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Original article

Assessment of Desalinated Water from Selected Stations in Janzour, Libya, Compared to Some Bottled Water Plants

Ismail Ben Sulaiman[1], Fathi Al Harari[1], Malak Qarisiah[1], Wafaa Alkarekshi[2]

[1]*Department of Chemistry, Faculty of Education-Janzour, Tripoli University, Tripoli, Libya*
[2]*College of Engineering Technology-Janzour, Libya*
Email. bsulaimani@yahoo.co.uk

Abstract
Desalinated and bottled water are generally considered safe and potable, as they meet strict quality standards. Bottled water is often superior in quality due to its naturally occurring minerals, while desalinated water provides ultra-pure water but may lack some essential minerals. This study evaluates and compares the quality of drinking water produced by selected desalination stations in Janzour, Libya, with several locally bottled water brands based on key physicochemical parameters, including pH, electrical conductivity (EC), total dissolved solids (TDS), oxidation-reduction potential (ORP), and nitrate concentration (NO_3^-). A total of 27 water samples (coded R1–R27) were analyzed, comprising three bottled water brands (Al-Safiya, Dijlah, Sultan) and one spring water source (Ain Bannon), using a HACH brand MP Series multiparameter meter for pH, EC, TDS, and ORP measurements, while nitrate concentration was determined by UV-Vis spectrophotometry. The results showed that with the exception of one sample (R8) which exhibited relatively higher TDS (669.5 ppm), all analyzed samples complied with the permissible limits set by WHO guidelines and Libyan drinking water standards, with pH values ranging from 6.26 to 8.06, TDS values below 200 ppm for most samples (Dijlah recorded the lowest at 85.8 ppm), EC values ranging from 31.42 to 1098 µS/cm, ORP values between 198 and 258 mV indicating adequate oxidative potential, and nitrate concentrations between 0 and 1.8 mg/L which are far below the WHO maximum of 50 mg/L. The study concludes that most desalinated water from the selected stations and the bottled water brands available in Janzour are safe for human consumption regarding the tested parameters, with Dijlah water exhibiting the lowest TDS and lightest taste, Al-Safiya showing the highest ORP for better preservation, and Ain Bannon Spring water demonstrating excellent quality comparable to commercial bottled water. Regular quality monitoring and proper maintenance of desalination equipment are recommended to sustain this performance, with special attention needed for the source of sample R8.
Keywords. Desalinated Water, Bottled Water, Water Quality, TDS, Nitrate.

Introduction

Water is an indispensable vital resource for the continuity of life on Earth, playing a pivotal role in all human activities, including health, agriculture, industry, and domestic use [1]. With increasing population pressures and climate change, providing clean and safe drinking water has become a major challenge for many countries, especially those located in arid and semi-arid regions such as Libya [2]. Libya relies heavily on non-conventional water sources, primarily seawater desalination, groundwater, as well as natural springs and bottled water production [3]. The city of Janzour, Libya, situated on the Mediterranean coast in the west of Tripoli, suffers from a scarcity of fresh water, which has led to the establishment of numerous small-scale desalination plants to meet the population's drinking water needs. Several private bottled water factories have emerged in recent years, supplying the local market with packaged water under various commercial brands [4, 5]. This situation is not unique to Janzour; similar challenges exist in other Libyan municipalities. For instance, a study by [6] in Tajoura (east of Tripoli) found that 90% of residents rely on private wells or desalination plants due to the lack of a public water network. Furthermore, the bottled water market in Libya has expanded rapidly.

A comprehensive study by [7] analyzed ten locally bottled water brands (Al Reem, Aseel, Sultan, Al-Ain, Erin, Eno, Al Safwa, Pure, Aquafina, Arwa) and found significant statistical differences between the actual values and the specifications listed on the labels for several chemical indicators, including pH, EC, TDS, and chloride. However, all samples complied with WHO standards. In western Libya, [8] highlighted the presence of microbiological contamination and variability in chemical-physical parameters of desalinated water, underscoring the urgent need for routine quality control. On an international level, [9] compared desalinated tap water with bottled water in Yanbu, Saudi Arabia, and concluded that tap water quality was comparable to or better than many bottled brands, while also being more economical and environmentally friendly. Therefore, the importance of this research lies in evaluating and comparing the quality of drinking water produced by some desalination plants in Janzour with that of local bottled water brands, by measuring a set of fundamental physical and chemical parameters, including pH, electrical conductivity (EC), total dissolved solids (TDS), oxidation-reduction potential (ORP), and nitrate ion concentration (NO_3^-). These parameters provide important indicators regarding the suitability of water for human consumption and compliance with local and international standard specifications [10, 11]. Furthermore, this evaluation contributes to consumer awareness regarding the quality of available water and assists relevant authorities

