2004) was used to data analysis (the effect of type of water and month of year in study parameters), the least significant difference – LSD test was used to compare between means. Tables [1, 2] show the effect of water type and month of year in the specified parameters.

Results and discussion

All samples of water were collected from the central Baquba liquefier station and tested for all parameters in the national laboratory of Baquba municipal water and sewerage bureau.

Table [1] presents the experimental results for raw and clean water.

At the beginning, our vision is of a world where all people have access to a safe drinking water.

Initially, the main suggestion is the possibility of detecting suspended objects and with high levels of the main causes of turbidity.

From God regard, and according to the reading values, the water coming into Baquba (River of Dayala) has good chemical and physical characterizations especially (TDS) with low compositions of inorganic compounds; this can be clearly shown in table [1] for raw water.

All the printed data in this table emphasize the fact of low concentrations of (TDS) for Baquba water and actually serve the human health of peoples since it have big deviation from the standards, in spite of the absence of effective treatment in the main station. Many of domain technical processes should be set out such as reverse osmosis and electro dialysis techniques to expand the ability of this station.

From simple reviewing of collected results for turbidity parameter with the two types of water (raw and clean), it can be concluded that Baquba water station has limited activity for all seasons to decrease the raw water turbidity values to meets the favorable standard, this can be caused by the absence of reverse osmosis units for the station, this technique actually has the big role of turbidity degradation, and this is noticed by (Al– Refaay) [8] (2001), only old filtration media and precipitation processes with the addition of ($Al_2(SO_4)_3.18H_2O$) to remove suspended solids are actually used. Otherwise, there are good significant differences between raw and clean water values and this is clearly observed in table [2].

For clean water and from the principal study of the primary results, it can be concluded that turbidity is the biggest problem of Baquba water while the other parameters are still in the allowable ranges, really, it should not be exceeded than (5 NTU) according to WHO standards, but some of these results are approximately closed by this value (especially for April, October and November 2009), while the other values for clean water are far away as in (May, September 2009) with healthy deviation in (December 2009, January and February 2010). The behavior of turbidity values for raw and clean water all over the experimental period can be shown in the figure [1], and then it should be investigate the real reasons for this strange behavior which may be summarized in the field of:

Initially, Baquba station severs from the low efficiency for turbidity degradation and this can be expressed by the domain fact of this station, which can be summarized by:

Through the first visit to Baquba water liquefier station (May, summer season 2009), it was seen the big clusters of clays and sludge are accumulated in the first vacuumed gate of the station without confident treatment in addition to old filters used with low performance of separating and continuous blockage with the absence of the reversed washing of unit pipes.

For summer season, May 2009, the high values of turbidity parameter for clean water can be attributed to many causes such as: the low efficiency for turbidity degradation for the station, also, the stopping of the third precipitation basin since the station works with full operating capacity (summer season), certainly this will decrease the efficiency of producing clean water with low turbidity values.

In the raw water side, there is another causes for increasing of turbidity values in May 2009, this can be clearly expressed by: In this month, Iraq witnessed natural events such as torrential rainfall* (Iraq meteorological organization and seismology) [9] lead to excessive erosion and landslides**, as water passes over soil in its natural cycle; it carries sediments and mineral deposits.

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*: In May 2009, Iraq witnessed notified excess in the raining rates, in Baghdad; it was registered 96.8 mm in comparison with 52.2 mm all over the last season of 2008, while, in Mousal; it was registered 370.8 mm in comparison with 174 mm in 2008.

**: Falling of a mass of earth and rocks

Soil and rocks erode over time, releasing more minerals into the water, which can be considered as the important causes, in the same time we can't ignore the effects of human activities [2] (2005), which in turn increase the content of suspended materials in affected Rivers, added to, River′s cleaning processes (debris picking up) which started through this period under the supervision of the ministry of irrigation.

Continuously snow melting through April 2009 consolidates the fact of high values of raw water turbidity; this can be shown clearly in table [1].

For June and July 2009, Baquba for decades has wrestled from the problem of water level diminution of Dayala River (summer season), then to moderate this fact, the station officers made unblock gate to ensure the accumulation of water to vacuum it into the first gate, so it is definitely with increasing of temperatures and evaporation rates, turbidity still with high values.

