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Assessment of water quality supplies in some areas of Basrah Governorate, Iraq

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ABSTRACT

Seventy samples were collected out from water supplies of seven stations at Basrah governorate from October, 2015 to April, 2016 to estimate physical characteristics and fecal coliform bacteria content. The fecal coliform bacteria ranged from 1–1370CFU/100 mL belonging to the species *E. coli*, *Citrobacter* sp and *Enterbacter* sp., The water temperature range (9 - 30) °C , turbidity (1.12 - 215.0) NTU, pH(7.0-8.8), electrical conductivity (0.24-9.48) ms/cm, salinity (0.15-6,07) g/L (PSU) and residual chlorine (0.01-3.56) mg/L. The results have shown contamination of water supplies with pathogenic microscopic organisms such as bacteria and pathogenic viruses. Furthermore, physical and chemical characteristics of water investigations have indicated the excess of the average values of some characteristics in most places subjected to the present study above the permitted WHO and Iraqi standards of drinking water.

Key words : *Water quality parameters, Basrah Governorate, Physical and chemical characteristics, Fecal Coliform Bacteria*

Introduction

The world in general and third world countries in particular have confronted a problem of providing potable water (Ramadan *et al.*, 1991). WHO states that more than 25, 000,000 persons die each year because of diarrhea where around one third of this number are children less than five years old and such deaths are attributed to human pathogens transmitted via water (Raml, 2010).

Microbial evidences are usually used to indirectly discover the presence of pathogenic bacteria in water. One of such microbial evidences is Coliform bacteria and *E. coli*, the presence of which is deemed as a proof confirming fecal contamination especially inhot regions (Al- Kofi, 2009).

Shatt Al-Arab river is considered as the main source to provide Basrah governorate with surface water and its water is used for many purposes such as the preparation of drinking water, irrigation, fishing, navigation and other industrial usages (Hussein *et al.*, 1991). This river has suffered the problem of contamination especially during the recent years which has led to massive deterioration the quality of drinking water and water supplies in this governorate. Many factors have contributed to deteriorate massively the quality of Shatt Al-Arab water such construction of dams in some countries (Al- Kofi, 2009), Mismanagement of water resources in the southern region of Iraq, the disposal of industrial, solid and liquid wastes, pesticides, butchery remains, fertilizations and untreated sewer water into Shatt Al-Arab water (Moyel, 2010).

The evaluation of Water quality can be done for drinking by biological and physico-chemical aspects. The pollution of water by organic and inorganic pollutants has detrimental impact on the environment and human health (AL-Farraj *et al.*, 2013).

The importance of such issue and its impact on human 's life in Basrah governorate, many studies have been conducted to study the physical , chemical and biological characteristics of drinking water including this present study which aims to determine some physiochemical contamination characteristics or indicators of drinking water stations in Basrah governorate and to investigate the microbial contamination of water supplies provided to houses from such stations and the assessment of disinfection operations efficiency processed in water purification stations.

Materials and Methods

Sampling : The 10 water samples were collected from the water tap directly from seven stations (Basra University site, AL Zubair, Safwan, Abil AL Khaseeb, AL Maqal, AL Hadi Districtand AL Hakimia) during October, 2015 to April, 2016.

Samples: The water samples were collected using two groups of bottles. The first one sterilized (100 mL capacity) provide with.0.1 mL of sodium thiosulphate to neutralize the effect of the residual chlorine, was used to discover the presence of fecal coliform bacteria. The other group of bottles made of polyethylene (50 mL capacity) fully filled with water sample to prevent water movement from causing any changes to their physiochemical properties. The, filled bottles were kept in an ice box.

Physical tests: The physical and chemical properties of water samples were measured directly at the field usinga graded mercury thermometer (0 – 100 C°) to determine the water temperature. Electrical conductivity meter (China, model: EC 1385) was used to determine the electrical conductivity (EC) and Salinity was calculated according to the equation:

Salinity = EC *0.64.

Turbidity meter(Lovibond, UK, model: TB 300 IR) was used to determine the water turbidity (APHA, 1998). pH was measured using pH meter (WTW, Germany, model: pH 7110) and residual chlorine was measured in each sample using (Lovibond 2000, UK and O- Toluidine).

