Journal of ENVIRONMENTAL Treatment Techniques

J. Environ. Treat. Tech.
ISSN: 2309-1185

Journal web link: http://www.jett.dormaj.com
https://doi.org/10.47277/JETT/9(2)514

Inland Water Quality Study of Mount Lebanon Range in the Region of Middle East

Adnan Falah *, Husein Yemendzhiev, Valentin Nenov

Department of Water Treatment, Faculty of Technical Sciences, Burgas "Prof. Asen Zlatarov" University, Burgas, Republic of Bulgaria

Received: 29/01/2021 Accepted: 20/02/2021 Published: 20/06/2021

Abstract

Lebanon is a country with several rivers and renewable water resources compared to other neighboring countries. Lebanon has several major rivers that are originating from mount Lebanon. Rivers in-fact entering to the Mediterranean Sea by passing about 20-30 km from their sources at mount Lebanon through the coastal zones (west of Lebanon). Sannine Aquifer at mountain district at an altitude of 1,500 m, is the major inland fresh water, groundwater, source for the coastal area and servicing many lands and cities. In this research, the quality of inland water, fresh-water resources of Mount Lebanon range in the Middle East region, were studied. Water samples were collected from different places among Lebanese mountains. The collected samples were analyzed to measure the average concentration of selected Physico-chemical parameters such as pH, electrical conductivity, total dissolved solids, total alkalinity, total hardness, magnesium, etc. Many other inland water sources (wells) are also existing, however, many of them are saline and are not suitable for direct domestic use or even for irrigation. The study approach water quality assessment and level of pollution and potential impact to seawater of Mediterranean basin since there is a direct connection with the Seawater at each range. The average of electrical conductivity value of fresh water found to be slightly high, TDS value were moderately high while phosphate recorded at high level. Other data assessment show that the quality of inland water has to be monitored since it is deteriorating due to uncontrolled usage.

Keywords: Inland water, Quality of water, Mount Lebanon, Middle East, Fresh water

1 Introduction

Inland water (fresh water) has the most attentiveness, valuable and strategic natural resource in the Middle East in general and specifically in Lebanon. It is fundamental for society, economic growth and sustainability of the environment. About 2.50 percent of all earth water is fresh and nearly thirty percent of it is potentially available in a form of groundwater [1]. The management of Inland water, freshwater reserves is becoming more important ever and essential for the guardians of natural resources. Generally, groundwater has higher quality feature and less affected by tough seasonal effects with steady temperature, low storage costs and it is available in large volumes. An increase of usage of groundwater leads deterioration and contamination of surface water quality standard. So that, an increase of population and economic growth have direct impact of the quality of inland water in-fact, high removal costs, high mineral concentration, the potential of land sinking as well as danger of seawater disturbance, equilibrium are examples of these un-managed activities. The coastal region of Lebanon has a Mediterranean climate where a wet winter and a hot with dry summer is the main characteristic of this climate. The precipitation happens in the period between October and April which is represents seven months of the year. In winter the atmospheric pressure is low originating from southern Europe region cause rich rainfall at the coast while in summertime, period ranges from May to September and the pressure record is fairly high with no rain noted. The main districts of mount Lebanon at Bekaa, Zahleh and Hosh El-Harimi are the fertile land passage, separating the Mount Lebanon and Anti-Lebanon ranges, drained to the North by the Aassi River (or Orontes) and to the South by the Litani River. The wide Bekaa area itself extends for 4,167 km^2 and represents 40 % of the national territory. Morphological and geological features are the main factors that make Lebanon a country with rich and renewable water resources compared to other nearby countries [2-6]. The main water sources of Mount Lebanon range come from Inland water in the form of springs, rivers and underground aquifers. The domineering factor of the underground water is the combination of geological structures and composition. Inland water in Lebanon is serving more than 2,000 major springs with discharge rate above 30 litters per second originating mostly from the karst mount Lebanon range. Urban demands are using the freshwater in the areas from mount Lebanon to the coastal areas. The flows of these springs are usually characterized by a high seasonal variability during a single water year (September-August) and inter-annual variability between dry and wet years. The total surface capacity from springs is estimated to 1.2 billion m^3 on an average year while about 0.2 billion m^3 being available during the dry summer period. Springs and other inland water

***Corresponding author:** Adnan Falah, Department of Water Treatment, Faculty of Technical Sciences, Burgas "Prof. Asen Zlatarov" University, Burgas, Republic of Bulgaria. E-mail: adnan@falahpwp.com

sources are currently highly exploited. [7-9]. Figure 1, illustrate the general view of selected sits of sample collections of inland water taken from Oyun-Orgosh (north), Rayfoun, Polonia, Tarchish, Zahleh (central) and Hosh El-Harimi (east) of mount Lebanon range in the Region of Middle East.