So, it is naturally to expect a significant positive relation between water temperature and turbidity.

For the second part of the results, September, October and November 2009, the increasing of turbidity for raw water which reached to its maximum values (27 in September) may be attributed to heavy rain weather for this month (Iraq meteorological organization and seismology) [7], which enhances the increasing of turbidity values for clean water; then turbidity values still with significant increasing in October and November with low rates of rainfall.

So, it can be concluded a positive significant relation between the turbidity parameter with the degree of raining, this behavior can be showed in table [2].

The last period of testing carried out in January and February 2010, for raw water which registered a healthy deviation from WHO standards and this can may be explained in the name of low rates of raining with River′s stability level. The range of turbidity values begun to increased again in the last test for the same reasons.

It is well known that turbidity with high levels has a serious effect upon the human health, since turbidity is mainly caused by the presence of suspended solids and sand which is accompanied with the organic metals with the possibility of alga swarm, there is a clear relation between

turbidity and bacteria growth [10] (1995), where, the nourishing materials stick to these suspended molecules and then enhance the bacteria growth, as well as, turbidity limits the investigation of bacteria and viruses and decreases the chlorine activity used for water sterilization. This fact was detected by (Othman) [11] (2001), who has achieved his study for water treatment plants in Al– Tammem province during January 1996 till January 1997, he founds that, the drinking water for these units is not valid since there was a bacteriological pollution due to the increasing of turbidity values.

For the other parameters, all the results of (pH) closely preserved with WHO standards with approximately good deviation. All the estimated values of raw and clean water have arranged between (7.2 – 7.84) with depression in pH values for clean water in reverse to raw water, this can be explained by the addition of some chemical compounds used for the precipitation processes of suspended solids such as ($Al_2(SO_4)_3.18H_2O$), and this is clearly detected by (Al– Refaay) [8] (2001) who concluded that there is a simple degradation in pH values after the addition of precipitated chemicals, in addition to this reason, the chlorination process has clear effect on pH degradation, this can be explained by the formation of HCL acid by:

$CL_2 + H_2O \Longrightarrow HCl + HOCl$

HCl acid exist with pH ≤ 7, accompanied with high degree of sterilization, but with pH > 7, HOCl ion (Hybochlorate ion) increases which does not has any active effect for water sterilization and this finally will guide to decrease the chlorination activity (Ames) [12] (1964), so, it may be expected that, there is a nearly good sterilization activity by using of chlorination process for Baquba water since pH has limited values between (7 – 7.9). The same conclusion is showed by the research team of (Hussan) [13] (2008) for their study upon the quality of sterilization with their effects for one district in Baghdad.

The electrical conductivity values (EC) are related with (TDS) and give us a good indicator for its presence; all the estimated values in table [1] have no dangerous deviation from WHO standards.

It is well showed from table [1] that TDS values for raw and clean water are relatively changed all over the months and arranged between (484 – 643 PPM) for raw water and (480 – 638 PPM) for clean water, with maximum values in April, May 2009 (summer season), and this may be explained by the continuously increasing of temperature which increases the ratios of water evaporation and leads to higher TDS values, in addition to the diminution of water levels of River in this season. (Fhad) [14] (2003) has concluded the same results.

In the other side, TDS values mostly decreased for winter season with the increasing of rainfall rates and water dilution. For November 2009, TDS values clearly increased and this may be attributed to the decreasing in rainfall rates. The behavior of TDS along the experimental date can be shown in the figure [2] and it may be concluded a good significant differences for TDS along the experimental period and this can be shown in table [2], with positive relation between TDS and temperature and negative relation between TDS and raining rates.

In the same time, the increasing of TDS values for summer season accompanied with increasing of electrical conductivity (EC) values. This behavior was noticed by many researchers such as (Sarhan) [15] (2001), who emphasized the same fact.

