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Assessment of Water Quality for Drinking and Domestic Use from Three Sources in the Mila Region, Northeastern Algeria

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Abstract: This study evaluates the suitability of water from three natural sources in the Mila region of northeast Algeria for human consumption over three months (February-April 2023). It compares physicochemical parameters with Algerian (AS) and World Health Organization (WHO) standards and calculates the Water Quality Index (WQI). Results show that while all parameters met Algerian standards, some exceeded WHO standards, particularly EC, TDS, and $Si(OH)_4$. WQI values ranged from 43.64 to 86.19, indicating water quality varied from good (78%) to excellent (22%). Although the water is generally suitable for consumption, daily chlorination is recommended to maintain safety. The study highlights the need for ongoing water quality monitoring to protect public health and preserve natural spring waters in Algeria.

Key words: Source water, NE Algeria, physico-chemical parameters, water quality, human consumption.

Introduction

Water is one of nature's most vital resources, essential for the survival of all living beings, from plants and microorganisms to humans. It is recognised as the predominant compound on the earth's surface, covering approximately 70% of it, and is distinguished by its unique chemical and physical properties (Onifade and Ilori, 2008; Obi and Okocha, 2007).

Water, crucial for life, acts as a versatile solvent with essential minerals for various uses (Venkatesan et al., 2013). Various physical and human activities degrade water quality, impacting climate and public health by introducing pathogens and toxic chemicals, causing infectious diseases (Meneses-Ruiz et al., 2004). The quality of drinking water significantly influences environmental health, with the World Health Organization attributing 80% of global diseases to inadequate sanitation, pollution, and contaminated water sources (WHO, 2011). Ensuring the safety of drinking water is paramount in preventing and controlling waterborne diseases. When water becomes polluted, it disrupts its essential characteristics and functions, severely influencing its suitability for drinking, household use, personal hygiene, and medical purposes a critical global challenge (Trivedi et al., 2010). This pollution contributes to a significant but often overlooked humanitarian crisis, claiming

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the lives of approximately 3900 children daily and impeding progress towards achieving the Millennium Development Goals, particularly in Africa and Asia (Bartram et al., 2005).

Waterborne diseases, which disproportionately affect children in developing nations, stand as a leading cause of global mortality and suffering (Schafera et al., 2009).

Access to high-quality drinking water is crucial for improving community health by preventing waterborne illnesses (Benjamin and Brown, 2003).

Despite its essential mineral content, excessive nonessential elements in drinking water can lead to developmental abnormalities, stunted growth, increased mortality rates, and mutagenic effects (Nkono and Asubiojo, 1998).

The WHO Guidelines for Drinking Water Quality stress the importance of Water Safety Plans (WSP) to protect public health. They set global standards for acceptable drinking water quality, highlighting the need to safeguard water sources and monitor water resources, particularly in developing countries like Algeria.

This study aimed to analyse the physicochemical parameters of drinking water from various sources in Mila, Algeria. Key parameters included pH, temperature, electrical conductivity, total dissolved solids, turbidity, salinity, major anions, and nutrients. The goal was to assess water quality and its suitability for drinking by comparing it to standards and the Water Quality Index (WQI).

Materials and Methods

Study Area

The three studied water sources are in northern Mila Province, northeastern Algeria. Source one (Tamda-Tm) is in Ahmed Rachedi at 36°21’06.2”N, 6°08’46.5”E. Source two (Ayoune Soltane-As) is in Oued-Endja at 36°25’18.6”N, 6°09’02.6”E. Source three (Chebbouba-Ch) is in Sidi Merouane at 36°30’23.9”N, 6°15’38.8”E (Figure 1). This area has a humid to sub-humid Mediterranean climate, with annual precipitation ranging from 400 to 700 mm and temperatures from 8.9