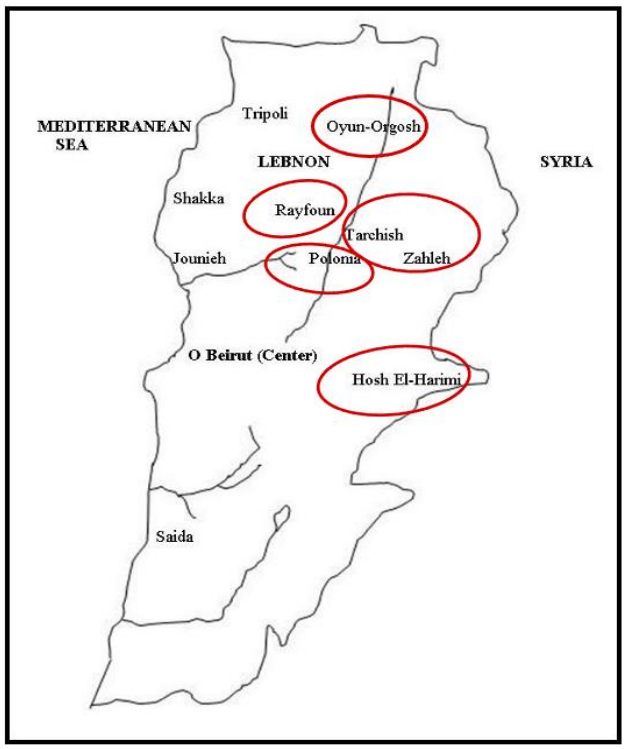

Figure 1: General view of selected sits of sample collections of inland water taken from Oyun-Orgosh (north), Rayfoun, Polonia, Tarchish, Zahleh (central) and Hosh El-Harimi (east) of mount Lebanon range in the Region of Middle East

2 Materials and Methods

Inland water samples of fresh water from selected districts of Rayfoun, Bekaa (Hosh El-Harimi area), Oyun-Orgosh, Zahleh (Tarchish and Talshiha areas) and Dhour El-Choueir (Polonia area) of major wells, springs and rivers at mount Lebanon range were directly collected in triplicate meaning three bottles for each sample from the source with different depths equal to 1, 2 and 4 meters. Water samples stored properly in a plastic bottle, samples are collected-in and analyzed within eight hours of collection, Physico-chemical parameters like pH, temperature (ºC), electrical conductivity (microsiemens per centimeter, µS/cm), dissolved oxygen, total dissolved solids (TDS), alkalinity, salinity and hardness measured in ppm were analyzed using portable device called "Multi Parameters Portable Water Quality Monitor "PWQM" Wagtech brand with model WT9122 that is capable of performing all tests listed above [10-12]. The average concentration values of inland water samples were presented in a table and the data is reflecting the average concentration values of those water samples taken at multiple sites of each district.

The Calibration of this multi-tester was done at the beginning of every sampling day using standard calibration solutions for pH and conductivity to ensure reliability of the test results and quality. The tester was well dipped by distilled water after each testing process. The measuring cup was dipped few times with each water sample to be tested. Prior to each sampling process, adequate volume of water was removed first by pumping to ensure that standing water either in the well or in pipes was discarded. UV/Vis spectrophotometer with appropriate reagents and test Kits from Merck Spectroquant were used to determine the concentration (ppm) of Inorganic substances like Chloride, Nitrogen, Copper (free and total), Manganese, Aluminum, Iron, Nitrate, Sulfate and Phosphate in water at specific wavelength (λnm). Mohr method was used for chloride concentration. Different parameters were selected, presented and reported as an average concentration. All other chemicals and reagents used for water analysis experiment were of analytical grade [13, 14].

