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Water Quality Determination and Classification Based on Physio-Chemical and Biological Characteristics of Kaam Spring, Zliten, Libya

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ABSTRACT

The aim of this study is to determine and to classify the water quality of Kaam Spring based on physio-chemical and biological Characteristics. A total number of 10 samples were collected in September of 2019. Tests have included physio-chemical parameters: (DO, BOD, COD, TDS, EC, pH, Salinity, Temperature, Turbidity, $NH3^{-}$ N, PO_4^{3-}, Velocity, Cl^{-}, F^{-}, SO_4^{-}, $HCO3^{-}$, $NO3^{-}$, Na+, K+, Mg++, and Ca+) and heavy metals (As, Cr, Cu, Mn, Ni, Pb, and Zn). Over and above, one biological parameter (Testing of Coliforms) was achieved. Water quality was determined by comparing results with the Libyan Standards and the international parameter limits set by the World Health Organization (WHO) of drinking water and classified according to the Water Quality Index (WQI). Results have revealed that the concentrations of COD for all points were extremely higher than the permissible limits with the highest concentration of 4235 mg/L recorded in point 4. Electrical Conductivity (EC) values were also slightly higher than the desirable limits, which are likely due to the contact between spring and seawater. The turbidity index was higher than the permissible limits due to anthropogenic activities taking place. Velocity values were almost zero in all sampling points making the spring stagnant. Heavy metals of As and Pb have shown high concentration meaning that the spring is exposed to industrial waste. Testing of coliforms has shown positive readings; indicating that water is contaminated with feces while all other parameters measured were within the acceptable levels. WQI calculations revealed that the spring has a moderate quality of water and extensive treatment is required.

1. Introduction

The Significance of this study comes due to the scarcity and the limitation of water resources in the State of Libya, as quality and availability of water are two substantial factors to ensure sustainable development in various sectors.

Nevertheless, the quality status of water surfaces is continuously degrading due to the anthropogenic activities taking place for development needs. The health of any water body is usually determined according to physio-chemical and biological characteristics and measurements. The determination of water quality can help in minimizing or avoiding the causes of water pollution in order to improve quality. Although those scientific measurements are involved in defining water quality, it is not a simple thing to say that water is in a good or bad condition. Therefore, the determination is typically made relative to the purpose of water usage. Good water quality is essential to a healthy human life and naturally a healthy marine ecosystem. (Chaudhry & Malik, 2017).

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2. Study Area

Kaam Spring (also known as Cevannes Spring of Cinyps River during the Phoenician era) is a coastal freshwater spring that rises from the abdomen of the earth from a hill called (Tal Al-Hessan) to merge with and to cast into the Mediterranean Sea. It is located in the northwest of the city of Zliten (32.521359º N, 14.445511º E) near Zliten-Al-Khums borders. The spring is about 140 km far from the capital city of Tripoli. It extends for about 1.7 km in length with an average width of about 105 m covering an area of approximately 178.5 km^2 and an average of 8.9 m in depth containing about 1588.65 km^3 of water. The spring was used to supply farmers with water needs for agriculture activities (about 120 farms). Furthermore, the spring is considered to be the largest in the western part of Libya (about 1.7 km long) and also considered to be a touring direction for many people as it locates between two important cities on the western coast (Zliten and Al-Khums), the density of trees on its edges and also because of its biodiversity.

