

RESEARCH ARTICLE

Study on the physiochemical and microbial content of drinking water in and around Al-Nasiriyah province

Amani Mohamed Jasim¹, Safa Abd Alhadi Fadhil², Amal Kamel³

Abstract

Objective: To identify microbial contents of water by physical and chemical analyses in different regions in a Middle East country.

Methods: The prospective, cross-sectional study was conducted in and around Al-Nassirya province of Iraq from March to July 2021, and comprised drinking water samples taken from water stations in city centre as well as Al-Dawaya, Al-Shatrah and Al-Nasr districts in the outskirts. Analysis included estimation of turbidity, temperatures, potential of hydrogen, total hardness, and estimation of chlorine, calcium and sodium measured in The-Qar university laboratories, Data was analysed using SPSS version 17. T-test was used to compare the mean values. A p-value of ≤ 0.05 was considered significant.

Results: Of the 10 water samples 1(10%) was collected from the city centre, 4(40%) from Al-Dawaya district, 2(20%) from Shatra district and 3(30%) from Al-Nasr district. Significant differences were found in the samples collected from city centre compared to those from the countryside ($p < 0.29$). Turbidity was less (1.7) in samples from the city centre compared to the three countryside water stations. High levels of chlorine (26), concentration of calcium (199) and sodium (479) were moderately high in samples from Al-Nasirya city. Microbial growth was detected in samples from Al-Nasr and Al-Dawaya districts where *Escherichia coli*, *staphylococcus aureus* and *cryptosporidium parvum* were detected in some water stations.

Conclusion: Countryside water stations showed changes in standard physiochemical normal values and contamination of drinking water with microorganisms.

Keywords: Chlorine, *Cryptosporidium parvum*, *Staphylococcus aureus*, Cryptosporidiosis, *Cryptosporidium*, *Escherichia coli*, Sodium. DOI: <https://doi.org/10.47391/JPMA.IQ-06>

Introduction

Water is essential for the health of our organism because our bodies are 90% water. Our age, in particular, has a significant impact on how much water is in our bodies.¹

Adults weigh about 80kg and their bodies consist of 52 litres of water.² Younger people have more water in their bodies than older people do, thus as we age, the amount of water in our bodies decreases.³ The water has many benefits for the human body, as it lubricates the joints, forms saliva, mucus and it delivers oxygen throughout.⁴ Water pollution is a widespread issue that can be caused by geological processes or anthropogenic activity.⁵

Pathogens like bacteria, viruses, and parasites like microscopic protozoa and worms are examples of microbial contaminants. These living organisms can be

spread by human and animal waste, either knowingly or unknowingly, and contaminants can generally be classified as inorganic, organic, radiological or biological.⁶

The main source of bacteria in water is human excrement, which also includes runoff from pastures, dog runs, and other places where animals leave waste.⁷ The presence of pathogenic organisms, called pathogens, in the water system is indicated by the presence of coliform bacteria in drinking water. All warm-blooded species, including humans, have coliform bacteria in their faeces and the environment. They are unlikely to spread disease.⁸

The testing involves diagnostic microbes of drinking water, and various selective media have been developed for the detection of indicator organisms in water by membrane filter (MF) methods. Recommended media for coliforms and *Escherichia (E.) coli* include membrane lauryl sulphate broth or agar and MacConkey agar. Additionally, the physicochemical assessments of drinking water quality have been determined along different water quality profiles, including temperature, potential of hydrogen (pH), electrical conductivity, total dissolved solids, and total

^{1,3}College of Medical & Health, Technology, Middle Technical, University, Baghdad, Iraq; ²Ministry of Education, Thi Qar, Education Directorate, Thi Qar, Iraq.

Correspondence: Safa Fadhil email: Raqy35103@gmail.com

hardness.⁹ A number of processes are available to inactivate and/or remove pathogens from drinking water, such as sedimentation, filtration and disinfection.¹⁰

The microscopic examination of the parasitic cryptosporidiosis outbreaks has been linked to the use of contaminated water. Deficits in water treatment systems are frequently identified as a primary cause of the outbreaks, but even the best systems can fail when a large number of oocysts enter the source waters in a short period of time.¹¹

The current study was planned to identify microbial contents of water by physical and chemical analyses in different regions in a Middle East country.