3 Results and Discussions

The minerals of inland water of Mount Lebanon range link the land ecosystems with coastal sea areas of Mediterranean Sea via natural-elements transport system. The unavoidable force of gravity moves elements from mountains to sea level through river networks over geologic time. During this passage, elements may be suppressed in lakes or springs sediments, consumed by tissues of living organism, fish and insects or even transformed in a form of gaseous compounds leading to avoiding or suspending their downstream transport. Samples of fresh water were collected from different districts at mount Lebanon and were analyzed according to the standard protocols. Average concentration data and result of inland water quality studies (mainly rivers) from districts of Rayfoun, Bekaa (Hosh El-Harimi), Oyun-Orgosh, Zahleh (Tarchish and Talshiha areas) and Dhour El-Choueir (Polonia area) are listed in table 1.

Table 1: Analysis of Physico-Chemical properties and average concentrations of selected inorganic substances of inland water samples of fresh water from selected district of major wells, springs and rivers at mount Lebanon range in the region of Middle East

Test Name Concentration (ppm)	Rayfoun District	Bekaa District (Hosh El-Harimi)	Oyoun-Orghosh District	Zahle District (Talshish a & Tarchich)	Dhour El-Choueir District (Polonia)
pH	9.87	8.29	8.12	7.43	8.12
Sp. Conductance (µs/cm)	1,211.01	960.12	989.01	1,001.32	1,000.00
Total Dissolved Solid (TDS)	657.11	452.44	599.00	540.22	608.10
Total Alkalinity	92.2.00	251.33	312.00	80.54	87.78
Total Hardness	101.43	318.22	112.00	91.91	99.23
Magnesium (Mg^{2+})	31.51	35.98	29.30	22.11	19.50
Copper (free - Cu^{2+})	0.00	0.01	0.00	0.01	0.00
Copper (Total - Cu^{2+})	0.00	0.04	0.02	0.00	0.00
Iron (Fe^{3+})	0.00	0.00	0.02	0.03	0.00
Chloride (Cl^-)	28.01	99.10	20.00	20.98	35.00
Sulfate (SO_4^{2-})	144.10	77.01	137	131.80	122.00
Salinity	495.30	504.11	500.4	422.15	501.40
Nitrogen (N)	0.10	0.52	0.30	0.10	0.07
Nitrate (NO_3^-)	3.10	2.44.11	2.98	2.61	2.40
Phosphate (PO_4^{3-})	10.40	47.09	20.3	46.41	39.10
Manganese (Mn)	0.00	0.01	0.00	0.00	0.00
Aluminum (Al)	0.05	0.00	0.05	0.02	0.00

Based on result's assessment, it was found that fresh water has an average pH at 8.37 where conductivity recorded at 1,032.29 µS/cm. the average concentration of total dissolved solids of inland water in mount Lebanon has value of 571.37 ppm so that hardness value as $CaCO_3$ was found to be 144.56 ppm where

magnesium (Mg^{2+}) recorded at 27.68 ppm. Finding the concentration of Ca^{2+} and Mg^{2+} in water, are essential indicators, it is equivalent to level of hardness in water sample, it is also reflecting the nature of the geology in the district of the stream. Hardness concentration value of 200-300 ppm as $CaCO_3$ is labeled as hard water with bitter taste. The recorded electrical conductivity value of fresh water found to be slightly high at 1,032.29 µS/cm, this could be unsafe to plants or living organism. Moreover, substances such as copper, iron, chloride and aluminium have average concentration values of 0.01, 0.01, 40.62 and 0.02 ppm respectively and seems within the standard level. Phosphate concentration shows average at 32.66 ppm while sulphate is 122.38 ppm and finally, the average Nitrogen concentration was recorded at 0.22 ppm and 2.77 ppm as NO_3-N [15, 16].