The relation between electrical conductivity and total dissolved salts are studied by (Shalan and Al – Darmy) [16] (1986), they concluded a mathematical expression linked these parameters and used for calculating of TDS values from the registered electrical conductivity values, as follows:

$$TDS = 1.375\ EC^{0.91}$$

Since the concentrations of dissolved salts of calcium and magnesium are far away from WHO standards with healthy deviation, then, the registered values of total hardness have good distinction from standards.

The hardness of water is the extent to which it prevents soap lathering, but it causes the accumulation of precipitates on the draining system additional to the weakness of cleaning detergents, it is usually caused by the presence of dissolved salts of calcium and magnesium and increased with increasing of their concentrations, occasionally also by those of iron or aluminum, which react with soap to form the typical scum seen around baths or wash basins. Certainly, so, according to the tabulated results, it is expected that Baquba water has the lower degree of hardness.

In spite of low raw water hardness values, really, the absence of water softening units for Baquba station, enhance to maintain the total hardness values with approximately same values for raw and treated water all over the experimental period. Good significant differences of total hardness all over the months indicate the effects of season weather (Temperature and raining rates) on total hardness values; this can be shown in table [2].

It has been recorded higher concentrations of total hardness in hot months with the increasing of evaporation rates and decreasing of raining rates, this is clearly noticed by (Fahad) [14] (2003).

The behavior of total hardness for the experimental period can be shown in the figure [3].

From the simple viewing in table [1], it is clearly seen that the concentrations of calcium and magnesium for raw water arranged between (55 – 83 PPM) and (26 – 36 PPM), all the registered concentrations of calcium are greater than magnesium, this is may be caused by the natural of these metals in the surrounding water soil and it can be seen the slightly increasing of calcium concentrations in the raining months if compared with the other months, and this is may be caused by the increasing of dissolution of rocks and sludge with the raining stream adding to the effects of residue effluents, but, the registered values did not exceed the allowable values for WHO, this similar behavior is detected by (Othman) [15] (1996).

The salty taste of water is well related to concentration of chloride, since, all the estimated results of raw water for chloride valid between (25.5 – 40.9 PPM), and did not exceed the limitations of WHO, so, it can be expected that Baquba water has a good taste.

With respect to sulfates, all results of raw water valid between (135 – 243 PPM), the maximum value is indicated in May 2009, this is due to the heavy rain weather which increases the dissolving of surrounded soil and then increases sulfates concentrations with the flowing of water streams, but, the concentrations did not exceed the limits of WHO with the effects of water dilution, and this is clearly estimated by the study of (Othman) [17] (1996). No significant differences between raw and clean water, this is a good indicator for the law efficiency of water treatment for the station.

All the samples of sodium for raw water have good deviations from the allowable value of WHO, they are arranged between (13 – 21 PPM) along the experimental period.

The degradation of aluminum values for all the tests can be considered as a good signal for the absence of poisoning metals, all these concentrations are registered for clean water in reverse to raw water, this is may be expressed by the addition of ($Al_2(SO_4)_3.18H_2O$) in the precipitation processes.

Finally, it should be mentioned that there is some increasing in the concentration of some parameters after the treatment processes such as, TDS and TH, for example, it can be clearly noticed for TDS in January 2010 and other. Really, this is a contrary behavior, but may be attributed to the effects of the excessive usage of ($Al_2(SO_4).18H_2O$) in coagulation and precipitation processes, in the other hand, all these registered values have pH > 7, which did not suitable for the best reaction of aluminum sulfates with water (the favorite values between (4 – 7), so, this will decrease the quality of precipitation and produce higher values of TDS in the treatment water, this is investigated by (Duggal) [18] (1988). Another explanation for this case is followed by the reaction of the excess of chlorine (sterilization processes) with aluminum sulfates to produce dissolved aluminum chlorides ($Al\ Cl_3$) which increased TDS values, this is obviously noticed by (Al– Imarah and his follows) [19] (1992), they conclude that the excess doses of chlorine in sterilization processes increased TDS values in the drinking water.

Conclusions

1 – Turbidity of water is the biggest problem of Baquba water while the other parameters are still in the allowable ranges of world health organization standards, this does not deal with heavy and poisoning metals.