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in improving the performance of desalination plants and bottling factories. The present study aims to provide similar evidence for the Libyan context, specifically by assessing desalinated water from selected stations in Janzour and comparing it with locally bottled water brands based on the aforementioned physicochemical parameters.

Materials and Methods

Study Area and Sample Collection

The study was conducted in Janzour, Libya, a coastal city approximately 20 km west of Tripoli. A total of 27 water samples (coded R1 to R27) were collected from various sources, including small-scale desalination plants, bottled water products, and a natural spring (Ain Bannon). Specifically, samples R24, R25, R26, and R27 represented: Al-Safiya bottled water, Dijlah bottled water, Sultan bottled water, and Ain Bannon Spring water, respectively. All samples were collected in clean, sterile polyethylene bottles (500 mL capacity) that were rinsed three times with the water to be sampled prior to filling. Samples were transported to the laboratory in a cool box at 4°C and analyzed within 24 hours of collection to preserve integrity.

Apparatus and Equipment

Multiparameter Meter (HACH MP Series Instrument)

A HACH brand MP Series Instrument Case (multiparameter meter) was used for the on-site and laboratory measurement of pH, electrical conductivity (EC), total dissolved solids (TDS), oxidation-reduction potential (ORP), and temperature. This portable, handheld device features a digital display and contains five integrated sensors that allow rapid, accurate measurements without the need for separate probes. The instrument operates by immersing the sensor array directly into the water sample; the sensors convert the measured parameters into electrical signals, which are processed by an internal microprocessor and displayed digitally. Before each use, the instrument was calibrated using standard buffer solutions. For pH, a three-point calibration was performed using buffer solutions of pH 4.01, 7.00, and 10.01 at 25°C. For EC and TDS, a standard calibration solution of 1413 µS/cm (corresponding to 1000 ppm TDS) was used. ORP was calibrated using a standard redox solution (220 mV). Calibration was verified at the beginning and end of each measurement session.

UV-Vis Spectrophotometer

A UV-Vis spectrophotometer was used to determine nitrate ion concentration (NO_3^-) based on the absorbance of light at specific wavelengths. The instrument consists of a light source (deuterium lamp for UV and tungsten lamp for visible), a monochromator (prism or diffraction grating) to separate wavelengths, and a detector to measure light intensity after passing through the sample. The spectrophotometer directs a beam of light through the sample. The amount of light absorbed at a given wavelength is proportional to the concentration of the absorbing compound in the sample, according to the Beer-Lambert law. Nitrate standard solutions (0, 0.5, 1.0, 2.0, 5.0 mg/L NO_3^-) were prepared from a stock solution (1000 mg/L KNO_3) for calibration. A reducing agent (e.g., cadmium granules or hydrazine sulfate) was used to convert nitrate to nitrite, followed by colorimetric determination using sulfanilamide and N-(1-naphthyl) ethylenediamine dihydrochloride (NED) to form a pink azo dye measured at 540 nm. Alternatively, direct UV absorbance at 220 nm was used after correction for organic matter at 275 nm. Duplicate measurements were performed for 10% of the samples, and a standard check solution (1.0 mg/L NO_3^-) was analyzed after every ten samples to ensure accuracy.

Results and Discussion

The study analyzed 27 water samples (coded R1 to R27) (Table 1). Samples R24, R25, R26, and R27 represent: Al-Safiya bottled water, Dijlah bottled water, Sultan bottled water, and Ain Bannon Spring/desalination water, respectively. A HACH brand MP Series Instrument Case (multiparameter meter) was used to measure pH, EC, TDS, ORP, and temperature. Nitrate concentration (NO_3^-) was measured using a UV-Vis spectrophotometer following standard procedures. All measurements were performed after calibration with appropriate buffer solutions.