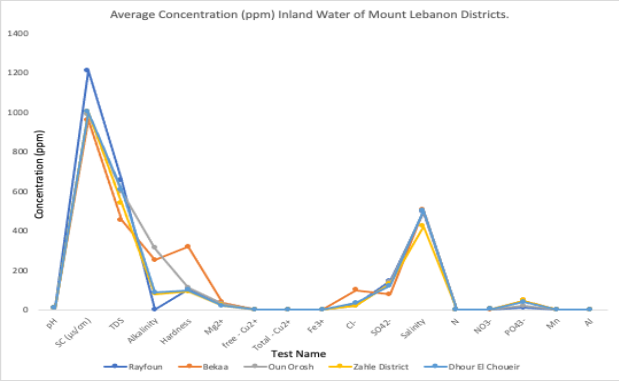

Figure 2: Comparative illustration of average concentrations of inland water samples of multiple districts in mount Lebanon range

A comparative illustration of average concentrations of inland water samples of multiple districts in mount Lebanon range presented in figure 2 and 3. These figures (Figures 2 and 3), show the average concentrations trend of fresh water chemical species decrease in the following order: Rayfoun district, Dhour El-Choueir district, Bekaa district, Oyun-Orgosh district and finally Zahleh district. In general, Inland water have their sources in mount Lebanon and there is a continuous move about 20-30 km to the sea (Mediterranean Sea; basin). Even though there is a short path to the sea, they are exposed to severe pollution. Damping such solid and other un-needed wastes at different sites, cities as well as industrial wastewater discharge into nearest points to the rivers and springs are the main causes of this pollution thus, indicator of pollutants is reflected from measurement of bacterial by product activities such as concentration of ammonia, nitrite and sulfide [17-19].

Seawater pollution affects living organisms as fish that transfer heavy metals into human. Moreover, skin diseases were also observed in people swimming in polluted sites. The main concerns facing the civilians with inland water, well-water in particular, is high value of hardness and salts as many of wells are close to underground waste tanks in-fact, the waterbed causing a reservoir of bacterial pollution. In general, the walls of waste tanks are usually made of stones in which this accelerates infiltration of waste into nearby soil sites. Fortunately, now a day the waste tanks are constructed with concrete or even with high technologies and control units. Economically, water resources are fundamental and important sector to Lebanese country. A lot of potable water purification factories are selling drinking water locally and internationally especially to nearby countries. Inland water such as rivers are passing though plains, historical cities and sites reaching at their final destination of Mediterranean Sea that really attract many tourists [20-23].

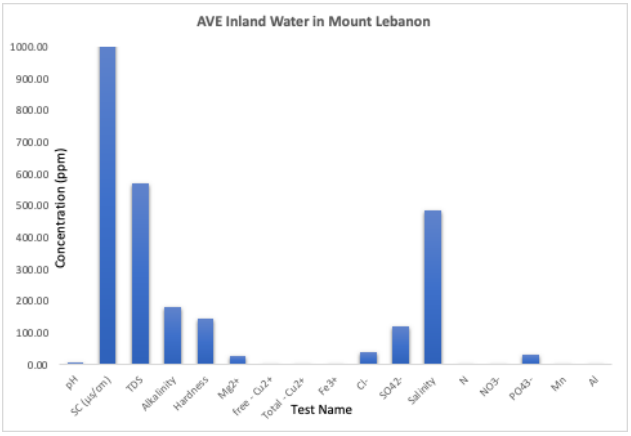

Figure 3: Comparative values of average concentrations of inland water samples of multiple districts in mount Lebanon range

Several industries are located on the sides of rivers using fresh water but, it was seen that few of these localized shop industries returning their wastewater directly into it. This has an opposing effect; it has caused shortages in supplying water to Lebanese people and costing money for water treatments. The Lebanese water quality in general is deteriorated year after year with increasing population and unimposing regulations that stop dumping solid or liquid waste into rivers, lakes and springs. Bekaa, Zahleh and surrounding districts at mount Lebanon, relies about 90 percent on groundwater resources for agriculture and domestic use. Based on data presented above, it is found that chemical constituents of Bekaa springs water concentration are below the upper permissible limits imposed by USA-EPA (Environmental protection agency) and WHO (World health organization) for drinking water. Value of 400 ppm, for sulfate concentration of drinking water is considered acceptable [24-26]. The selection of districts at mount Lebanon was based on high traffic attraction and strategics importance matter of the district in-fact, the results were considered as an average concentration of the sample from multiple places of the district. The district Oyoun-Orghosh which is situated on the eastern side of Qornet es-Sawda of mount Lebanon, it is only 25 Km away from the Cedars, the most famous Lebanese area for tourism, heritage, history and economics. This stunning area surrounded by rough mountain hills is full of ponds and springs called Oyoun. Furthermore, the ponds, springs and rivers accumulated and fed by snowmelt of Jabal al-Mekmel and Qornet es-Sawda, the highest mountain in mount Lebanon with more than 3,000 Km attitude. On the other hands, Bekaa including Zahle and Hosh el-Harimi districts, is Lebanon's largest province with largest area of arable land to date, it has a moderate dry and warm climate in summers and wet to snowy winters (Mediterranean climate). The Bekaa is located about 30 km east of Beirut Capital. The deterioration of inland water at Bekaa is the hot topic for many authorities and researchers. Low quality of water supplies would severely affect the economy of the province since Bekaa is the agricultural land with a fertile soil and low population compared