2 – Baquba main water liquefier station has no activity to desalinate water except the degradation of turbidity parameter with the addition of chlorine and suffers from the absence of water softening systems which decrease the quality of hardness treatment, it is supposed to set real solutions.

3 – No significant differences between raw and clean water except turbidity with the presence of significant differences for most parameters all over months with significant positive relation between water temperature and turbidity, also, between water temperature and total dissolved salts and negative relation between total dissolved salts and the raining rates.

Recommendations

1 – The private study to determine the efficiency of Baquba main water liquefier station is an important session for further researches, this should focus upon the quality of all units.

2 – The main future session is the study of the probability presence of heavy and poisoning chemical metals in Baquba drinking water and determine the real concentrations.

3 – There was a strong request to study the efficiency of domestic water (human consumption water) and determine the free residual chlorine and supposition solutions.

4 – The most dangerous upon the public health is attributed to the presence of organic chemicals (pesticides and herbicides) with trace concentrations, more demand to study this possible presence.

5 – Baquba needs to construct of big station to cover the increased demand of water with the expansion of this city, otherwise, A priority demand targets for the station are summarized in the requirements to construct ozone and ultra violet rays units for ensuring of organisms

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removal, ozone is the most effective disinfectant (killing bacteria, inactivating viruses).

6 – To increase the people enlightenment for water using by TV, radio and announcement posters. The logical question is why drinking water should be used on hundreds of applications (such as car washes) while the city is still suffered from water diminution especially in summer, serious solutions should be performed, for example constructing of big storage towers in the station as an auxiliary step.

7 – To held special committee from many of ministries to check up all the residue effluents of the industrial factories and institutes located along the River and planning to achieve the suitable studies.

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Table [1]: The chemical analysis of the collected samples

Parameter	Water type	WHO standards	April 2009	May 2009	Sep. 2009	Oct. 2009	Nov. 2009	Dec. 2009	Jan. 2010	Feb. 2010
Temp. °C	Raw	---	20	21	31	28	20	18	16	19
	Clean		20	21	31	28	20	18	16	19
T NTU	Raw	5	8.5	15	27	12	14.5	7	3.9	7
	Clean		4.75	8	7.5	4	4.4	3.5	3	3
pH	Raw	6.5 – 8.5	7.84	7.69	7.65	7.57	7.65	7.4	7.45	7.4
	Clean		7.70	7.55	7.35	7.36	7.55	7.2	7.35	7.35
TDS ppm	Raw	1000	616	643	484	510	603	523	499	504
	Clean		614	638	480	506	603	513	509	501
EC ms / cm	Raw	1600	947	989	745	786	929	806	767	776
	Clean		944	981	739	778	929	790	783	770
TH ppm	Raw	500	361	337	283	274	268	282	280	317
	Clean		342	340	278	263	257	268	275	313
Ca ppm	Raw	150	84.5	78	60	60	60.7	63	66	70
	Clean		83.0	75	60	56	55	63	64	70
Mg ppm	Raw	100	38.85	34	32	29.7	27.9	29	27.5	33.7
	Clean		32.2	36	30.4	29.5	28.5	26	27	33
Cl ppm	Raw	250	38.3	41	35.8	34.7	27	28	30	28.4
	Clean		40	40.9	32.4	30.3	27	27	29	25.5
SO4 ppm	Raw	500	236	247	171	164	152	139	158	159
	Clean		227	243	174	158	148	135	151	150
Na ppm	Raw	200	23	20	17.5	22	15	15	15	15
	Clean		20	21	16	19	15	14.5	14.5	13
K ppm	Raw	----	2.1	2.4	2.1	2.1	2.55	2.1	2	2.2
	Clean		1.65	2.4	2.2	1.65	2.1	2.0	2	1.9
Al ppm	Raw	0.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Clean		0.05	0.08	0.14	0.11	0.11	0.09	0.04	0.06

T: Turbidity TDS: Total dissolved salts. EC: Electrical conductivity. TH.: Total hardness.

Table [2]: Effect of water type and month of year in Temp., T, pH, TDS, EC, and T.H.