Materials and Methods

The prospective, cross-sectional study was conducted in and around Al-Nassirya province of Iraq from March to July 2021, and comprised 500ml drinking water samples taken from water stations in city centre as well as Al-Dawaya, Al-Shatrah and Al-Nasr districts in the outskirts. The samples were obtained directly from the water pump, first allowing water to run for 20 minutes. The samples were divided in 2 samples of 250ml each. For chemical assessment, the determinants were filtered through a Millipore cellulose membrane of 0.45µm pore size, which were stored in 500ml polyethylene bottles. Chemical analysis was done to evaluate calcium, sodium, chlorine value by atomic absorption spectrometry (Figure 1).¹¹

The ethical approval was obtained from the Dhi Qar Health Department before starting the study. A sample of 250ml was stored in 500 bottles for physical analysis which included estimation of turbidity using Hanna instrument, temperatures and pH clean container, cuvette solution and standard device sample of drinking water battery, according to the method used by Soylak M et.al.in their study.¹²

All clinical specimens were cultured on MacConkey and blood agar media, then subjected to indole test (Neogen, USA) and incubated for 24h at 37°C to identify gram-negative and gram-positive bacteria consecutively.^{13,14}

Water samples were prepared by sedimentation method after centrifugation. The precipitate was placed on glass slides. On the slide rack, the smear was fixed by applying a few drops of 96% methanol for 3min. Carbol fuchsin was added to the fixed smear and left for 15min, washed and decolourised in acid alcohol for 30sec, stained by methylene blue for 2min, washed again, and left to dry. Power used for oocyst detection was 40X and 100X oil immersion.^{15,16}

The sample size was calculated using the formula:¹⁷

Sample Size = (Z-score)² * StdDev*(1-StdDev) / (margin of error)²

Data was analysed using SPSS version 17 T-test analysis of variation by standard deviation was used to compare the mean values.¹⁸ A p value of ≤ 0.05 was taken as significant.

Results

Of the 10 water samples 1(10%) was collected from city centre, 4(40%) from Al-Dawaya district, 2(20%) from Al-Shatrah district and 4(40%) from Al-Nasr district. Significant differences were found in the samples collected from the city centre compared to those from the countryside ($p < 0.29$) (Table 1).

Turbidity was less in samples from the city centre (1.7) compared to the countryside water stations (Table 2).

High levels of chlorine (26), calcium and sodium were moderately high in samples from Al-Nasr district concentration of calcium (199) and sodium (479) were moderately high in samples from Al-Nasiriya city. (Table 3).

Microbial growth was detected in samples from Al-Nasr

Table-1: Distribution of samples between city centre and countryside.

No.	Place	n (%)	Centre of city	Countryside
1	Al-Dawaya district	4 (40)	2	2
2	Al-Nasiriyah city	1 (10)	0	1
3	Al Nasr district	3 (30)	2	1
4	Shatrah district	2 (20)	1	1
Total		10 (100)	5	5
M.S.		1	0.5	0.5
S.D.		1.69	1.87	1.73
P value		0.18	0.29*	0.27

F: Frequency, %: Percentage, M.S.: Mean of score, S.D.: Standard deviation.

$p < 0.05$ is significant

Table-2: Physical examination of the samples studied.

City	No. station	pH	Temperature	Turbidity
Al Dawaya District	Station 1	7.7	19°C	7
	Station 2	7.8	19°C	9
	Station 3	7.6	20 °C	26
	Station 4	7.5	19°C	9
Al Nasr District	Station 5	7.8	18 °C	15
	Station 6	7.5	21 °C	14
	Station 7	7.7	17 °C	6
	Station 8	7.9	16°C	2
Al Shatrah District	Station 9	7.6	18 °C	1.7
	Station 10	7.8	17 °C	2.8
M.S.	7.69	18.4	9.25	
S.D.	0.13	1.50	7.47	

M.S.: Mean of score, S.D.: Standard deviation, pH: Potential of hydrogen.

Non-Significant at $p = 0.31$.

Table-3: Chemical findings

City	No. station	Chlorine	Calcium	Sodium
Al-Dawaya district	Station 1	3.5	83	131
	Station 2	1.5	86	134
	Station 3	2	86	125
	Station 4	1	89	128
Al-Nasr district	Station 5	1	183	444
	Station 6	1	175	424
	Station 7	2	172	417
Al-Nasiriya city	Station 8	1.5	199	479
AL Shatrah District	Station 9	2	84	123
	Station 10	2.5	82	120
M.S.	1.8	123.9	252.5	
S.D.	0.79*	50.73*	163.07*	

M.S: Mean of score, S.D: Standard deviation.

*Non-significant.

Normal Values: Chlorine= 0.2-1.0 mg, Calcium: 4.5-5 mg, Sodium: 0.1-1900mg²⁹

Table-4: Microbial findings.