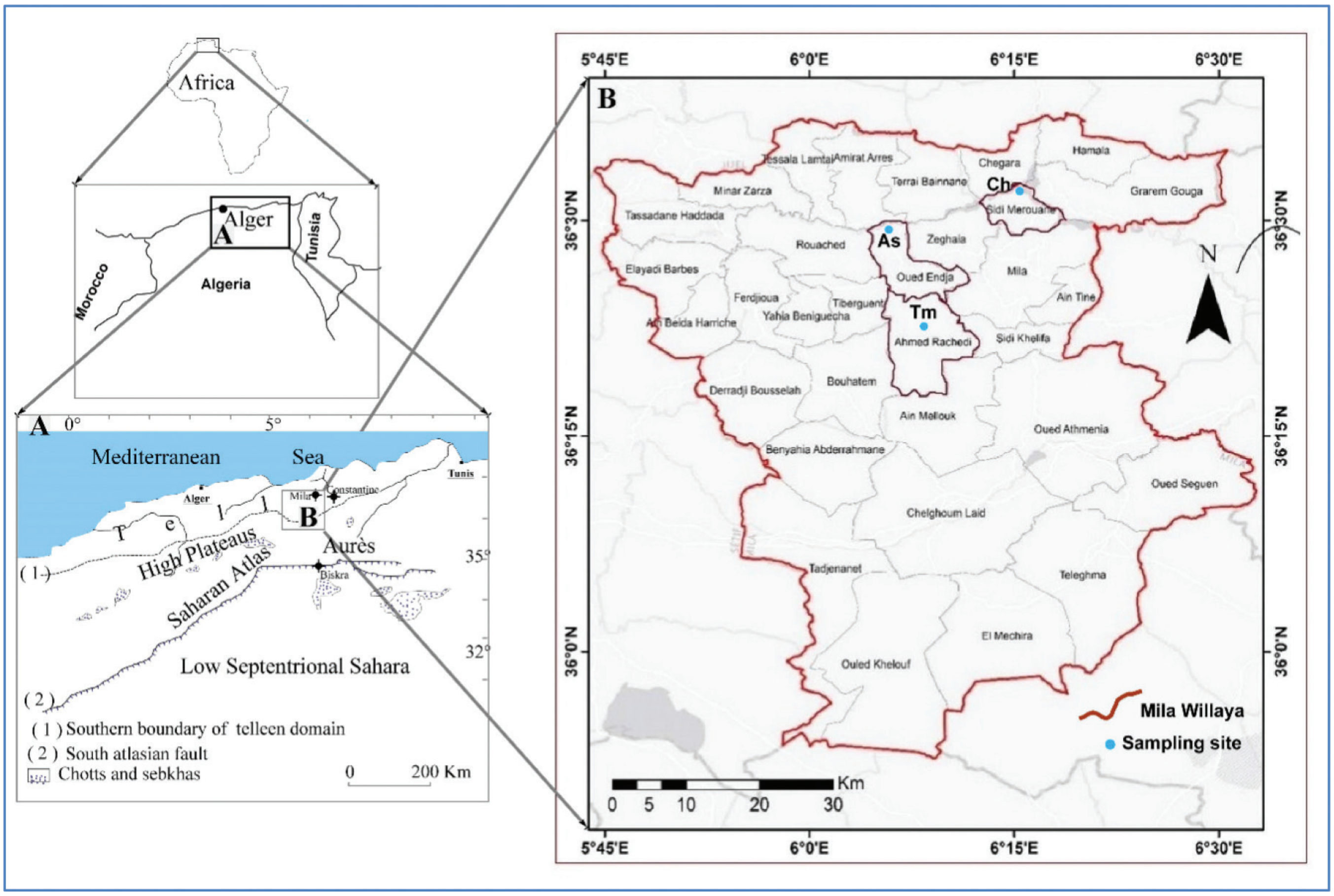

Figure 1: A. Major geomorphologic units of North Algeria (Chebbah et Lamouroux (2012); B. Sampling Sources Location (Tamda -Tm; Ayoune Soltane - As; Chabouba - Ch) in Mila region (Northeastern Algeria).

to 28.6 °C. Geologically, Chebbouba Spring emerges from Upper Miocene limestone, Tamda Spring from Cenomanian-Albian formations, and Ayoune Soltane Spring from Mio-Pliocene clay deposits.

Sample Collection and Analysis

Standard methods (APHA 2005) were used to collect and analyse water samples from three sources (Tm, As, and Ch) over three months (February, March, and April 2023). Samples were taken in disinfected polyethylene bottles and kept in refrigerated containers to avoid alteration. Bottles were washed and rinsed with distilled water before filling. Temperature, pH, electrical conductivity (EC), and total dissolved solids (TDS) were measured on-site with portable devices. Principal ions (Na, Cl, CO_3, HCO_3, SO_4, NO_3, NH_4, NO_2, PO_4 and $Si(OH)_4$) were analysed in the laboratory at Mila University Center using standardised methods. Sampling site coordinates were recorded using GPS.

Results and Discussion

Physical-Chemical Characterisation of the Studied Source of Waters

Water quality parameters were analysed, and average physical-chemical values with Algerian and WHO drinking water standards are presented in Table 1. Figures 2 and 3 show graphical representations for each site.