Parameters	Type of water	Month								LSD value
		4	5	9	10	11	12/2009	1/2010	2	
Temp.	Raw	20	21	31	28	20	18	16	19	2.66*
	Clean	20	21	31	28	20	18	16	19	2.66*
LSD value	--	ns	ns	ns	ns	ns	ns	ns	Ns	--
T	Raw	8.5	15	27	12	14.5	7	3.9	7	2.07*
	Clean	4.75	8	7.5	4	4.4	3.5	3	3	1.82*
LSD value	--	0.73*	1.48*	2.94*	1.27*	2.14*	0.86*	ns	0.67*	--
pH	Raw	7.84	7.69	7.65	7.57	7.65	7.40	7.45	7.40	ns
	Clean	7.70	7.55	7.35	7.36	7.55	7.20	7.35	7.35	ns
LSD value	--	Ns	ns	ns	ns	ns	ns	ns	Ns	--
TDS (ppm)	Raw	618	662	484	510	603	523	499	504	28.85*
	Clean	618	625	480	506	603	515	509	501	27.47*
LSD value	--	Ns	ns	Ns	ns	ns	ns	ns	Ns	--
E.C.	Raw	952	1020	745	786	929	806	767	776	86.38*
	Clean	952	1003	739	778	929	790	783	770	82.53*
LSD value	--	Ns	ns	ns	ns	ns	ns	ns	Ns	--
T.H.(ppm)	Raw	361	337	283	274	268	282	280	317	12.48*
	Clean	342	340	278	263	257	268	275	313	12.24*
LSD value	--	ns	ns	ns	ns	ns	ns	ns	Ns	--

* ($P<0.05$), ns: non-significant.

Table [3]: Effect of water type and month of year in Ca, Mg, Cl, SO_4, Na, K and AL.

Parameters	Type of water	Month								LSD value
		4	5	9	10	11	12/2009	1/2010	2	
Ca (ppm)	Raw	84.5	78	60	60	60.7	63	66	70	4.18*
	Clean	83	75	60	56	55	63	64	70	4.29*
LSD value	--	ns	ns	ns	ns	ns	ns	ns	ns	--
Mg (ppm)	Raw	35.85	34	32	29.7	27.9	29	27.5	33.7	2.31*
	Clean	32.2	36	30.4	29.5	28.5	26	27	33	2.46*
LSD value	--	ns	ns	ns	ns	ns	ns	ns	ns	--
Cl (ppm)	Raw	38.3	41	35.8	34.7	27	28	30	28.4	4.71*
	Clean	40	40.9	32.4	30.3	27	27	29	25.5	4.35*
LSD value	--	ns	ns	ns	ns	ns	ns	ns	ns	--

SO_4 (ppm)	Raw	236	247	171	164	152	139	158	159	12.68*
	Clean	227	243	174	158	148	135	151	150	11.47*
LSD value	--	ns	ns	ns	ns	ns	ns	ns	ns	--
Na (ppm)	Raw	23	20	17.5	22	15	15	15	15	1.68*
	Clean	1.25*	21	16	19	15	14.5	14.5	13	1.48*
LSD value	--	ns	ns	ns	1.23*	ns	ns	ns	ns	--
K (ppm)	Raw	2.1	2.4	2.1	2.1	2.55	2.1	2	2.2	ns
	Clean	1.65	2.4	2.2	1.65	2.1	2	2	1.9	ns
LSD value	--	ns	ns	ns	ns	ns	ns	ns	ns	--
AL (ppm)	Raw	0	0	0	0	0	0	0	0	ns
	Clean	0.05	0.08	0.14	0.11	0.11	0.09	0.04	0.06	0.04*
LSD value	--	ns	ns	ns	ns	ns	ns	ns	ns	--