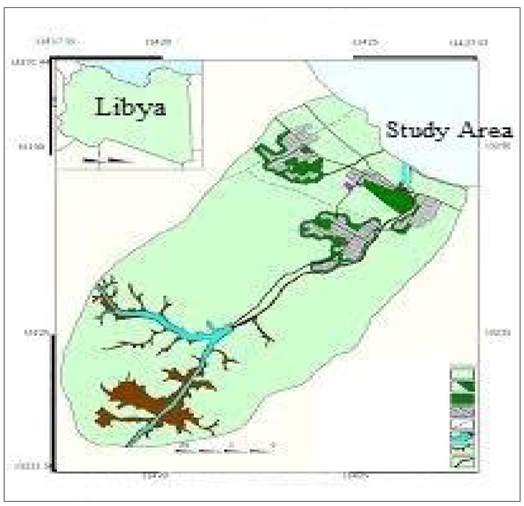

Figure 1. *Study Area (Ighwela, 2016)*

3. Methodology

A couple of site visits were carried out before sampling along the stretch of the spring to identify and to observe suitable sampling points on both edges. A total number of 10 samples were collected based on ease of accessibility and divided into ten-tenths using Geographical Positioning System (GPS) according to the length of the spring (every 170 m). All 10 samples were collected from the middle of the spring in order to avoid inconsistencies in readings. The collection of the representative samples was done using the Van-Dorn water sampler to ensure accuracy in terms of Oxygen readings. Some measurements were directly conducted on-site right after sampling using the Multi-Probe system (ProDSS model) while further analyses were done in the laboratory. The spring was also profiled, as no data were available about its length, width, and depth due to a lack of studies. The average reading for each dimension was recognized. The velocity of water was also measured using the Digital Water Velocity Meter (flow probe). Measurement of Heavy Metals was conducted using Inductively Coupled Plasma (ICP). Moreover, the test of Coliforms was also achieved using the total coliform indicator. Data obtained were compared with the Libyan Standards and the international parameter limits set by the World Health Organization (WHO) of drinking water and classified according to the Water Quality Index (WQI).

Figure 2. *Sampling & Analyzing*

4. Results and Discussion

4.1. Physical and Chemical Characteristics

Physical and chemical parameters were measured for each point (Table 1). The values obtained were compared with the Libyan Standards and the international parameter limits set by the World Health Organization (WHO) of drinking water. Dissolve Oxygen (DO) values fall within the permissible limits for all sampling points ranging (4.2 – 6 mg/L). BOD and COD readings are an indicator of the presence of degradable and non-degradable pollutants in water. Values of BOD and COD ranged from 0.97 to 2.40 mg/L and from 193 to 4235 mg/L respectively, reflecting the presence of different types of wastes (industrial and agro-based) discharged from pointed and non-pointed sources. TDS concentrations for all samples collected fall in between 68.7 – 79.3 mg/L, making the spring water considered as freshwater TDS > 100 (Rozelle & Wathen, 1993). Electrical conductivity (EC) scored the highest reading in point 10 at 1550 µS/cm as it is the nearest to the seawater which means that the spring is exposed to pollution as stated by Harun et al., (2010). The range of pH values makes the water slightly acidic as all pH values < 7 which might be interpreted due to the high values of Ammonia and Phosphate concentrations (0.4 – 1.4) mg/L and (0.5) mg/L respectively (Wurts, 2003). A high concentration of Ammonia and Phosphate may also encourage the growth of algal blooms and reduces the amount of Dissolved Oxygen in water (Sen *et al.,* 2013). The lowest temperature degree recorded was at 29 º C while the highest was at 36.8º C.

Table 1. *Physio-Chemical Parameters (Point 1 – 10)*

Parameter	P 1	P 2	P 3	P 4	P 5	P 6	P 7	P 8	P 9	P 10	Libyan Standard	WHO
DO (mg/L)	5.8	5.0	6.0	6.0	6.0	6.0	5.3	5.1	4.2	4.6	-	5-8
BOD_5 at 20ºC (mg/L)	1.46	1.00	2.10	2.25	2.06	2.40	1.20	1.10	0.98	0.97	0	6
COD (mg/L)	193	178	4157	4235	2789	2969	156	168	269	245	-	10
TDS (mg/L)	73.4	71.5	71.5	77.3	78.0	68.7	77.3	78.0	78.0	79.3	1000	600
EC (µS/cm)	1220	1180	1170	1390	1450	1080	1420	1460	1520	1550	300	1400
pH	5.7	5.6	5.5	6.0	6.4	5.1	6.0	6.0	6.6	6.8	6.5-8.5	6.5-9.2
Salinity (%)	0.05	0.05	0.06	0.05	0.06	0.06	0.05	0.06	0.06	0.04	-	10
Temp (º C)	29.4	29.0	36.8	30.1	29.9	29.6	30.1	30.3	30.2	30.4	25	40
Turbidity (NTU)	24.0	22.4	37.0	38.9	36.7	40.0	24.9	20.0	19.8	27.9	1	5
$NH3^-$ N (mg/L)	0.4	0.4	0.4	0.8	0.8	0.6	0.8	1.0	1.2	1.4	0	1.5
PO_4^{3-} (mg/L)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0	0
Velocity	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.1	-	-
Cl^-	382	395	365	399	407	399	385	409	517	500	250	500
F^-	0.2	0.2	0.2	0.5	0.3	0.3	0.5	0.6	1.2	0.9	-	0.5
SO_4^-	13	19	23	43	112	87	133	229	312	299	400	200
$HCO3^-$	129	163	122	187	179	165	221	177	322	344	-	-
$NO3^-$	12	18	23	21	27	29	33	31	44	39	-	45
Na+	215	217	227	233	201	277	222	282	277	253	200	200
K+	23	27	28	25	36	23	34	37	35	44	40	75
Mg++	136	124	138	139	131	125	135	134	147	155	150	150
Ca+	185	189	191	202	207	253	271	311	309	317	200	-