City	No. station	MacConkey Agar	Blood agar	Indole test	Diagnosis
Al-Dawaya district	Station 1	No growth	No growth	Negative	No
	Station 2	No growth	No growth	Negative	No
	Station 3	Growth	Growth	Positive	Escherichia coli and Cryptosporidium parvum
Al Nasr district	Station 4	No growth	Growth	Negative	Staphylococcus aureus
	Station 5	No growth	Growth	Negative	Staphylococcus aureus
	Station 6	No growth	Growth	Negative	Staphylococcus aureus and Cryptosporidium parvum
	Station 7	No growth	No growth	Negative	No
Al Nasiriya city	Station 8	No growth	No growth	Negative	No
AL Shatrah District	Station 9	No growth	No growth	Negative	No
	Station 10	No growth	No growth	Negative	No

and Al-Dawaya districts where *E. coli* (Figure 2), *staphylococcus aureus* (Table 4) and *cryptosporidium* (*C.*) *parvum* (Figure 3) were detected.

Discussion

The range of temperature of all samples was 17-21°C, while optimal degree for drinking water temperature is 15°C, according to Canadian guidelines for drinking water quality, changes in temperature can affect the growth of microorganisms.¹⁹

The World Health Organisation (WHO) has advocates lower turbidity threshold compared to the current study.²⁰ Turbidity in water can be caused by a variety of materials, and it is one of the most commonly used parameters for measuring water quality prior to disinfection. The current results showed turbidity in samples taken from city centre near the filtration stations to be less than the samples from

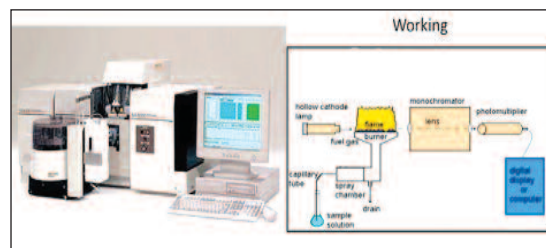


Figure 1: Atomic absorption spectrophotometer device.



Figure 2: Water sample culture in MacConkey agar *Escherichia* (*E.*) *coli* growth.

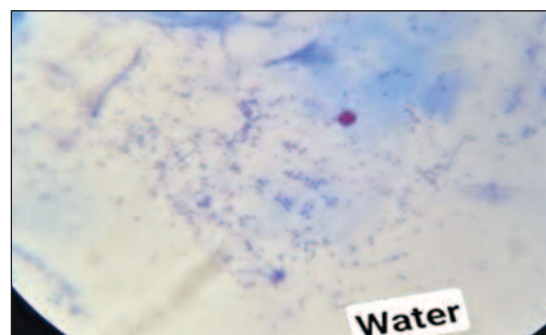


Figure 3: *Cryptosporidium* (*C.*) *parvum* in water sample (40x)

the countryside. The highest value was 26NTU in a sample collected from a place away from the filtration station. The current study was in line with an earlier study.²¹

In another study, the physical and chemical parameters of the drinking water plant in another Iraqi governorate were subpar and required treatment for purification.²²

Chlorine is very important for killing microorganisms that cause diseases, and it must be involved within the normal range of 0.2-0.5mg/l.²² Increasing chlorine concentration usually causes irritation in the oesophagus, a burning sensation in the mouth and the throat, and spontaneous vomiting.²³ The classification of calcium concentrations <60mg/l is generally considered soft, 60-120mg/l moderately hard, 120-180mg/l hard, and >180mg/l very hard.²⁴

All samples were considered moderately hard, and the average taste threshold for sodium (as sodium chloride) at

room temperature was about 200mg/l, while the results of samples were higher than the normal range.

One study reported increasing values for some trace elements and pH in all the studied sites, as well as rising chlorine levels. According to bacteriological tests, there was microbial contamination in the Najaf centre, Kufa centre and Menathera districts, which is consistent with the current study.¹⁴

The current study suggested that exposure to chlorine concentrations may lead to an underestimation of the real effect on quality of water and public health consequences in routine monitoring of chlorinated wastewater treatment effluent. Depending on the efficiency of the chlorination process, the controlling for microorganism limitation by chemical and physical factors was observed, like the turbidity was higher than normal in sample from one station, and bacterial growth was observed in samples from 3 stations. The study demonstrated that while chlorine inhibited the activity of microorganisms in the water, it did not destroy beneficial bacteria. *S. aureus* must be detected early and accurately in order to stop the outbreak of the disease caused by this bacterium.^{24,25}

Coliform survival rates varied between 7.5% in an acidic environment to 66.11% in an alkaline environment. In 2012 and 2013, the pH of seawaters in the Madura Strait varied from 6.3 to 8.3. More complete biochemical test is strongly recommended to correlate between pH characteristics and the occurrence of coliform bacteria in Madura Straits waters,²⁶ and this was in line with the current findings.