Results from Table 1, pH values ranged from 6.26 (lowest, sample R8) to 8.06 (highest, sample R23). The majority of samples fell within 6.7 – 7.5. For bottled water samples: Al-Safiya (R24) = 7.20; Dijlah (R25) = 7.17; Sultan (R26) = 7.22 and Ain Bannon (R27) = 6.91.

The permissible pH range for drinking water according to Libyan Standard [10] and WHO [11] is 6.5 – 8.5. All samples analyzed fall within this safe range, which is consistent with findings from other Libyan studies on bottled and desalinated water [2, 5]. Values near 7.0 indicate neutral water, neither acidic nor excessively alkaline, making them suitable for drinking and posing no risk to consumer health or to plumbing systems. Slightly lower values (e.g., R8 = 6.26) may suggest a minor influence of dissolved carbon dioxide or weak acidic substances, but remain within acceptable limits [8]. Notably, all three bottled water brands exhibited pH values very close to neutral (7.17–7.22), indicating good buffering capacity and chemical stability, which aligns with results reported by [3] for bottled water in Misurata markets. Ain Bannon spring water (6.91) is slightly more acidic but still well within standards.

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Table 1. Physicochemical parameters of desalinated and bottled water

Sample	pH	EC (µs/cm)	ORP (mV)	TDS (ppm)	NO_3^- (mg/l)
R1	7.45	226.7	218	138.2	0.7
R2	7.92	45.39	234	27.7	0.1
R3	7.37	134.6	225	82.1	1.2
R4	7.4	69.6	236	42.4	0.1
R5	7.09	161	227	98.2	0.3
R6	7.21	66.81	223	40.7	0.9
R7	7.2	41.98	244	25.6	0.2
R8	6.26	1098	203	669.5	0.5
R9	6.91	56.68	241	34.6	0.2
R10	6.73	191.1	223	116.5	1.8
R11	7.0	50.13	238	30.6	0
R12	6.7	267.4	223	163.0	0.2
R13	6.97	49.85	247	30.4	0.2
R14	6.94	57.04	258	34.8	1.1
R15	6.96	46.66	256	28.5	1.3
R16	6.95	73.6	240	44.9	1.1
R17	6.71	162.5	236	99.1	1.3
R18	6.94	43	238	26.2	0.3
R19	6.99	32.71	245	19.9	1
R20	6.97	50.53	237	30.8	0.3
R21	7.06	31.42	208	19.2	1.1
R22	8.02	35.06	198	21.4	0.2
R23	8.06	33.11	199	20.2	1
R24	7.2	176.7	199	107.7	1.3
R25	7.17	140.7	215	85.8	1
R26	7.22	158.7	198	96.8	0.4
R27	6.91	179.9	210	109.7	1.1

Total Dissolved Solids (TDS)

Salinity refers to the amount of total dissolved solids (TDS) in the water and is frequently measured by electrical conductivity (EC). Waters with higher TDS concentrations will be relatively conductive. TDS is measured in parts per million or mg/L, and EC is measured in micro-Siemens per centimeter (µS/cm). The general formula adopted to calculate the TDS [12] is

$$TDS\left(\frac{mg}{L}\right) = 0.64 \cdot EC\left[\frac{\mu S}{cm}\right] \ldots\ldots\ldots \quad (1)$$

TDS ranged from 19.2 ppm (R23) to 669.5 ppm (R8) (Table 1). Bottled water samples: Al-Safiya (R24) = 107 ppm; Dijlah (R25) = 85.8 ppm; Sultan (R26) = 96.8 ppm and Ain Bannon (R27) = 109.7 ppm.