Bacteriological tests

Fecal coliform bacteria: Fecal coliform population was counting according to membrane filtration technique (APHA, 1998). A suitable volume of water sample was passed through 0.45 µm pore size cellulose nitrate membrane filter (Sartorius, Germany), placed on Mf-cagar (Himedia) and incubated at 44.5±1C° for 24 hours in waterbath (Memmert, Germany). The fecal coliform bacteria is counted after incubation period. If lactose fermenter colonies that exhibited blue color, the blue colonies were only counted. Fecal coliform bacteria was calculated by the equation below:

$$\text{Colonies Forming Unit (CFU)/100 mL} = \frac{\text{Numbers of counted colonies}}{\text{Volume of sample (mL)}} * \text{dilution factor} * 100$$

The morphological properties of colonies growing on culture media which included its shape, color, edges, diameter and stature as well as the microscopic properties of cells stained with gram stain Machfaddin, 2000.

They included s tests to identify fecal coliform bacteria such as Indol Production test, Vogues Pros Kauer test, methyl red test, citrate utilization test, hydrogen sulfide production and glucose fermentation test as stated in (Machfaddin, 2000).

Statistical analysis: Analysis of variance (one – way ANOVA) was applied by Minitab ver-16.1 software to identify the existence of spatial significant differences. The relationship between the parameters was tested using the Pearsons correlation coefficients.

Results and Discussion

Physical tests: Thephysical and chemical properties of the water samples were shown in Table 1.

Water temperature: The water temperature is ranged from lowest value 9 °C at St.3 to the highest value 30 C° at St.1, such temperature variation is attributed to differences in sample collection time as well as the nature of the significant atmospheric variation among seasons in Iraq, high sunlight intensity and temperature variation between day and night (Hartand Zabbey, 2005).

Turbidity: The water turbidity ranged from 1.12 NTU at St.3 to 215.00NTU at St.2 as shown Table 1. The water turbidity variation in various places is attributed to differences in the quantity of suspended materials. The high turbidity at St.2 may be due to inadequacy of sedimentation and filtration operation which removes suspended materials.

Razoqi and AL Rawi(2010) stated that the increase of turbidity ratio may be attributed to excessive dust into surface water due to the effect of sandstorms which is common in the region especially during the summer season.

Moreover, the results have also shown that turbidity averages were above the standards approved by Central Organization for Standardization & Quality Control (1997) and American Environment Protection Society (2010) which amount to 5-25 NTU. The obtained results were disagreed with Al-Mayahi (2008) and Tawfiq (2013) where turbidity was within the permissible limits approved by Iraqi Drinking Water Standards.

There is a high correlation direct relationship (between turbidity and the presence of bacteria at St.2 district because the increase of turbidity averages helped to protect bacteria or provide the proper conditions for bacteria growth.

pH: The results revealed that lower pHvalue of water recorded is 7.0 at St.1 and higher pH value is 8.8 at St.2 (Table 1). The minimum and maximum pH limits for Iraqi standards of drinking water which was ranging between 6.5- 8.5. The minimum pH values recorded in the present study was within the permissible limits of Iraqi standard, while maximum pH values recorded in the present study was above permissible limits of Iraqi standard.The results indicating that the tapwater in Basrah city is alkaline, this may be due to the water treatment methods and using additional doses of alum to precipitate calcium carbonate ($CaCO_3$) to control pipes corrosion (Morin, 2009). Tawfiq (2013) reported similar results within the International and Iraqi permissible limits of drinking water. The minimum and maximum pH recorded in the present study was within the permissible

Electrical Conductivity: The electrical conductivity (EC) of the water has been ranged from 0.24 at St.3: to 9.48 mS/cm at St.1(Table 1). This is attributed to the difference in the quantity of salts dissolved in water as well as the time of samples collection and the fluctuation of the levels of water and variations of treatment techniques (Moyel, 2009). The increase of electrical conductivity (EC) value is due to contamination occurred in Shat AL-Arab water caused by human and agricultural activities , industrial wastes disposed into water from plants and factories stationed at both river shores which add salts to water (Hassan *et al.,* 2011).

Salinity: Water salinity ranged from 0.15 g/Lat St.3 to 6.07 g/L at St.1 (Table 1). This is due to variation of dissolved salts and temperature variation which plays a significant role in changing water salt concentration. The rise of salinity level may be due to water supplied from Shat AL-Arabriver, was due to high level of salinity. While decrease of salinity values in the other studiedstations is attributed sources of water supplied which have low level of salinity (Al-Hejuje, 2014). The results of the present study (Table 1) are not in conformity with international and Iraqi standard specifications of drinking water Central Organization for Standardization and Quality Control (COSQC, 1997, EPA, 2010).