Physical Parameters of Source Waters

Temp: Temperature significantly affects the solubility of gases and minerals in water, as well as its biological processes. Elevated temperatures can foster the growth

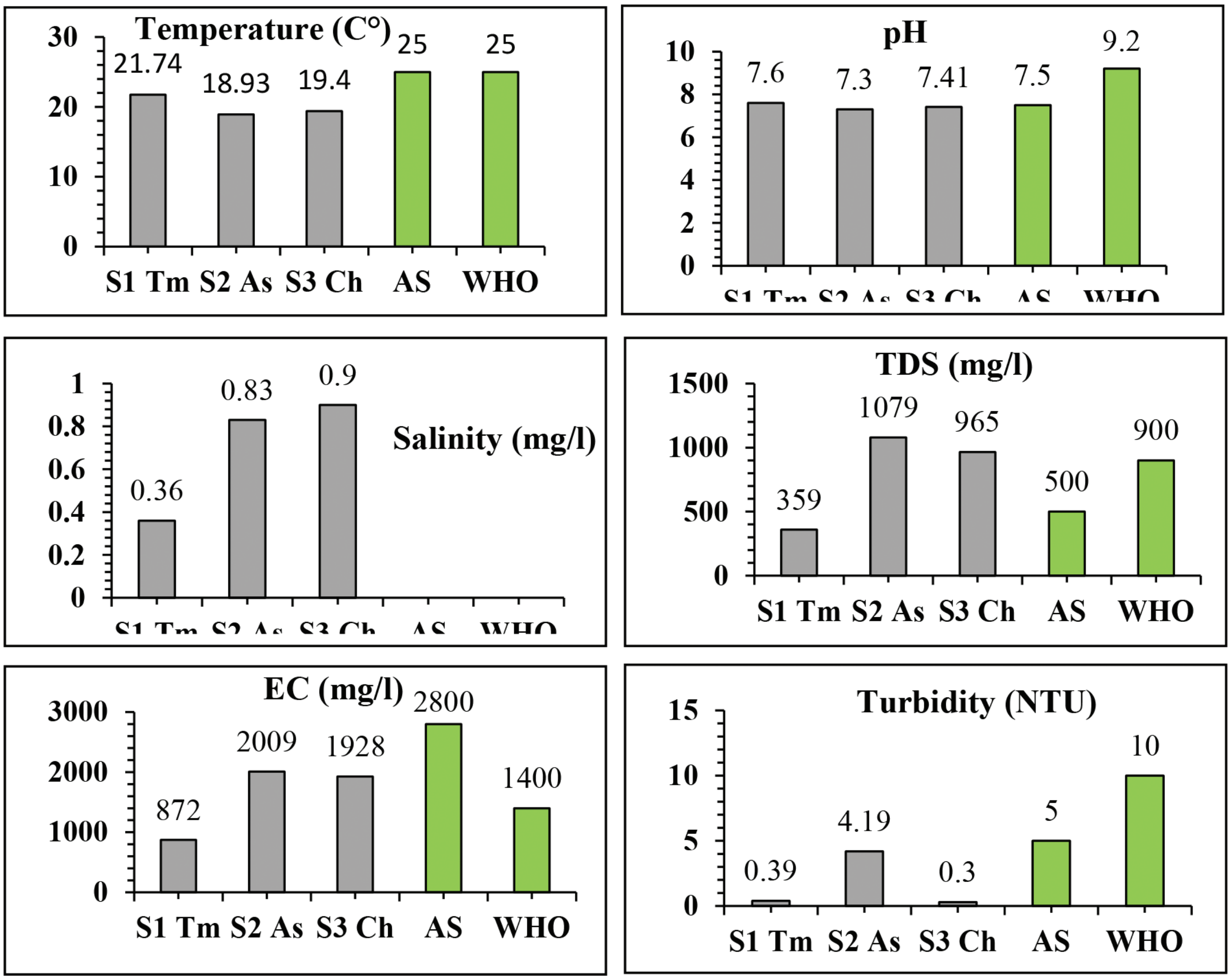

Figure 2: Average values of physical parameters and their comparison between sites (Tamda -Tm; Ayoune Soltane - As; Chabouba - Ch) and standards (SA: Algerian Standards; WHO: World Health Organization Standards).

of microorganisms (Jacobsen et al., 1997). The water studied temperature ranged from 15.5 to 25.9 °C. All recorded values fall below the standards set by both Algerian and WHO guidelines (25°C), one sample showed a temperature of 25.9°C in April (Table 1, Figure 2). pH measures water's acidity or alkalinity, affecting chemical formation, pathogen survival, and gastrointestinal irritation (Toure et al., 2019). Water with a pH between 6.5 and 8.5 is considered safe for consumption. Acidic water (pH below 6.5) can corrode plumbing, while alkaline water (pH above 8.5) may taste bitter (Table 1, Figure 2). The pH of the studied water ranged from 7.3 to 7.6, which is within the safe range set by the World Health Organization (WHO) and Algerian standards. These findings confirm that the drinking water samples are safe and do not pose health risks.

