Comprehensive Journal of Science
Volume (10), Issue (37), (NOV. 2025)
SICST2025, www.sicst.ly
ISSN: 3014-6266

مجلة العلوم الشاملة
عدد خاص بالمؤتمر الدولي الثالث للعلوم والتقنية
المجلد (10)، العدد (37)، (نوفمبر2025)
ردمد: 3014-6266

Evaluation Of Surface Water Quality of Samples from Some Archaeological Cities in Northeastern Libya

Amani Abdugadar[1*], Habeb Mohammad[2] and Ayidah Mohammed Atiyahullah[3]

[1] Chemistry Department, Faculty of Arts and Sciences, The University of Benghazi, Al-Marj, Libya

[2] Department of Educational Resources, Faculty of Arts and Sciences, The University of Benghazi, Al-Marj, Libya

[3] Chemistry Department, Faculty of Sciences, The University of Benghazi, Benghazi, Libya

*Corresponding author: *amani.atiyalla@uob.edu.ly. ORCID: 0009-0001-5549-4808*

تقييم جودة عينات من المياه السطحية في بعض المدن الأثرية شمال شرق ليبيا

أماني عبدالقادر*[1]، حبيب محمد[2] , عايدة محمد عطيةالله[3]

[1] قسم الكيمياء، كلية الأداب والعلوم المرج، جامعة بنغازي، المرج، ليبيا

[2] قسم الوسائل التعليمية، كلية الأداب والعلوم المرج، جامعة بنغازي، المرج، ليبيا

[3] قسم الكيمياء ، كلية العلوم ، جامعة بنغازي ، بنغازي ، ليبيا

Received: 02-06-2023; Revised: 02-07-2023; Accepted: 17-07-2023; Published: 20-08-2023

Abstract:

The purpose of this study was to evaluate water quality in three different locations in north eastern Libya and was done by the assessment of some physiochemical and microbiological parameters. The chemical evaluation focused on parameters that indicates water quality including pH, alkalinity, heavy metal contamination, and conductivity. Additionally, biological status of these samples has been evaluated. The warning signs provided by authorities in the ancient city of Shahat indicated that Ain Apollo water is not potable. However, no more details were given specifying whether it is chemical, microbial, or other types of pollution. Because of the historical importance of the ancient Libyan cities, we chose to collect samples from three cities including Tolmeitha (Ptolemais), Benghazi (Hesperides/Berenice originally Euesperides), and Shahat (Cyrene). Results show that the lead metal exceeded the local and international limits. However, other metals including cadmium, nickel, copper, and iron were in the acceptable range. No acid rain was found in Tolmeitha, and the pH levels for the surface water samples were acceptable. As for bacteriological analysis, there was no indication for the presence of Total Coliform (T.C.F), Escherichia Coli (E.Coli), and Streptococcus Faecalis bacteria.

Keywords: Water quality, physio-chemical parameters, environmental evaluation, surface water pollution, Lethe River, Ain Apollo.

الملخص:

الغرض من هذه الدراسة هو تقييم جودة المياه في ثلاث مناطق مختلفة في شمال شرق ليبيا من خلال تحليل بعض الخصائص الفيزيائية والكيميائية والميكروبيولوجية. ركز التقييم الكيميائي على المعايير التي تدل على جودة المياه مثل الرقم الهيدروجيني (pH)، والقلوية، والتلوث بالعناصر الثقيلة، والتوصيلية الكهربائية. بالإضافة إلى ذلك، تم تقييم الحالة البيولوجية لهذه العينات. أشارت اللافتة التي وضعتها الجهات المسؤولة في مدينة شحات الأثرية إلى أن مياه عين أبولو غير صالحة للشرب. إلا أنه لم يتم تقديم تفاصيل إضافية لتحديد ما إذا كان التلوث كيميائيًا أو ميكروبيًا أو من نوع آخر. ونظرًا للأهمية التاريخية للمدن الليبية القديمة، تم اختيار ثلاث مدن لجمع العينات منها، وهي طلميثة (بطوليمايس)، بنغازي (هسبريديس/برنيكي، والتي كانت تُعرف أصلاً باسم أويُسْبِريديس)، وشحات (قورينا). أظهرت النتائج أن تركيز الرصاص يتجاوز الحدود المحلية والدولية المسموح بها، في حين كانت تركيزات المعادن الأخرى مثل الكادميوم، والنيكل، والنحاس، والحديد تقع ضمن الحدود المسموح بها. ولم يتم العثور على أمطار حمضية في طلميثة، وكانت قيم الرقم الهيدروجيني لعينات المياه السطحية ضمن المستوى المقبول. أن جميع العينات خالية من بكتيريا القولون الكلية (*T.C.F*)، أو الإشريشيا كولاي (*E. Coli*)، أو ستربتوكوكس البرازية (*Streptococcus Faecalis*).