According to WHO guidelines [11], drinking water with TDS below 500 ppm is considered good, while the Libyan standard [10] allows for 100 to 500 ppm. All samples except R8 fall within the safe range, similar to findings from desalination plants in Tajoura [6] and bottled water in Benghazi [7]. Remarkably, most samples have TDS below 200 ppm, indicating low salinity and high efficiency of desalination and purification processes at the studied stations and bottling plants, which is typical for reverse osmosis desalinated water [1]. Sample R8 (669.5 ppm) likely originates from a different source (possibly untreated groundwater) and requires further investigation, as elevated TDS can affect taste and palatability [4]. Among bottled waters, Dijlah has the lowest TDS (85.8 ppm), giving it a lighter taste, followed by Sultan (96.8 ppm) and Al-Safiya (107 ppm). Ain Bannon spring water (109.7 ppm) shows excellent quality comparable to bottled brands. The EC values follow the same trend, with Dijlah showing the lowest ionic content, and all EC measurements are well below the WHO advisory level of 1500 µS/cm [11].

Results from (Table 1 and Figure 2): ORP ranged from 198 mV (R22 and R26, Sultan) to 258 mV (R14). Bottled water samples: Al-Safiya (R24) = 199 mV, Dijlah (R25) = 215 mV, Sultan (R26) = 198 mV and Ain Bannon (R27) = 210 mV.

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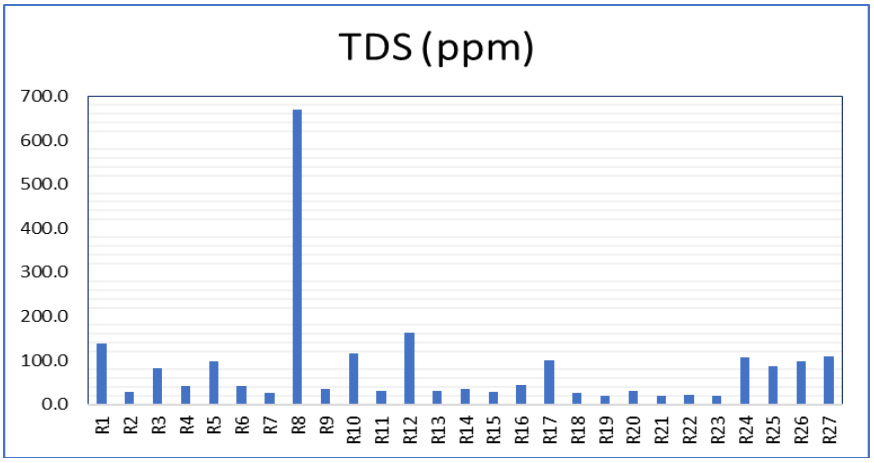

Figure 1. Total Dissolved Solids Concentration

ORP measures the water's ability to act as an oxidizing or reducing agent. High positive values (>200 mV) indicate an oxidizing environment, meaning the water contains oxidizing agents such as free chlorine or dissolved oxygen [8, 12]. This is desirable for chlorinated drinking water as it helps kill bacteria and prevent microbial growth during storage. The recorded values (198–258 mV) are considered good and indicate that both bottled and desalinated waters retain sufficient oxidation capacity to maintain microbiological purity, which is consistent with the range reported for properly treated drinking water in Libyan studies [8]. Sultan bottled water (198 mV) has the lowest ORP among the brands, which might imply slightly lower disinfection residual compared to Al-Safiya (199 mV) or Dijlah (215 mV). However, all values are within acceptable ranges for packaged drinking water [5]. Ain Bannon spring water (210 mV) shows moderate oxidizing potential, similar to values reported for natural spring sources [3]. According to Kelly (1940) [12], ORP values above 200 mV generally indicate water with good self-purification capacity.