- EC: Electrical conductivity reflects the solution's capacity to conduct an electric current, influenced by the migration of ions and the presence of ionic species. It is a valuable tool for assessing water purity (Milliman, 2001). The EC values of the water studied in the three springs ranged from 872 to 1928 µS/cm. While these values are below the permissible limit of 2800 µS/cm for AS, they exceed the WHO recommended limit of 1400 µS/cm for As and Ch sources over the three-month period (Table 1, Figure 2).
- TDS: Total Dissolved Solids indicate water quality by affecting its clarity. High TDS levels, exceeding the 500 mg/L standard, impair drinking and irrigation suitability. In this study, TDS ranged from 386 to 1140 mg/L, with February's peak at 1140 mg/L due to limestone dissolution. Most samples surpassed the WHO limit, posing risks like gastrointestinal issues and reduced palatability (Garg et al., 2009).
- Sal: Salinity measures dissolved salt concentration, with levels in the studied waters ranging from 400 to 1000 mg/L, which are relatively low.
- Turb: Turbidity affects water clarity due to suspended particles like clay and organic matter, potentially carrying toxins and microorganisms (Chiavola et al., 2023). In the present study, Turb across the three sources ranged from 0.10 to 4.20 NTU, well below the WHO tolerance range of 5 NTU, indicating good water clarity.

Chemical Parameters of Source Waters

The results depicted in Figure 3 present an analysis of various chemical parameters within the waters of three distinct sources over a span of three months. These parameters are also compared with Algerian standards and World Health Organization (WHO) guidelines to evaluate drinking water quality.

Na (Sodium): Recent study (Harvard, 2021) reported that chronic ingestion of excess sodium has been associated with high blood pressure, heart disease, and stroke. Na levels vary between 23 and 161 mg/L and consistently remain below the 200 mg/L threshold set by both standards.

Cl (Chloride): Chlorine treatment can prevent coliform contamination, but water must be coliform-free to be safe for drinking. High chloride levels in water pose serious health risks (Uriu-hare et al., 1995). Chloride concentrations varied between 35.5 and 248.5 mg/L and are well below both Algerian (500 mg/L) and WHO (600 mg/L) standards, indicating acceptable levels for water potability.

CO_3 (Carbonate) and HCO_3 (Bicarbonate): CO_3 and HCO_3 are crucial in regulating pH and water hardness, thus influencing potability and taste. Studies have shown that excess bicarbonate can produce biomass yields and metabolite profiles equivalent to those of carbon dioxide (Umetani et al., 2021). Their presence underscores the comprehensive evaluation of water quality. CO_3 and HCO_3 concentrations in studied source waters range from 0 to 4.8 and 12.2 - 48.8 mg/L, respectively, and are below WHO standards.

SO_4 (Sulphate): SO_4 concentrations ranging from 19.26 to 151 mg/L fall below both Algerian and WHO standards (400 mg/L and 500 mg/L, respectively). While there is notable variation, the levels remain within acceptable limits, highlighting overall satisfactory water quality. Penner et al. (2020) reported that drinking water with high sulfate concentrations reduced dry matter intake and water intake and potentially caused osmotic-induced diarrhea.

NO_3 (Nitrate): NO_3 concentrations range from 0.124 to 8.15 mg/L and consistently remain below the established 50 mg/L threshold by both standards, although a spike is observed at As. Nevertheless, the levels are considered acceptable.

NH_4 (Ammonium): NH_4 Ammonium concentrations of studied waters range from 0.019 to 0.13 mg/L. Detected levels fall comfortably below the prescribed limits of 0.5 mg/L (Algerian standards) and 0.1 mg/L (WHO) except for one sample, signaling minimal contamination by ammonium.

PO_4 (phosphate): Phosphate in drinking water systems prevents corrosion and keeps harmful substances out. However, high levels can foster