to other provinces. Fresh water of Dhour El-Choueir district of mount Lebanon is lies slightly north of the main Beirut - Damascus highway (International border) with overlooking the city of Beirut and the Mediterranean Sea. The ecological location of this district is amazing, it is well-developed with summer resorts and attractions which is known for its outstanding fresh air and environment.

On the other side, Litani river is the important water resource in southern Lebanon which is rises in the fertile Bekaa of west of Baalbek, the historical city of Bekaa province, and empties into the Mediterranean Sea from the north. The costal line of Lebanon expands over 210 km in length in which industrial, commercial, entertainments, beeches, resorts and financial activities along with major Lebanese cities are generally concentrated. Mixing of inland water with the sea with slight managed aspects, surpassed the acceptable limit of water quality which requires more attention to sustain desired quality of water. Lack of treatment from the sources such as Litani river and other inland water entering the seawater led to deterioration of seawater thus, seawater continue to invade inland which overlaps with areas of high population densities. Over construction of wells with focusing on high usage of such areas have negative impact to residents to access good quality of water since the groundwater won't be fresh as supposed to be. Such access of low quality of water might became more serious if people continue to ignore the standards protocols of the groundwater like the current state behaviour [24-31].

4 Conclusions

Referring to the results, data comparison and standards in literatures, it is advised to continue monitoring as well as water quality review of inland water at mount Lebanon. Data assessment shows the quality of fresh water getting poor to very poor-quality trends in-fact, action is required toward water management. Continuous checking, treating contaminated water and reduce sources of pollution is highly recommended however, water quality for drinking and irrigation use to comply with those standards regulations. This comparative review study is aiming to provide a useful information and awareness for future interpretations and better management.

Aknowledgment

Authors would like to present their thankfulness for the support of two Projects: 1) Clean technologies for sustainable environment – water, waste, energy for circular economy (Clean & Circle) for the development of a Centre of Competence. Project BG05M2OP001-1.002-0019 and 2) Universities for Science, Informatics and Technologies in e-Society (UNITe) Project BG05M2OP001-1.001.

Ethical issue

Authors are aware of, and comply with, best practice in publication ethics specifically with regard to authorship (avoidance of guest authorship), dual submission, manipulation of figures, competing interests and compliance with policies on research ethics. Authors adhere to publication requirements that submitted work is original and has not been published elsewhere in any language.

Competing interests

The authors declare that there is no conflict of interest that would prejudice the impartiality of this scientific work.

Authors' contribution

All authors of this study have a complete contribution for data collection, data analyses and manuscript writing.