- ($P<0.05$), ns: non-significant

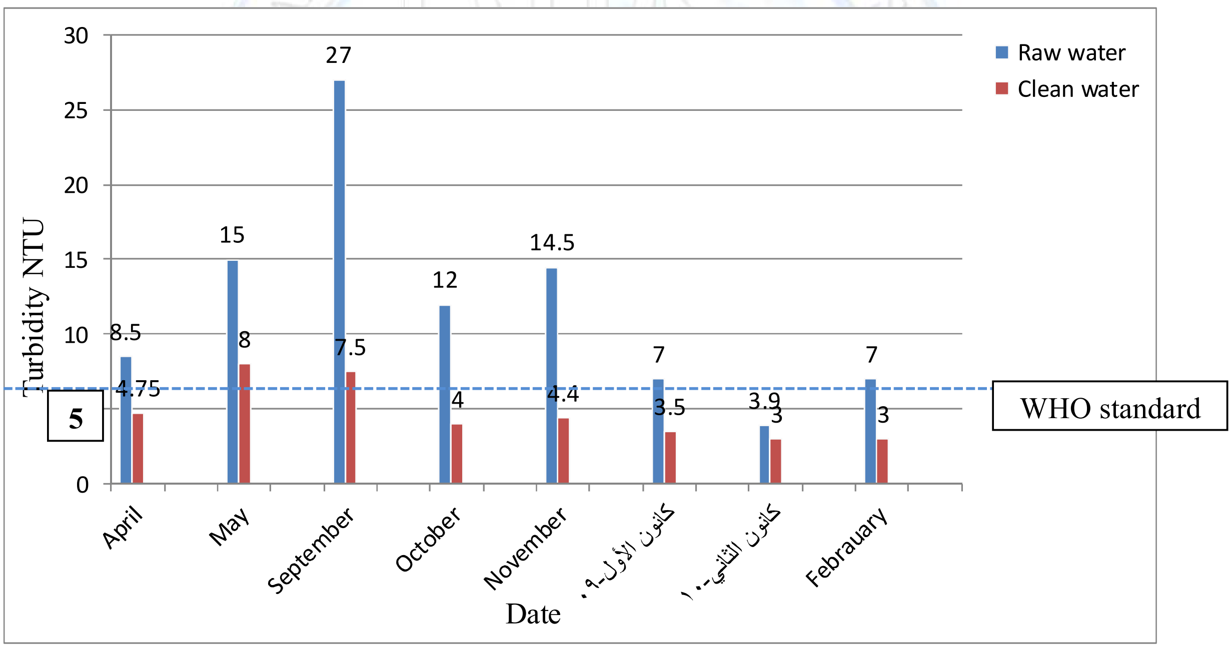

Figure [1]: Turbidity values for raw and clean water

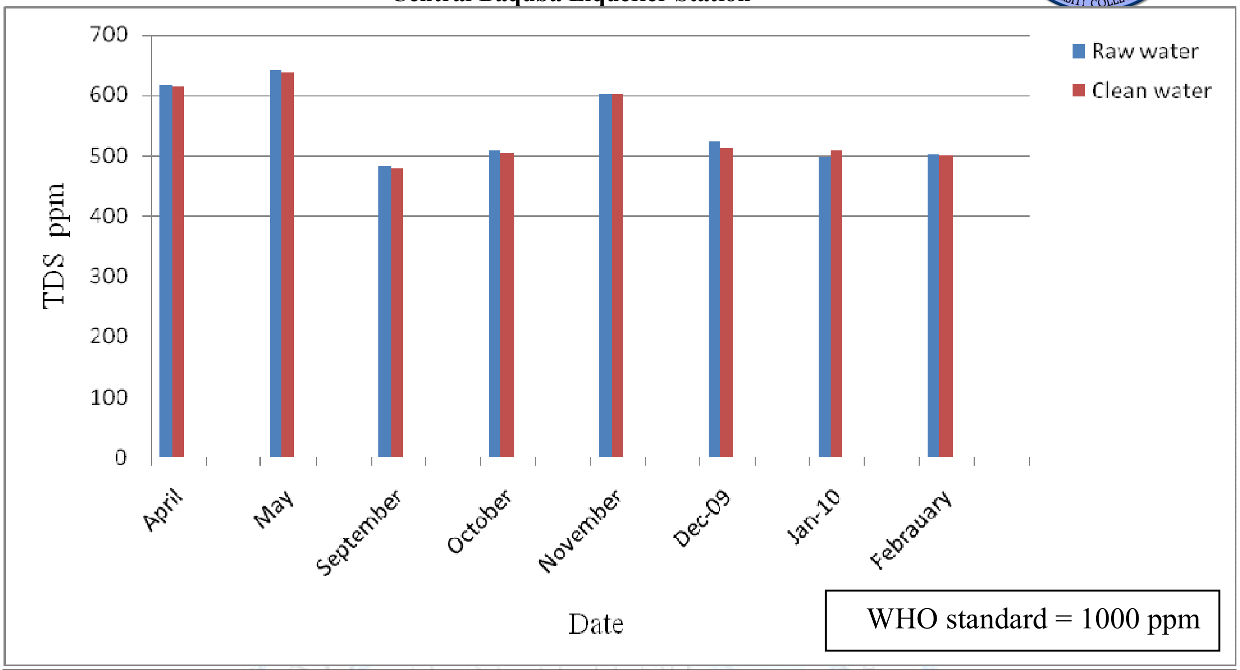