الكلمات المفتاحية: جودة المياه, المؤشرات الفيزيوكيميائية, تقييم بيئي, تلوث المياه السطحية, نهر الليثي, عين أبوللو.

Introduction

Surface water pollution refers to the contamination of rivers and other open streams by health hazards including pathogens and chemicals (Singh, Andaluri, & Pandey 2022). Anthropogenic sources including agricultural and industrial activities contribute to surface water pollution (Igwe et al., 2017). Pollutants could across to groundwater since there is an interaction between surface water and groundwater (Sophocleous, 2002). Chemical and microbial pollution represent a threat to archaeological sites (Collepardi,1990; Patil et al., 2021; Sabbiom et al., 2025). The present work attempts to contribute to the available literature on the chemical composition and the environmental status of surface water in ancient cities in northeast of Libya. There is no sufficient research on the examination of chemical and biological parameters of surface water that surrounds ancient walls and monuments in eastern Libya.

The east of Libya, Al-Jabal Al- Akhdar district, hold some cities from the ancient world mainly Cyrene(Reynolds, 2016).The city of Cyrene contains momentum that was created mainly from limestone which can be affected by acids. Acid-rain is considered a problem when it comes in maintaining ancient cities(Camuffo, 1992). Ain Apollo is surrounded by the forest of Al-Jabal Al-Akhdar (the green mount), where individuals usually destroy environmental life by illegal charcoal production (Elshatshat & Mansour, 2014). We suspected that the acidity of Ain Apollo might be high due to illegal anthropogenic activities by neighboring cities in the district. We did not collect any rain water from Shahat or Benghazi. Thus, the only parameter available for evaluating acidity in these two cities was pH.

Our ultimate goal is to help conserve some of Libya's archaeological heritage by drawing attention to the environmental pollution and its impact on archaeological ancient cities. We chose three ancient sites: Tolmeitha (Ptolemais), Benghazi (Hesperides), and Shahat (Cyrene). The aim of this current study is two folds: (1) evaluating water quality not only for human

consumption but for the maintaining of historical sites. (2) Emphasizing the importance of these sites by conducting more research and get more of public and government attention to the environment.

We collected rainwater samples from Tolmeitha, water samples from the Spring of Apollo (Ain Shahat), and a water sample from the Lethe River in Benghazi. The purpose was to test water quality in these sites using parameters such as pH, alkalinity, and chemical as well as biological pollutants. These parameters not only affect public health in the nearby cities but also can accelerate the deterioration of ancient walls and monuments. We chose these three locations because of their historical and regional importance as three cities of the Pentapolis (Reynolds, 2016). The Lethe River is mentioned in Greek mythology as one of the five rivers of the underworld. Ain Apollo or the Spring of Apollo is located in the ancient city of Shahat which is indexed in the World Heritage by UNSCO (UNSCO, 2025). According to the literature, Ain Apollo was found to contain high levels of cadmium, arsenic, copper and zinc (Shaltami et al., 2017). However, we are interested in investigating the levels of other heavy metals and biological contaminants.

Materials and Methods

Sample Collection, Handling and Storage

Three representative water samples were collected from three archaeological locations in the north east of Libya. Samples for chemical and microbiological examination were collected on July of 2025. From every location, 2 different samples were collected and then mixed to get a representative sample, and the total volume was about one liter. Using the model (PHS-3C Precise PH meter), the pH was measured the same day the samples arrived to the laboratory. However, the pH was not measured on the site of collection and one reason for that is one of the sites was inside of a restricted military location, and the pH meter used in this study was a bench top type. Handling the samples and storage was done according to the guidelines of American Public Health Association, American Water Works Association, and Water Environment Federation (2023).

After measuring the pH, the samples were stored in a freezer and was sent to the Water Quality Control Department at The Man-Made River Authority for water quality assurance. Some tests were done inside of our laboratory at the College of Arts and Sciences, Al-Marge including pH, and qualitative analysis of cations to investigate what heavy metals are present in the samples.