References

1 Government of Canada. Water resourses and groundwater. website: https://www.canada.ca/en/environment-climate-change/services/water-overview/sources/groundwater.html
2 Hughes TP, Graham NA, Jackson JB, Mumby PJ and Steneck RS. Rising to the challenge of sustaining coral reef resilience. Trends in Ecology and Evolution. 2010; 619-680.
3 Kabbani A, Hammud H and Itani H. Spring Water of Lebanese Bekaa Valley. Ultra Science - Dimension of Pollution. 2001; 1, 48.
4 Kabbani A, Hammud H, Afifi N. and Mounzer A. Dissolved Oxygen and Water Hardness in Iklemm El-Kharroub and South Lebanonў. International Conference on Research Trends in Science and technology. RTST. 2002; 109-113.
5 Pimentel, D. Water resources: agriculture. the environment and society. Bioscience 1997; 47(2): 97–106.
6 Srour S, Sleiman B. Water management plan for the Litani River and Karoun reservoir. Workshop on Pollution in the Litani River and Lake Karoun, and Environmental Problems in the Western Bekaa and Rashaya. Lebanon.1998.
7 Hammud H. Water Quality Studies of Damour and Litani. Le Premier Colloque Franco Libanais sur L'eauet La Sante, Beirut, Lebanon. 1998.
8 Falah A, El-Khatib R, Yahfoufi N. Water Quality Survey of Arabian Peninsula in Regions of Dubai in the United Arab Emirates. Canadian Journal on Chemical Engineering & Technology. 2012; 1-6.
9 Jaber BA. Development and Use of Non-conventional Water and Appropriate Technology to Manage Groundwater in the ESCWA Countries. Manama Bahrain Economic and Social Commission for Western Asia and New York USA. 1997; pp. 36–42.
10 Nimee M. The effects of agriculture on pollution in the Litani watershed and Karoun Lake, and the use of irrigation water. Workshop on Pollution in the Litani River and Lake Karoun, and Environmental Problems in the Western Bekaa and Rashaya. Lebanon.1998.
11 McDonald T. Nearly 200 water fountains in Jersey City schools contain lead above fed standards. The Jersey Journal. 2013.
12 ESCWA Economic and Social Commission for Western Asia. Survey of economic and social developments in the ESCWA region 1997–1998. United Nations New York USA. 1998; 5/194 pp.
13 FAO Food and Agriculture Organization of the United Nations. Irrigation in the Near East in figures. FAO Rome Italy. 1997; 137 pp.
14 Gregersen HM, Draper S, Elz D. People and trees. The role of social forestry in sustainable development. World Bank, Washington DC USA. 1989.
15 Tuijil W. Improving water use in agriculture. Experience in the Middle East and North Africa. World Bank, Washington, DC, USA. 1993; 158 pp.
16 ESCWA Countries, Manama, Bahrain. Economic and Social Commission for Western Asia and New York USA. E/ESCWA/ENR/WG.3/CP.3. 1997; pp. 36–42.
17 Hamdan F. Waste trade in the Mediterranean: toxic attacks against Lebanon. Green Peace Mediterranean Office. Malta. 1995.
18 Hammud H. Determination of Soil Pollution as a Result of Solid Waste. Unesco Chair for Environmental Protection. Homos – Syria 1998.
19 Hammud H. Determination of Heavy Metals Toxic to Plants in Lebanese water and Soil. Unesco Chair for Environmental Protection. Homos – Syria. 1999.

20 Hammud H. Quality and Pollution Studies of Water in Lebanon. Ultra Science – Dimension of Pollution. 2001;1, 19.
21 Eaton A, Clesceri L, Greenberg A and Franson M. Standard Methods for the examination of water and waste Quality. APHA. 1995.
22 Kabbani A, Hammud H, Afifi N and Mounzer A. Dissolved Oxygen and Water Hardness in Iklemm El-Kharroub and South Lebanon. International Conference on Research Trends in Science and technology RTST. 2002; 109-113.
23 OWOW - US EPA. Coral Reefs. From Office of Wetlands. Oceans and Watersheds – USA. 2005 and 2012.
24 Shabib M, Al-Abed I, and Hellyer P. United Arab Emirates. A new perspective London. Trident Press. 2001.
25 Henderson JC. Tourism in Dubai: overcoming barriers to destination development. International Journal of Tourism Research. 2006; 87-99.
26 Rezai H, Wilson S, Claereboudt M, and Riegl B. Coral Reef Status in the Ropme Sea Area. Arabian/Persian Gulf, Gulf Of Oman and Arabian Sea in Status of Coral reefs of the World. Townsville Australian Institute of Marine Science. 2004; 155-170.
27 Pidwirny M. Fundamentals of Physical Geography. 2nd edition. University of British Columbia Okanagan Canada. 2006.
28 Kruger SN. A Blue Revolution: The Global Crisis of Water Quality and Accessibility. 2013.
29 Kabbani A, Hammud H, Itani H and Itani H. Spring Water of Lebanese Bekaa Valley. Ultra Science - Dimension of Pollution. 2001; 1-48.
30 Integrated Water Resources Management in CAMP. ARD. 2003.
31 Rohmann SO, Hayes JJ, Newhall RC, Monaco ME and Grigg RW. The area of potential shallow-water tropical and subtropical coral ecosystems in the United States. Coral Reefs. 2005; 370-383.