Figure [2]: TDS values for raw and clean water

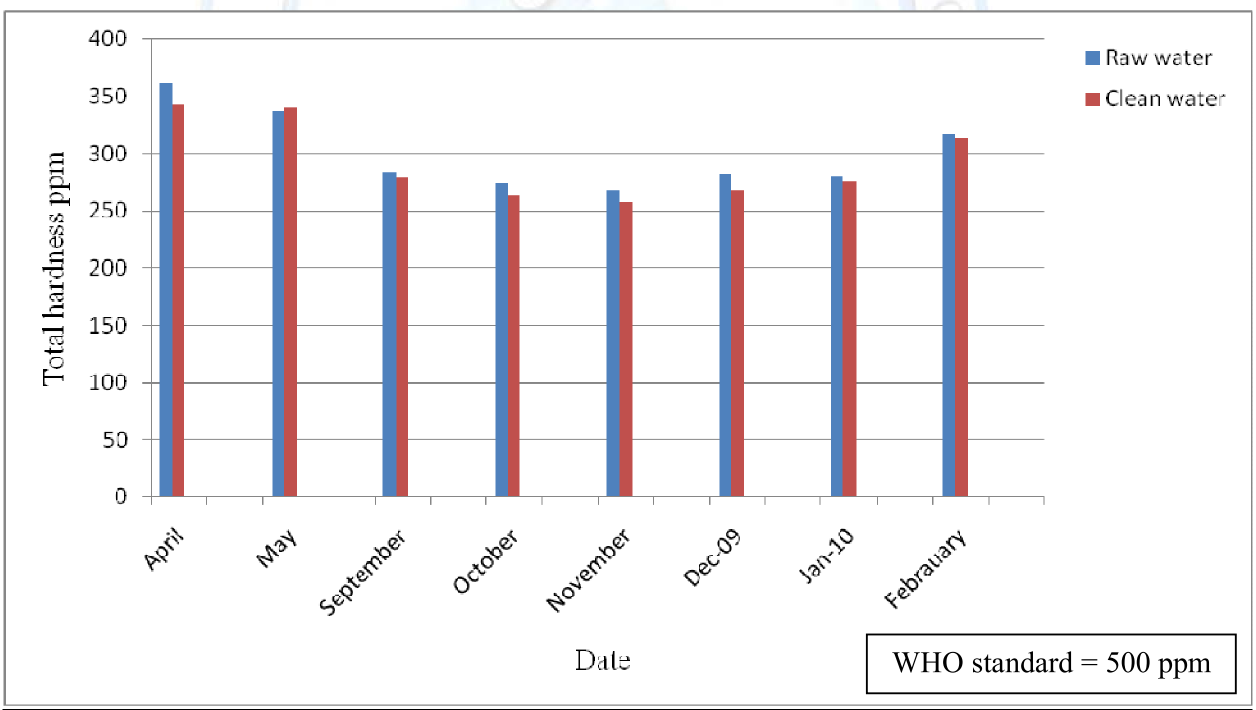

Figure [3]: Total hardness values for raw and clean water

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