Residual Chlorine: Chloride values ranged from 0.01mg/L at most stations to 3.56 mg/L at St.2 (Table 1). This variation in residual chlorine may attributed to the unregularly addition ofchlorine pumped by the stations. Residual Chlorine concentrations within the concentrations approved by the Iraqi Specifications of drinking water (COSQC, 1997).

Table 1. Physical Properties of water.

Areas	Water Temperature	Turbidity (NTU)	pH	EC mS/cm	Salinity g/L	Residual chlorine mg/L
St.1	19.0 -30.0	2.59-61.00	7.0-7.8	4.14-9.48	2.65-6.07	-
St.2	20.0 - 25.0	2.39-215.0	7.6-8.8	0.71-0.90	0.45 - 0.58	0.01-3.56
St.3	9.0 – 14.0	1.12 - 11.0?	7.1 - 7.5	0.24 -3.09	0.15 -1.98	Nil- 1.91
St.4	18.0 - 22.0	3.93-13.70	7.1-7.7	3.55-4.27	2.27- 2.73	0.07-0.50
St.5	20.0 – 25.0	2.93 – 43.0	7.6 – 8.0	1.56-7.35	1.00 - 4.70	0.01-1.91
St.6	12.0 - 25.0	3.84-36.90	7.4-7.7	3.40-5.48	2.18 - 3.51	0.02-0.04
St.7	15.0 -28.0	3.79-54.20	7.6-8.03	1.47-3.00	0.94-1.92	0.01-0.10
Standard (Iraq)	20-30	5	6.5- 8.5	2	100-350	350
WHO	10-15	5	6.5-8.5	1	100-250	250

St.1: Basrah University site, St. 2: AL- Zubair, St. 3: Safwan, St. 4 : Abil AL- Khaseeb, St. 5 : AL- Maqal, St. 6: AL- Hadi District, St.7: AL-Hakimia

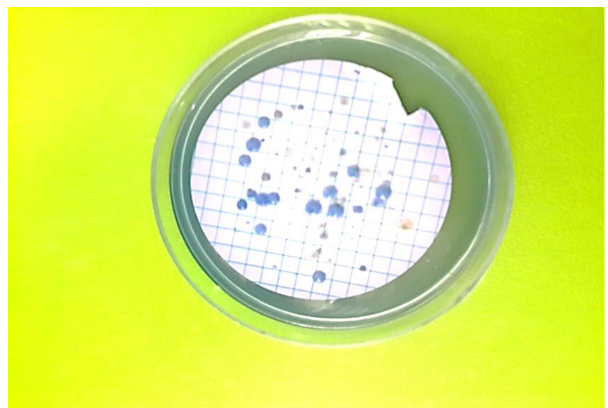
Chlorine is added to water at supplies plants for disinfection purposes, Chlorine is added with sufficient quantities with remaining part thereof (0.2–0.3) mg/L (COSQC, 1997) as per Iraqi Standard Specifications while International standard specifications has determined the concentration of residual Chlorine around (0.2 – 0.5) mg /L (17) in order to protect water against microbial contamination during transportation and storage (Al- Ta'ee *et al.,* 2008; Al-Safawi *et al.*, 2018).

The absence of residual Chlorine in some stations leads to increase the risks of pathogens contamination during transportation and storage and this may be attributed to insufficiency of chlorine compounds used in water supplies stations. The, high temperature during summer plays a serious role in decreasing residual Chlorine (Aubaid, 2011*)*. Chlorine concentration is gradually decreased in distribution systems via volatilization. This may be attributed to a shortage in water circulation or stagnation inside pipes (Adock *et al.,* 2008; Raml, 2010). The presence of high concentration of chlorine in drinking water means the occurrence of a contamination of raw water sources feeding the water supplies stations making drinking water to turn to be non-potable water neither for man and cattle drinking (Khudair, 2013). The increase of chlorine quantity in water beyond the limits internationally permissible may result in negative healthy effects to people causing serious diseases such Cancer, heart diseases, apportion, respiratory disease and hair and skin (WHO, 1997*)*.

The present study disagrees with Al- Ta'ee *et al.* (2008) study in confirming the fact that chlorine levels in some places in Basrah governorate have exceeded the permissible limits approved by International and Iraqi drinking water specifications. AL–Imarah *et al*. (2017) concluded in study conducting about drinking water purification stations located in Basrah,that the average of chemical measurements of drinking water released from water treatment plants within Basrah Governorate were never reach excellent levels. Only few of such stations were acceptable and appropriate that water ISO indicator of Basrah water supplies has not reached the international ISO degree.