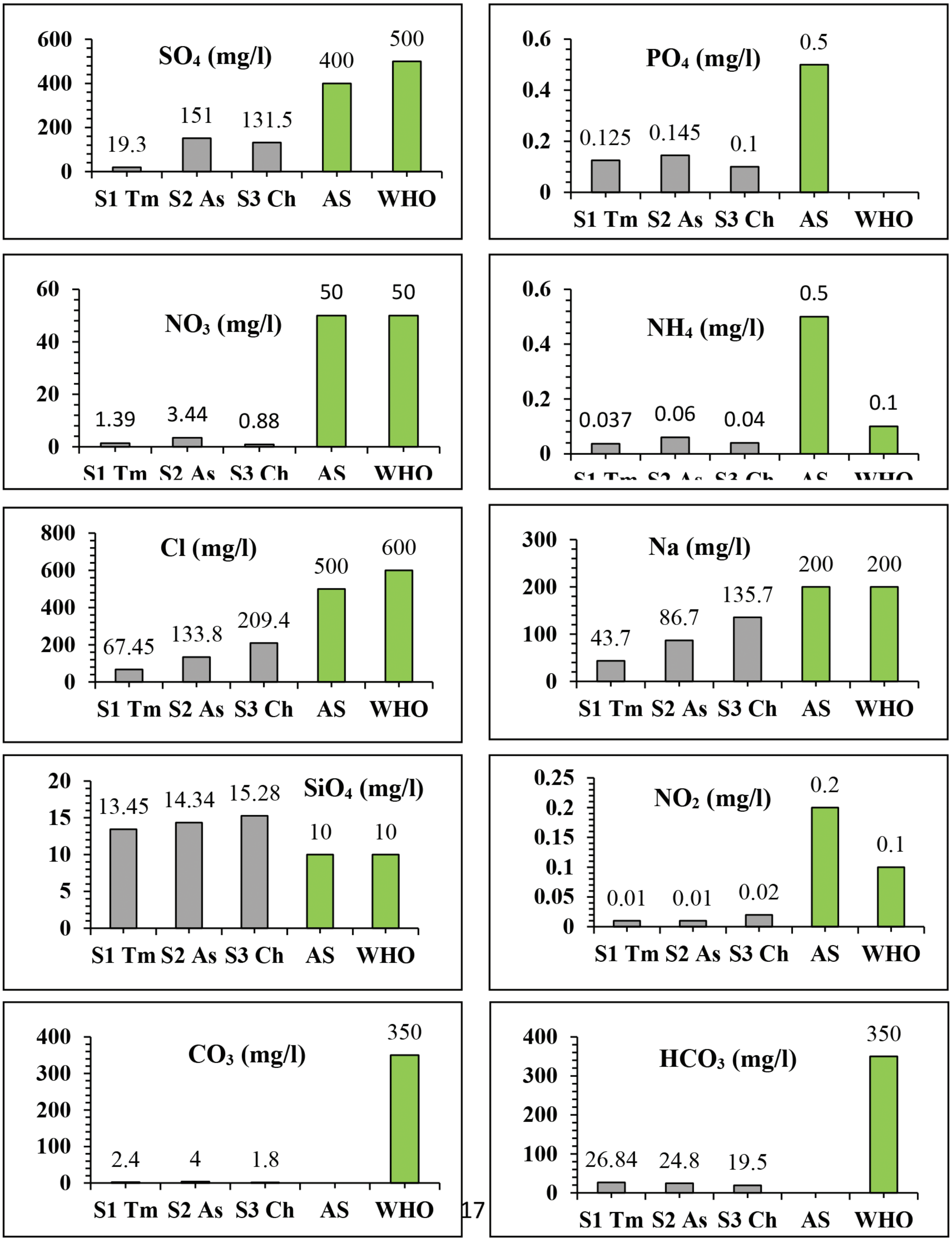

Figure 3: Average values of chemical parameters and their comparison between sites (Tamda -Tm; Ayoune Soltane - As; Chabouba - Ch) and standards (SA: Algerian Standards; WHO: World Health Organization Standards).

Table 1: Average values of drinking water quality parameters in the source waters with standards values for drinking water quality of AS (2014) and WHO (2017)

Parameters	*Month*	*Site*			*Algerian standards*	*WHO standards*	
		Tamda	*Ain Soltane*	*Chebouba*		*DL*	*MPL*
T (C°)	February	18.4	15.7	15.5	25	25	-
	March	20.9	17.7	19.4			
	April	25.9	23.4	23.3			
pH	February	7.9	7.4	7.44	6.5 -8.5	6.5 -8.5	9.2
	March	7.6	7.2	7.3			
	April	7.3	7.3	7.5			
EC (µs/cm)	February	1028	2110	2330	2800	900	
	March	789	2030	1795			1400
	April	800	1889	1659			
TDS (mg/L)	February	565	1140	1056	1500	600	900
	March	422	1090	951			
	April	425	1008	887			
Sal (mg/L)	February	470	600	1000	-	-	-
	March	400	1000	900			
	April	400	900	800			
Turb (NT U)	February	0.55	0.59	0.15	5	5	10
	March	0.31	2.20	0.10			
	April	0.30	4.20	0.67			
Na^+ (mg/L)	February	48.3	92	138	200	-	200
	March	59.8	98.9	161			
	April	23	69	108.1			
Cl^- (mg/L)	February	74.55	142	213	500	250	600
	March	92.3	152.7	248.5			
	April	35.5	106.5	166.9			
SO_4^{2-} (mg/L)	February	19	132	116.4	400	200	500
	March	14.3	132	104			
	April	24.5	189	174			
CO_3^{2-} (mg/L)	February	4.8	2.4	0.6	-	125	350
	March	2.4	6	1.2			
	April	0	3.6	3.6			
HCO_3^-(mg/l)	February	12.2	31.72	19.52	-	125	350
	March	19.52	18.3	14 .6			
	April	48.8	24.4	24.4			
NO_3^{2-} (mg/l)	February	3.32	8.15	2.24	50	-	
	March	0.6	1.5	0.26			50
	April	0.124	0.68	0.14			
NO_2^- (mg/l)	February	0.006	0.01	0.05	0.2	0.1	-
	March	0.003	0.001	0.001			
	April	0.01	0.02	0.01			
NH_4^+ (mg/L)	February	0.07	0.13	0.08	0.5	0.1	-
	March	0.023	0.02	0.03			
	April	0.019	0.02	0.024			
PO_4^{3-} (mg/L)	February	0.01	0.01	0.01	0.5	2	-
	March	0.002	0.002	0.008			
	April	0.36	0.42	0.27			
$Si(OH)_4$ (mg/L)	February	17.24	16.17	19.95	10	-	10
	March	10.5	13.14	11.68			
	April	12.63	13.72	14.21			