Sample 1. This sample is rainwater and was collected from four different locations in the city of Tolmeitha in the Fall 2024. The sites were chosen to be close to the ancient city. The only test was done to this sample was measuring the pH of the four samples separately. Four plastic water bottles were kept in four private locations. We designate a wide clean glass funnel and attached it to the water bottles. The rain water was collected after the rain is over.

Sample 2. This sample was collected from the Lethe River in Benghazi. The pH was not measured directly after collecting the sample nor on the site because it is located in a restricted military location.

Sample 3. This sample was collected from the ancient city of Cyrene known today as Shahat. Ain Apollo in Shahat is located inside of the protected region in the ancient city. There is a sign indicating that this water is not drinkable. However, no clarification was provided indicating the type of contamination.

Procedures

Right after the sample collection, samples were sent to the laboratory where pH was measuring and then a qualitative analysis of cations was conducted to confirm the presence of heavy metals. Alkalinity and hardness experiments were done using titrimetric methods (Public Health Association, American Water Works Association, and Water Environment Federation, 2023). Heavy metal detection was done using spectrophotometric techniques in a private Laboratory (The Man-Made River Authority). Microbiological safety of the samples was done according to the traditional cultivation method at the laboratory.

Results

Chemical Parameters

Sample 1 represents the rain water sample that was collected from four different locations to test acid rain. The only test was conducted for this sample was the measurement of the pH. The pH for these sub-samples were as follows: 7.10, 6.67, 7.10, and 6.7. These results show that the rain in Tolmeitha is not acidic. Table 1 below shows the results for Sample 2 and Sample 3. The only heavy metal detected in both samples was lead (Pb) which exceeded the local and international limits. The pH values were a little higher than expected and that might be due to the nature of the geological area near to these locations (Goudarzi, 1970). The pH is not of a health concern; however, it is an important physiochemical parameter that determines acidity and basicity of water. It determines water acceptability of drinking according to the World Health Organization (WHO).

Biological parameters

In The Man-Made River Authority lab, investigation of biological pollutant was conducted. Total Counts (T.C) for sample 2 and sample 3 were 770.1 and 16.8 per 1.0 mL of the samples respectively. Other bacteria including Total Coliform (T.C.F), Escherichia Coli (E.Coli), and Streptococcus Faecalis were not found in our samples. These biological results indicated that there is no threat or concern on the archaeological sites targeted by this study.

Table (1): Chemical parameters.

Parameters	*Sample 2 (The Lethe River)*	*Sample 3 (Ain Apollo)*	*WHO Limits*
pH	8.79	8.29	6.5-8.5
Conductivity (E.C)	3970	3430	
Total Dissolved Salts (TDS)	2580	2230	1000
Total Hardness (mg/L as $CaCO_3$)	680	440	>180 very hard water
Calcium Hardness (mg/L as $CaCO_3$)	260	120	
Magnesium Hardness (mg/L as $CaCO_3$)	420	320	
Total Alkalinity (mg/L as $CaCO_3$)	320	160	
Iron (Fe) in mg/L	0.00	0.005	0.3
Cadmium (Cd) in mg/L	N. D	N. D	0.003
Nickel (Ni) in mg/L	0.001	0.002	0.07
Copper (Cu) in mg/L	0.39	0.001	2
Lead (Pb) in mg/L	0.022	0.031	0.01

Discussion

In Sample 1, four different sites might not be representative for the entire city. Thus, authorities should designate monitoring sites near the archaeological cities to detect acid rain. The current study was not large enough to be generalized to the entire city of Tolmeitha. However, the preliminary results we got could be a positive indication.Shahat and Benghazi could be monitored as well for acid rain.

Since the results we got in this current study are slightly different than the study by Shaltami et al., 2017, regarding cadmium and copper, further research to monitor the levels of heavy metals through years is still needed. Also, no investigation was carried out in regards of organic pollutants including pesticides nor inorganic contaminants. Further research is needed to identify all possible contaminants present in these locations.

Future Work

Measuring pH was not done at the site of collection. That might have contributed to a slight difference since the pH is temperature dependent. We were only interested in cations present in samples. However, anions can affect water quality as well. In future work, anions such as sulphates and nitrates This study could have been enlarged by including rain water would be tested. from Shahat and Benghazi. However, we did not have access to private locations in these cities that enable us to collect rain samples. In addition, acid rain should be monitored in several locations by local research centres. Regarding microbiological examination, cyanobacteria represent a threat to archaeological sites (Crispim et al., 2003; C. Gaylarde, 2020). However, no testing was done to investigate the presence of these bacteria. In future work, cyanobacteria would be tested.