To link pH characteristics with the presence of coliform bacteria in water contaminated with *E. coli*, a more thorough biochemical test is strongly advised. Microorganisms have been reported to be positively related with turbidity and total suspended solids (TSS).²⁷ The current study also found that coliforms and turbidity were positively correlated.

The current findings with earlier reports²⁸ which documented factors affecting the quality of drinking water processed from the river Tigris, and reported that coliform counts and faecal *E. coli* counts at 3 stations in all seasons exceeded the WHO-recommended international permissible levels.²⁹ The results also demonstrate the existence of protozoan parasites.³⁰ *C. parvum* found in some areas highlighted the urgent need for improved drinking water monitoring systems to prevent illnesses brought on by these infections, and to pinpoint the sources of contamination.³¹

Conclusion

Countryside water stations showed changes in standard physiochemical normal values and contamination of drinking water with microorganisms compared to the water sample collected from the city centre.

Acknowledgement: We are grateful to the staff of the water department of Al-Nasiriya for their cooperation.

Disclaimer: None.

Conflict of Interest: None.

Source of Funding: None.

References

1. Fatima C. Uncertainty from sampling in microbiological water analysis. [Online] 2019 [Cited 2023 August 14]. Available from URL: https://www.eurachem.org/images/stories/workshops/2019_11_M_U/pdf/PL2-03_Microbiol_water_Coimbra.pdf
2. Hanaor DA, Sorrell CC. Sand Supported Mixed-P hase Ti O 2 Photocatalysts for Water Decontamination Applications. Adv. Eng. Mater 2014;16:248-54. Doi: 10.1002/adem.201300259.
3. Kinsella S, Moran S, Sullivan MO, Molloy MG, Eustace JA. Hyponatremia independent of osteoporosis is associated with fracture occurrence. Clin J Am Soc Nephrol 2010;5:275-80.
4. James M. Fifteen Benefits of Drinking Water. News release. The Medical News Today Media Centre. [Online] 2018 [Cited 2023 August 14]. Available from URL: <https://www.medicalnewstoday.com/articles/290814>
5. Fawell J, Nieuwenhuijsen MJ. Contaminants in drinking water. Br Med Bull 2003;68:199-208. doi: 10.1093/bmb/ldg027.
6. Sharma S, Bhattacharya . Drinking water contamination and treatment techniques. Appl Water Sci 2017;7:1043-67. Doi: 10.1007/s13201-016-0455-7
7. Mohammed AB, Sahabo AA. Water supply and distribution problems in developing countries: a case study of Jimeta-Yola, Nigeria. Int J Sci Eng Appl Sci 2015;1:473-83.
8. Washington State Department of Health. Coliform Bacteria and Drinking Water. [Online] 2016 [Cited 2023 August 14]. Available from URL: <https://doh.wa.gov/sites/default/files/legacy/Documents/Pubs/331-181.pdf>
9. Anderson S, Cindy D. Great Adventures in the Microbiology Laboratory, 7th ed. London, UK: Pearson, 2013; pp 175-6.
10. Sarker S, Mahmud S, Sultana R, Biswas R, Sarkar P, Munayem M, et al. Quality Assessment of Surface and Drinking Water of Nakla Paurosova, Sherpur, Bangladesh. Adv Microbiol 2019;9:703-27. doi: 10.4236/aim.2019.98043.
11. Gullian M, Espinosa-Faller FJ, Núñez A, López-Barahona N. Effect of turbidity on the ultraviolet disinfection performance in recirculating aquaculture systems with low water exchange. Aquac. Res 2012;43:595-606. Doi: 10.1111/j.1365-2109.2011.02866.x.
12. Soyak M, Aydin AF, Saracoglu S, Elci L, Dogan M. Chemical Analysis of Drinking Water Samples from Yozgat, TurkeyPolish Pol J Environ Stud 2002;11:151-6.
13. Alabassi MM, AL Naqeeb NA, Guda MA, Jabbar BS. The study of drinking water pollution by studying some chemical and biological characteristics in Najaf province, Iraq Eurasia J Biosci 2020;14:7159-64.
14. Al-Bayatti KK, Al-Araji KH, Al-Nuaemy SH. Bacteriological and physicochemical studies on Tigris River near the water purification stations within Baghdad Province. J Environ Public Health