microorganisms and algae, leading to eutrophication (Glibert, 2020). Phosphate concentrations varied from 0.002 to 0.42 mg/L and despite a significant increase in April, especially at as but remained below the 0.5 mg/L permissible limit.

$Si(OH)_4$ (Silicate): $Si(OH)_4$ has long been investigated for its possible ability to prevent metallic pipe materials from corroding (Mishrra et al., 2021). $Si(OH)_4$ concentrations varied from 10.5 to 19.95 mg/L and surpassed the standard value of 10 mg/L across all samples. The elevated silicate levels could be a specific concern for this region.

Evaluation of Drinking Source Water Quality

The suitability of source water for drinking and domestic use is directly related to various physicochemical parameters and their concentrations. The drinking water quality in the study area was evaluated by comparing these parameters with the recommended values set by WHO (2017) and AS (2014), along with monitoring the Water Quality Index (WQI).

Evaluation of Drinking Water Quality Based on the Physicochemical Parameters

The study assessed drinking water quality in the Mila region by analysing parameters such as temperature, pH, EC, TDS, salinity, turbidity, and concentrations of and concentrations of Na, Cl, CO_3, HCO_3, SO_4, NO_3, NH_4, NO_2, PO_4 and $Si(OH)_4$. Results from three sources were compared to WHO and AS guidelines for drinking and domestic use (Table 1).

The analysis indicates that most tested parameters are within acceptable limits for drinking and domestic use, except for $Si(OH)_4$ (according to AS and EC), TDS, NH_4, and $Si(OH)_4$ (according to WHO standards). While the EC in all samples was below the AS standard of 2800 µS/cm, only the Tamda source met the WHO limit of 1400 µS/cm. TDS was under the AS standard of 1500 mg/L, but 44.44% of samples exceeded the WHO limit of 900 mg/L. One sample surpassed the WHO NH_4 limit of 0.1 mg/L, and all exceeded the 10 mg/L $Si(OH)_4$ limit. Despite these issues, the water is generally acceptable for use if treated with daily chlorination to address microbial contamination.

Evaluation of Drinking Source Water Quality Based on the WQI

The suitability of water for human consumption depends on various physicochemical parameters and their concentrations. This study assessed water quality using the Water Quality Index (WQI) in line with AS and WHO standards. The WQI offers a comprehensive numerical rating reflecting overall water quality for specific uses (Allia et al., 2022). The Water Quality Index (WQI) simplifies extensive physicochemical data into a single term, representing the overall water quality. It quantifies the impact of various parameters, providing clear and valuable information to decision-makers and the public (Horton, 1965).

The Water Quality Index (WQI) was calculated based on WHO drinking water standards (WHO, 2017), using a weighted arithmetic index method (Allia and Lalaoui, 2024). Fourteen parameters were considered, each assigned a weight (Wi) reflecting its impact on water quality, from 1 (lowest) to 5 (highest) (Dheeraj et al., 2023). Wi values were derived using $Wi = wi / \sum wi$, where wi is the weight of each parameter.

The quality rating (Qi) of each parameter was determined by $Qi = (Ci / Si) \times 100$, where Ci is the concentration in the sample and Si is the WHO standard. The sub-index (SIi) for each parameter was then calculated as $SIi = Wi \times Qi$. The aggregated WQI was obtained by summing all SIi values.

Water was categorised based on WQI scores into excellent (<50), good (50-100), poor (100-200), very poor (200-300), and unsuitable for drinking (>300) (Ramakrishnalah et al., 2009). The WQI was assessed using 10 parameters across three stations over three months, with results presented in Table 2, showing water quality status.