Bacteriological tests: The results of the present study showed that the highest number of fecal coliform bacteria was for st.6 followed by st.7, st.1, st.4, st.2, st.5 and st.3 and it was 1370 CFU/100 mL, 228 CFU/ 100 ml, 46 CFU/100 mL, 11 CFU/100 mL, 10 CFU/ 100 ml, 7 CFU/100 mL and 1 CFU/ 100ml respectively (Picture 1).

The International and Iraqi drinking water specifications state that the drinking water should be free of fecal coliform bacteria 0/100 ml (COSQC, 1997, WHO, 1997) .



Pic. 1. Isolation of fecal coliform bacteria on MFC agar.

The reason of increasing the numbers of fecal coliform bacteria occurrence may be attributed to the fact the damages and breaks of network pipes which leads water to be mixed with contaminated water brought from leakages occurring in sanitary network and surface water besides the occurrence of some operational problems at some of water supplies projects such as improper filtration and sedimentation operations conducted to get rid of bacteria, such basins could be not clean enough, chlorine and Alum feed pumps are malfunctioned, doses are not precisely added (Rzooqi and AL Rawi, 2010*)*.

Table 2. The biochemical tests of fecal coliform bacteria species.

TestsBacteria	Indol test	Citrate utilization test	Methyl red test	Voges-proskauer test	Hydrogen sulphide production	Glucose test fermentation test
E. coli	+	-	+	-	-	+
Citrobacter	+	+	+	-	-	+
Enterobacter	-	+	-	+	-	+

Other reasons of increasing fecal coliform bacteria numbers are attributed to the contamination via transmission through water supplies pipes particularly during the last two decades due to the deterioration of services which motivates people to connect water pumps directly from the network to bring water from the network and lift it up to the tanks placed at the highest location of buildings. It quite well – known that such trespasses reflect potential health risks that such process leads to pressure rarefaction inside the network if any break or malfunction occurs in the connection parts (Al-Azawi *et al*., 2011). The problem is aggravated in the absence of chlorine in water associated the increase of temperature during summer and the presence of dissolved nutrients in water which causes for microscopic organisms to increase as well as the problem of increasing the numbers of fecal coliform bacteria in raw water due to the trespasses committedduring the disposal of liquid wastes directly to rivers (Yahya, 2002; Al-Safawi *et al*., 2018). The present study agree with studies conducted by Al- Ta'ee *et al.* (2008) in Basrah and Rzooqi and AL Rawi (2010) in Baghdad confirmed the contamination of drinking water with fecal coliform bacteria. The results of other studies conducted by Tawfiq (2013) in Al hillah and Al-Saffawi *et al.* (2018) in Mosel demonstrated that drinking water is free from microbial contamination.

The diagnostic results of fecal coliform bacteria of all stations show that it is short bacilli, negative gram stain, not producing spores and it is one of the diagnostic morphological features of fecal coliform bacteria (Machfaddin, 2000). Based on the results of biochemical tests (Table 2) of such bacteria, a variation of the species of fecal coliform bacteria such as *E. coli*, *Citrobacter* sp and *Enterobacter* sp have been reported in various stations of the study.

The present results agree with studies conducted byAbid (2006) in Al-Nasiriyah and Al- Ta'ee *et al.* (2008) in Basrah where a significant variation has been recorded infecal coliform bacteria types isolated from drinking water. Such variation is attributed to many reasons. It is usually available everywhere that it is isolated from water, plants, and decomposed materials. It is part of the natural flora in animals and human digestive canal and this facilitates for such types to reach drinking water from different sources due to the leakages of sewer and rain water to the distribution networks through the broken and damaged positions occurring through such networks (Lechervallier *et al*., 1996).

The results of the present study have concluded that there are big numbers of fecal coliform bacteria in some places of Basrah governorate which indicate the insufficiency of water purification stations, insufficiency of Chlorine added to eradicate bacteria and also the occurrence of breaks and cuts in the Governorate pipelines network resulted in mixing sanitary with drinking water. Therefore, this present study recommends to construct and erect new water distribution networks in Basrah City, the replacement of old pipes with new ones, use the standard ratios of Chlorine in water, activate the role of environment protection and improvement in Basrah because of the limitation of its role in monitoring water treatment operations in purification stations.

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