Conclusion

Biological and physiochemical evaluation of surface water samples from the eastern of Libya was done using standard methods summarized by American Public Health Association et al., 2023. This investigation was conducted not only for public health but for the preservation of the archaeological sites in the ancient cities. The results we got suggested a positive indication that the chemical and biological contamination are not a threat to the archaeological cities. Further research should be conducted to support the current study and for monitor the chemical and biological parameters overtime.

Conflict Of Interest. This research article is devoid of any competing interests .

Funding Information. This work is unfunded.

Authors' Contributions. The authors contributed equally in data collection, analysis, and reporting the results.

Acknowledgements

The authors are grateful to the Water Quality Control Department at The Man-Made River Authority for water quality testing.

References

American Public Health Association, American Water Works Association, Water Environment Federation

(2023). Lipps WC, Braun-Howland EB, Baxter TE, eds. Standard Methods for the Examination of Water and Wastewater. 24th ed. Washington DC: APHA Press.

C. Gaylarde, C. (2020). Influence of environment on microbial colonization of historic stone buildings with

emphasis on cyanobacteria. *Heritage*, *3*(4), 1469-1482.

Camuffo, D. (1992). Acid rain and deterioration of monuments: how old is the phenomenon?. *Atmospheric*

Environment. Part B. Urban Atmosphere, *26*(2), 241-247.

Crispim, C. A., Gaylarde, P. M., &Gaylarde, C. C. (2003). Algal and cyanobacterial biofilms on calcareous

historic buildings. *Current microbiology*, *46*(2), 0079-0082.

Collepardi, M. (1990). Degradation and restoration of masonry walls of historical buildings. *Materials and*

Structures, *23*, 81–102. Retrieved from: https://doi.org/10.1007/BF02472568

Elshatshat, S., & Mansour, A. (2014). Disturbance of flora and vegetation composition of Libya by human

impacts: Costal Region of Al-Jabal Al-Akhdar area as model. *Advances in Applied Science Research, 5*(5), 286-292. Retrieved from: https://www.primescholars.com/articles/disturbance-of-flora-and-vegetation-composition-of-libya-by-human-impactscostal-region-of-aljabal-alakhdar-area-as-model.pdf

Goudarzi, G. H. (1970). *Geology and mineral resources of Libya--a reconnaissance* (Vol. 660). US Government

Printing Office. Retrieved from: https://pubs.usgs.gov/pp/0660/report.pdf

Igwe, P. U., Chukwudi, C. C., Ifenatuorah, F. C., Fagbeja, I. F., & Okeke, C. A. (2017). A review of

environmental effects of surface water pollution. *International Journal of Advanced Engineering Research and Science*, *4*(12), 237340.

Patil, S. M., Kasthurba, A. K., & Patil, M. V. (2021). Characterization and assessment of stone deterioration on

Heritage Buildings. *Case Studies in Construction Materials*, *15*, e00696.

Reynolds, J. (2016). Pentapolis. *Oxford Classical Dictionary*. Retrieved 18 Jul. 2025, from https://oxfordre.com

/classics /view/10.1093/acrefore/9780199381135.001.0001/acrefore-9780199381135-e-4845.

Sabbiom, C., Zappia, G., Gobbi, G., &Pauif, M. G. (2025). *Deterioration of ancient and modern buildings*

materials due to environmental factors (Vol. 4). WIT Press.

Shaltami, O. R., Fares, F. F., Salloum, F. M., Elghazal, R., & El Feituri, M. A. (2017). Assessment of surface

water quality for drinking and irrigation purposes in Ain Apollo, Shahat city, NE Libya. In *2nd Libyan Conference on Chemistry and its Applications (LCCA-2), Benghazi, Libya, Proceeding Book* (pp. 127-134).

Singh, R., Andaluri, G., & Pandey, V. C. (2022). Cities' Water Pollution—Challenges and Controls. In V. C.

Pandey (Ed.), *Algae and Aquatic Macrophytes in Cities* (pp. 3-22). Elsevier. https://doi.org/10.1016/b978-0-12-824270-4.00015-8

Sophocleous, M. (2002). Interactions between groundwater and surface water: the state of the science.

Hydrogeology journal, *10*(1), 52-67.

UNSCO. (2025). World Heritage List. Accessed on July 2025. Retrieved from:https://whc.unesco.org/en/list/

World Health Organization (WHO). Retrieved on July 2025 from: https://iris.who.int/bitstream/handle/10665/352532/9789240045064-eng.pdf?sequence=1&isAllowed =y#page=195