The study shows Water Quality Index (WQI) values between 43.64 and 86.19, averaging 69.76, across three sources. In February, WQI ranged from 51.6 at Tamda to 86.19 at Chebouba. In March, values varied from 43.64 at Tamda to 77.04 at Ayoune Soltane, and in April, from 44.46 at Tamda to 78.83 at Ayoune Soltane (Table 2). Overall, 78% of the samples were classified as “good” quality for drinking, with Tamda showing “excellent” quality in March and April. The water is suitable for consumption, with high WQI influenced by moderate levels of TDS, EC, and $Si(OH)_4$.

Conclusion

This study assessed the water quality of three sources in the Mila region to determine their suitability for human consumption. Nine samples were analysed for 16 parameters monthly. Most parameters met standards, though some slightly exceeded WHO limits for EC, TDS, NH4, and Si(OH)4, and silicate exceeded Algerian standards. Water Quality Index (WQI) values ranged from 43.64 to 86.19, indicating good to excellent

Table 2: The WHO standards for source water quality parameters, the weight values and WQI computation for individual source samples

	Si	*(Rw)*	*Wp*
pH	8.5	4	0,09524
T (°C)	25	3	0,07143
CE (µs/cm)	1000	5	0,11905
TDS (mg/L)	500	2	0,04762
Turb (NTU)	5	2	0,04762
Na (mg/L)	200	4	0,09524
Cl (mg/L)	250	4	0,09524
CO_3 (mg/L)	125	2	0,04762
HCO_3 (mg/L)	125	2	0,04762
SO_4 (mg/L)	200	4	0,09524
NO_3 (mg/L)	50	2	0,04762
NH_4 (mg/L)	35	2	0,04762
PO_4 (mg/L)	5	3	0,07143
$Si(OH)_4$ (mg/L)	10	3	0,07143
Total weight		42	1

WQI Computation for individual source samples			
Site	*Month*	*WQI value*	*Class*
Tamda	February	51.60	Good
	March	43,64	Excellent
	April	44,46	Excellent
AyouneSoltane	February	79,05	Good
	March	77,04	Good
	April	78,83	Good
Chebouba	February	86,19	Good
	March	75,32	Good
	April	75,31	Good

quality. The water meets both Algerian and WHO standards and is suitable for consumption. However, to prevent microbial contamination, daily chlorination is advised.

References

Allia, Z. and M. Lalaoui (2024). Formation mechanism of hydrochemical and quality evaluation of shallow groundwater in the Upper Kebir sub-basin, Northeast Algeria. *Journal of Groundwater Science and Engineering*, **12(1):** 78-91. http://gwse.iheg.org.cn/en/article/doi/10.26599/JGSE.2024.9280007

Allia, Z., Lalaoui, M. and M. Chebbah (2022). Hydrochemical assessment for the suitability of drinking and irrigation use of surface water in Grouz Dam Basin, Northeast Algeria. *Sustain. Water Resour. Manag* ; **8(88):** 3-16. https://doi.org/10.1007/s40899-022-00663-8

APHA (2005). Standard methods for the examination of water and waste water. Washington, DC: American Public Health Association.

Bartram, J., Lewis, K., Lenton, R. and A. Wright (2005). Focusing on improved water and sanitation for health. *Lancet [Lancet],* **365(9461):** 810-812.

Benjamin, A.P. and R. Brown (2003). Encyclopedia of Food science and Nutrition, 2nd Edition. Vol.10: UK Academic Press.

Chebbah, M. and C. et Lamouroux (2012). La Fosse Sud Aurésienne Au Néogène (domaine Pré-saharien, Algérie): Séquences De Dépôt, Propositions De Corrélations Et évolution Sédimentaire (The South Auresian Trough in the Neogene (Pre-Saharan domain, Algeria): Depositional sequences, proposed correlations and sedimentary evolution). *Bulletin du Service Géologique de l'Algérie*, **23(3):** 219-239. https://www.asjp.cerist.dz/en/article/948

Chiavola, A., Di Marcantonio, C., D'Agostini, M., Leoni, S. and M. Lazzazzara (2023). A combined experimental-modeling approach for turbidity removal optimization in a coagulation–flocculation unit of a drinking water treatment plant. *Journal of Process Control*, **130:** 103068. https://doi.org/10.1016/j.jprocont.2023.103068

Dheeraj, V.P., Singh, C.S. and A.K. Sonkar (2023). Assessment of surface and ground water quality around Korba Coalfield, India: An integrated approach of water quality index, multivariate statistics analysis and GIS technique. *Sustain. Water Resour. Manag.*, **9:** 191. https://doi.org/10.1007/s40899-023-00973-5