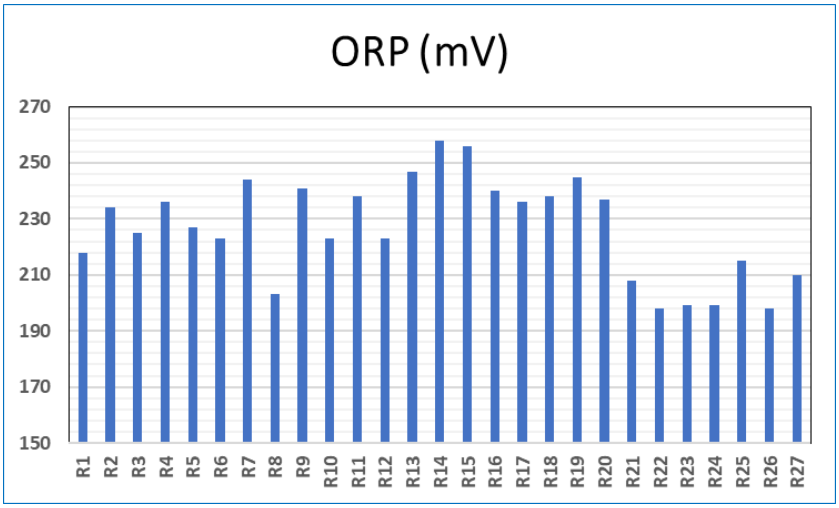

Figure 2. Oxidation-Reduction Potential

Results from (Table 1 and Figure 3); Nitrate concentrations ranged from 0 mg/l (R11) to 1.8 mg/l (R10). Bottled water samples: Al-Safiya (R24) = 1.3 mg/l, Dijlah (R25) = 1.0 mg/l, Sultan (R26) = 0.4 mg/l and Ain Bannon (R27) = 1.1 mg/l.

The maximum permissible limit for nitrate in drinking water according to the WHO [11] and Libyan Standard [10] is 50 mg/l (to protect infants from methemoglobinemia or "blue baby syndrome"). All analyzed samples have extremely low nitrate concentrations (0 – 1.8 mg/L), posing no health risk whatsoever, which is in agreement with studies on bottled water in Ubari [2] and Benghazi [7]. Values below 2 mg/l indicate pristine water sources free from organic or agricultural pollution, a characteristic often observed in well-maintained desalinated water supplies [1, 6]. Sultan bottled water shows the lowest nitrate (0.4 mg/l), while Al-Safiya has the highest among brands (1.3 mg/l), still negligible. Ain Bannon spring water (1.1 mg/l) reflects a clean natural source, comparable to spring water quality reported in other Libyan studies [4]. Such low nitrate levels are typical for desalinated water and properly treated groundwater, and are far below the levels that would require regulatory action [8, 9].

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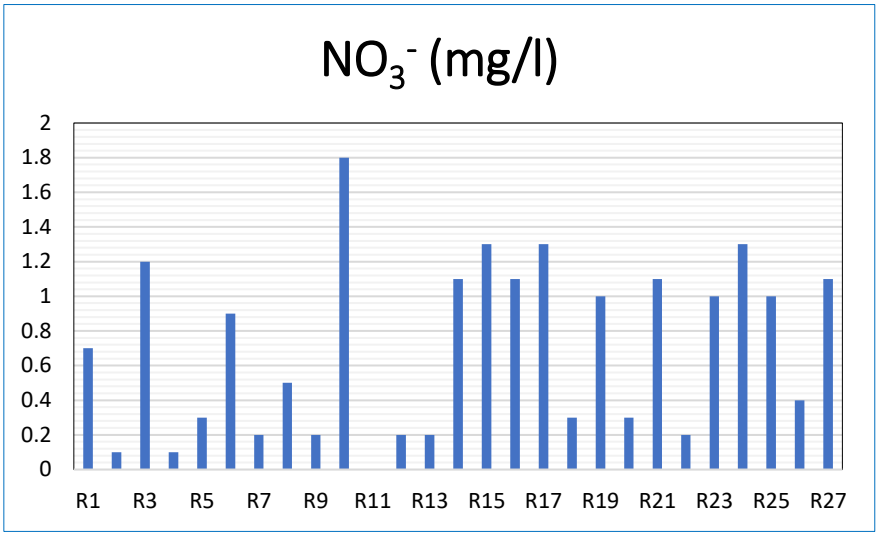

Figure 3. Nitrate Ion Concentration

Conclusion

This study evaluated 27 water samples from desalination stations and bottled water plants in Janzour, Libya. The measured parameters (pH, EC, TDS, ORP, and NO_3^-) all fell within the safe limits established by the World Health Organization and Libyan national standards, with the exception of one outlier sample (R8). Bottled water brands showed excellent quality, with Dijlah having the lowest TDS and Al-Safiya the highest ORP. Ain Bannon spring water proved to be a high-quality natural alternative. The findings confirm that both desalinated and bottled waters available in Janzour are safe for human consumption regarding the tested parameters. Regular quality monitoring and proper maintenance of desalination equipment are essential to sustain this performance.

Conflict of interest. Nil

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