Land erosion, clearing activities, plowing, and earthworks are most probably the main causes of high turbidity readings obtained (20 – 27.9) NTU. Suspended particles in water may reduce sunlight penetration and that may lead to photosynthesis process reduction. Velocity readings for almost all points were approximately zero, which makes the spring considered stagnant. Chloride, Fluoride, and Sodium values scored the highest values in sampling points near the seashore due to the physical contact of the spring with seawater. Sulfate readings for all sampling points were within the desirable levels. Bicarbonate readings were slightly high as they have a reverse proportion with values of pH as reported by Arumugam & Elangovan (2009). Nitrate, Potassium, Magnesium, and Calcium values have shown a similar pattern as higher concentrations were scored in points 8, 9, and 10 due to impinging with seawater.

4.2. Heavy Metals

Heavy metals from industrial waste may accumulate in water bodies, transfer through the food chain, and cause severe health problems (Abida *et al.,* 2009). The existence of Cu, Mn, and Ni was recorded in all sampling points and all readings were within the permissible limits. Even though, heavy metals of (As and Pb) were below detectable levels in some samples they have scored high readings in other points which may indicate that the spring is highly exposed to industrial waste through a variety of human activities such as illegal dumping. Nevertheless, the values of Cr and Zn were within the normal range.

Table 2. *Heavy Metal Characteristics (Point 1 – 10)*

Parameter	P 1	P 2	P 3	P 4	P 5	P 6	P 7	P 8	P 9	P 10	WHO
As (µg/L)	-	30	90	70	-	-	55	62	-	-	10
Cr (µg/L)	-	-	3	2	5	4	2	2	2	3	50
Cu (µg/L)	2	4	3	5	7	9	9	8	6	10	2000
Mn (µg/L)	2	3	5	8	4	7	5	2	3	2	500
Ni (µg/L)	5	12	17	13	12	18	17	33	12	14	20
Pb (µg/L)	44	-	53	-	-	53	-	-	33	19	10
Zn (µg/L)	-	4	4	4	7	8	7	-	-	-	3000

4.3. Biological Characteristics (Testing of Coliforms)

Five ml of water from each sample were added to the coliform test tube in order to detect the presence of possible contaminations. Results were observed after 48 hours and all samples tested have shown positive results.

The number of Total Fecal coliform was detected using the MPN index method. Results in all sampling points (Table 3) have confirmed that the spring might be exposed to sewage or any other fecal regions (Bartram & Ballance, 1996).

Table 3. *Testing of Coliforms and Number of Total Fecal Coliforms (Point 1 – 10)*

Parameter	P 1	P 2	P 3	P 4	P 5	P 6	P 7	P 8	P 9	P 10	Libyan Standard	WHO
Coliform test	+	+	+	+	+	+	+	+	+	+	Negative	Negative
Total Fecal Coliform MPN/ 100 ml	22	13	27	24	31	28	25	23	18	9	0	0

5. Profiling the Spring

The spring was profiled for its length, width, and depth. Water Depth Sensor was utilized to find the depth of the spring. The length scored was at 1700 m. The average width was at 105 m, which makes the area of the spring equal to 178.5 km^2. The average depth was at 8.9 m that makes the spring capable to hold an amount of about 1588.65 km^3 of freshwater.

6. WQI and Spring Water Quality Classification

The water quality index was estimated by the weighted arithmetic water quality index method stated by Akkaraboyina & Raju (2012). Results obtained were utilized to classify the water quality of Kaam Spring according to the water quality index standard (Table 4). Results have brought to light the overall water quality index was at 57.76 which falls in the category of medium water quality indicating that extensive treatment is required.

Table 4. *Water Quality Index (WQI) Standard*

Water Quality Index Level	Water Quality Status
0 - 25	Very poor water quality
26 - 49	Poor water quality
50 - 70	Medium water quality
71 - 89	Good water quality
90 - 100	Excellent water quality

7. Conclusion

This work confirms that COD values were extremely higher than the allowed limits. That indicates that the spring is highly exposed to organic and inorganic pollutants and due to the fact that the spring is not 100% active due to backfilling and illegal dumping activities as well as to agro-based wastes. Concentrations of (As and Pb) were higher than the acceptable levels which may lead to severe health problems. Testing of coliforms emphasized that the spring is exposed to untreated sewage discharge. Calculations of Water Quality Index (WQI) proved that the spring has a medium water quality, which is not drinkable.

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Conflict of Interest: The authors declared no conflict of Interest

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