Garg, V.K., Suthar, S., Singh, S., Sheoran, A., Garima, Meenakshi, and S. Jain (2009). Drinking water quality in villages of Southwestern Haryana, India: Assessing human health risks associated with hydrochemistry. *Environ Geol.*, **58:** 1329-1340. https://doi.org/10.1007/s00254-008-1636-y

Glibert, P.M. (2020). Harmful algae at the complex nexus of eutrophication and climate change. *Harmful Algae*, **91:** 101583. https://doi.org/10.1016/j.hal.2019.03.001

Harvard, T.H. (2021). Chan School of Public Health. Biol. Behav. Asp. Salt Intake [Int. Conf.]. Available from. https://www.hsph.harvard.edu/nutritionsource/salt-and-sodium/

Horton, R.K. (1965). An index number system for rating water quality. *Journal of the Water Pollution Control Federation*, **37(3):** 300-306. http://www.jstor.org/stable/1730827

Meneses-Ruiz, E., Turtos-Carbonell, L.M. and I. Oviedo-Rivero (2004). Drinking water in Cuba and seawater desalination. *International Journal of Nuclear Desalination*, **1(2):** 219-229. https://doi.org/10.1504/IJND.2004.003674

Milliman, J.D. (2001). Delivery and fate of fluvial water and sediment to the sea: A marine geologist's view of European rivers. *Scientia Marina*, **65(2):** 121-132.

Mishrra, A., Wang, Z., Sidorkiewicz, V. and D.E. Giammar (2021). Effect of sodium silicate on lead release from lead service lines. *Water Research*, **188 :** 116485.

Nkono, N.A. and O.I. Asubiojo (1998). Elemental composition of drinking water supplies in three states in Southeastern Nigeria. *Journal of Radioanalytical and Nuclear Chemistry*, **227:** 117-119.

Obi, C.N. and C.O. Okocha (2007). Microbiological and physicochemical analysis of selected borehole waters. *Journals of Engineering Applied Science*, **257:** 920-929.

Onifade, A.K. and R.M. Ilori (2008). Microbiological analysis of sachet water vended in Ondo state, Nigeria. *Environmental Research Journal*, **2:** 107-110.

Parson, S.D., Bierman, J.R.V.J. and S.E. Silliman (1989). An evaluation of methods for the estimation of tributary mass loads. *Water Resour. Res*, **25(6):** 1379-1389.

Penner, G.B., Johnson, J.A., Sutherland, B.D., Clark, L.P. and C.J. Elford (2020). Effects of drinking water sulfate concentrations on feed and water intake, growth, and serum mineral concentrations in growing beef heifers1. *Applied Animal Science*, **36(2):** 201-207. https://doi.org/10.15232/aas.2019-01919

Ramakrishnalah, C.R., Sadas Hivalah, C. and G. Ranganna (2009). Assessment of water quality index for the groundwater in Tumkur Taluk, Karnataka state, India. *E-J Chem*, **6(2):** 523-530.

Rodier, J. (2009). The analysis of water: Natural waters, wastewater, seawater. 9th edition, Dunod, Paris, France, 1600 pages.

Schafera, A.I., Rossitera, H.M.A., Owusub, P.A., Richardsc, B.S. and E. Awuah (2009). Physico-chemical water quality in Ghana: Prospects for water supply technology implementation. *Desalination*, **248:** 193-203.

Toure, A., Duan, W., Keita, Z., Dembele, A. and E.E.A. Elzaki (2019). Drinking water quality and risk for human health in Pelengana commune, Segou, Mali. *J. Water Health*, **17:** 609-621. https://doi.org/10.2166/wh.2019.004

Trivedi, P., Bajpai, A. and S. Thareja (2010). Comparative study of seasonal variation in physico-chemical characteristics in drinking water quality of Kanpur, India with reference to 200 MLD filtration plant and ground water. *Nature and Science*, **8(4):** 11-17.

Uriu-hare, J.Y., Swan, S.H., Bui, L.M., Neutra, R.R. and C.L. Keen (1995). Drinking water source and reproductive outcomes in Sprague-Dawley rats. *Reproductive Toxicology*, **9(6):** 549-561. https://doi.org/10.1016/0890-6238(95)02005-5

Venkatesan, G., Swaminathan, G. and R. Nagarajan (2013). Study on groundwater quality in and around solid waste landfill site at Tiruchirappalli, Tamil Nadu, India. *International Journal of Environmental Engineering*, **5(2):** 179-196.

WHO (2011). World Health Organization Guidelines for Drinking Water Quality, 4rd editions. Incorporating the First and Second addendum. , Vol 1. Recommendation. Geneva. http://apps.who.int/iris/bitstream/10665/44584/1/9789241548151

WHO (2017). World Health Organization Guidelines for Drinking-water quality, 4th ed, Incorporating the First addendum. https://www.who.int/publications/i/item/9789241549950