- 2012;2012:695253. doi: 10.1155/2012/695253
15. AL-Khalidy KAH, Jabba HK. Detection of entamoeba histolytica and cyptosporidium parvium in drinking water of Al-diwanayah City, Iraq. *Eurasia J Biosci* 2020;14:1839-43.
 16. Levantesi C, Bonadonna L, Briancesco R, Grohmann E, Toze S, Tandoi V. Salmonella in surface and drinking water: occurrence and water-mediated transmission. *Food Res Int* 2012;45:587-602.
 17. Organisation for Economic Co-Operation and Development (OECD). Problem Solving for Tomorrow's World: First Measures of Cross-Curricular Competencies from PISA 2003. Paris Cedex, France: OECD Publications; 2004.
 18. SAS Institute Inc. SAS/STAT® 9.1 User's Guide. Cary, NC: SAS Institute Inc; 2004.
 19. Government of Canada. (2009, Feb. 6). Guidelines for Canadian Drinking Water Quality: Guideline Technical Document - Temperature. Retrieved from <https://www.canada.ca/en/health-canada/services/publications/healthy-living/guidelines-canadian-drinking-water-quality-guideline-technical-document-temperature.html?wbdisable=true>
 20. Beaudreau P, Schwartz J, Levin R. Drinking water quality and hospital admissions of elderly people for gastrointestinal illness in Eastern Massachusetts, 1998-2008. *Water Res* 2014;52:188-98. doi: 10.1016/j.watres.2014.01.005.
 21. Farrell C, Hassard F, Jefferson B, Leziart T, Nocker A, Jarvis P. Turbidity composition and the relationship with microbial attachment and UV inactivation efficacy. *Sci Total Environ* 2018;624:638-47. doi: 10.1016/j.scitotenv.2017.12.173.
 22. Al-Azaway ESN, Naji HF, Hassan FM. The study of some physical and chemical characteristics in drinking water treatment plant of Jurf Al-Sakar Subdestric in Babylon Governorate, Iraq. *Baghdad Sci J* 2007;4:338-43.
 23. World Health Organization (WHO). Water Quality and Health Review of turbidity: Information for regulators and water suppliers. [Online] 2017 [Cited 2023 August 14]. Available from URL: <https://www.who.int/publications/i/item/WHO-FWC-WSH-17.01>
 24. Dong L, Liu H, Meng L, Xing M, Wang J, Wang C, et al. Quantitative PCR coupled with sodium dodecyl sulfate and propidium monoazide for detection of viable Staphylococcus aureus in milk. *J Dairy Sci* 2018;101:4936-43. doi: 10.3168/jds.2017-14087
 25. Wahyuni EA. The Influence of pH Characteristics on the Occurance of Coliform Bacteria in Madura Strait. *Procedia Environ Sci* 2015;23:130-5. Doi: 10.1016/j.proenv.2015.01.020
 26. Chatanga P, Ntuli V, Mugomeri E, Keketsi T, Chikowore NV. Situational analysis of physico-chemical, biochemical and microbiological quality of water along Mohokare River, Lesotho. *Egypt J Aquat Res* 2019;45:45-51. Doi: 10.1016/j.ejar.2018.12.002.
 27. World Health Organization (WHO). Publications of the World Health Organization can be obtained from WHO Press. Geneva, Switzerland: WHO Press; 2022.
 28. Al-Baytee AJ, Jawad SQ, Mehdi HS. Prevalence of Cryptosporidium oocysts in different types of water in Al-Mansoria DIALA Province. *Al-Nahrain Journal of Science* 2012;15:103-7.
 29. Saleh Mohammed Al-Samarrai A, Razooq Hameed Al-Samarrai R, Ibrahim Hamdi B. An Investigation of Parasitic Protozoa in Drinking Water in Samarra, Iraq. *Arch Razi Inst* 2022;77:e821-5. doi: 10.22092/ARI.2022.357106.1977.
 30. Olaolu TD, Akpor OB, Akor CO. Pollution Indicators and Pathogenic Microorganisms in Wastewater Treatment: Implication on Receiving Water Bodies. *International Journal of Environmental Protection and Policy. IJEPP* 2014;2:205-12. doi: 10.11648/j.ijepp.20140206.12
 31. World Health Organization (WHO). In: Cotruvo J, Bartram J, eds. Calcium and Magnesium in Drinking-water: Public health significance. Geneva, Switzerland: WHO Press; 2009.
-