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Assessment of the Quality of Tap Water Intended for Potability Using the IQE Water Quality Index Case of the Municipality of Sendjas (Algeria)

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Abstract: Water quality is an important criterion for meeting water demand and supply. Ensuring freshwater quality that meets human and ecological needs is therefore an important aspect of integrated environmental management and sustainable development. The objective of this study is to monitor and evaluate the quality of the water distributed to the municipality of Sendjas from the Sidi Yakoub dam to the consumer using the index of water quality which includes 10 parameters. (PH, TDS, nitrate, sulphate, bicarbonate, chloride, calcium, potassium, sodium and magnesium). Physico-chemical analyses were carried out on samples taken from the Sidi Yakoub dam, a reservoir which distributes water to the municipality of Sendjas called reservoir 500, and a sample from the house of one consumer directly from the tap. The results of the analyses obtained during our work show that there is a slight difference in the latter, but the quality of the physico-chemical water remains good and consumable at the level of two stations (Sidi Yakoub Dam, Reservoir 500) and Bad quality of the station which represents the municipality of Sendjas, the latter is due to the high content of chloride and the degradation of distribution networks.

Key words: The water quality index (IQE), the municipality of Sendjas, physico-chemical analyses, the consumer.

Introduction

The availability of potable water is being addressed by urbanisation, population increase and climate change across the world (Global Water Partnership, 2014). The deterioration of the quality of water resources therefore becomes a concern on a global scale. Several studies have been made on water quality, particularly on the African and Asian continents, where a large part of the population does not have access to drinking water or has access to poor quality water (Ayenuddin et al., 2019; Dhawde et al., 2019; Orelien and Frantzy, 2017; Palamuleni and Akoth, 2015; Sila Onesmus, 2019).

Thus water resources are a major concern in areas with arid or semi-arid climates as they are absolutely essential for the development of economic and social human activities (Tampo et al., 2015). Awareness of its quality gives a global vision of risks in order to ensure the protection of resources and to identify possible sources of water quality impairment (Myers, 2015; Normatov et al., 2015).

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pollution can be mineral or microbiological. Surface water is highly polluted unlike groundwater, which is well protected. Polluted water must undergo different treatments: physical, chemical and biological, depending on the degree and nature of the pollution, in order to make them drinkable (Cuq, 2007). In Algeria, water is an increasingly precious resource. The competition between agriculture, industry and drinking water supply for access to limited water supplies (Remini, 2010). This work aims to evaluate and characterize the physico-chemical quality of drinking water distributed in the area of Sendjas, a municipality of the Wilaya of Chlef through the water quality index IQE.

Materials and Methods

Geographical Location of the Study Area

Sendjas is one of the municipalities of the Wilaya of Chlef in Algeria; it is located 12 km south of Chlef at the foot of Ouarsenis (Figure 1).

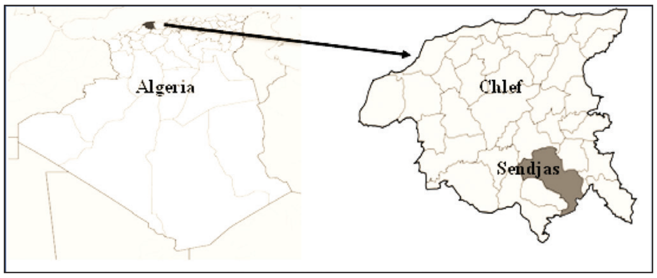


Figure 1: Geographic location of the study area (Google Earth 2022) (ASAL 2021).

Presentation of Sidi Yakoub Dam

The Sidi Yakoub dam is located on the Oued Ardjem 20 kilometers south of the city of Oued Fodda in the Wilaya of Chlef. Its capacity is 286 hm^3. It is intended for:

- Irrigation of a perimeter of approximately 10,000 ha
- The drinking water supply of the Chlef Wilaya.

The surface of the watershed of the ARDJEM wad is 920 km^2, whose average intake of the wad is 98 hm^3/year. The average annual siltation is 0.17 hm^3/year (ANBT, 2021).

Climatology

The Ombrothermic Diagram of BAGNOULS and GAUSSEN

The most widely used method in the Mediterranean region is the EMBERGER rainfall climagram. These two systems summarise the bioclimate of a given station by three fundamental elements of the climate: precipitation (mm) - maximum and minimum temperatures (°C) (Figure 2). The difference in precipitation between the driest month and the wettest month is 68 mm. Between the lowest and highest temperature of the year, the difference is 18.8 °C. The month with the highest relative humidity is January (76.29%). The month when the rate of relative humidity is the lowest is July (43.39 %). The month with the most rainy days is November (9.97 days). The month with the lowest number is July (0.33 days).

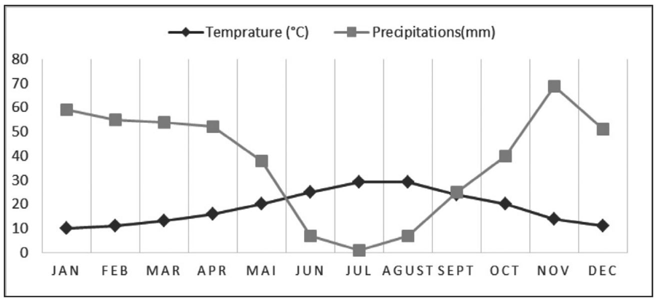


Figure 2: Ombrothermic Diagram of BAGNOULS and GAUSSEN.

Location of Sampling Sites

The sampling period was during the month of February. The table shows the locations and dates of sampling in the study area (Table 1).

Table 1: Places and dates of samples

Surface water	*Location*	*Date*
Sidi Yakoub dam	Oued Lardjem	22/02/2022
Reservoir 500	Sendjas	23/02/2022
Consumer	Sendjas	23/02/2022

Methods of Analysis of Physico-chemical Parameters

The table below represents respectively the methods of calculation and analysis of the different physico-chemical parameters of our experimental study. The physico-chemical parameters include pH, TDS and temperature T°C, measured (in situ) in the field, and $SO4^{2-}$, Cl^-, Na^+, K^+, NO^{3-}, Ca^{2+}, HCO^{3-}, Mg^{2+} analysed by laboratory. These parameters were determined using the analysis methods recommended by Rodier et al. (2009).

Calculation of the Water Quality Index (IQE)

This index is a water quality classification technique based on the comparison of water quality parameters with international or Moroccan national standards in our case study. In other words, the WQI summarises large amounts of water quality data in simple terms (Excellent, Good, Poor, Very Poor, etc.). This method was originally proposed by Horton (1965) and Brown et al. (1970). In this study, the IQE index was applied to estimate the influence of natural and anthropogenic factors on the basis of several key parameters of the drinking water chemistry of Sendjas. This index was calculated using the weighted arithmetic index method (Brown et al., 1970; Brown et al., 1972; Chatterji and Raziuddin, 2002; Yidana and Yidana, 2010). In this approach, a numerical value called relative weight (Wi), specific to each physico-chemical parameter, is calculated (Table 2) according to the following formula:

$$W_{\mathrm{i}} = \frac{k}{S_i} \tag{1}$$

k = proportionality constant and can also be calculated using the following equation:

$$k = \frac{1}{\sum_{i=1}^{n}(1/S_i)} \tag{2}$$

n is the number of parameters S_i is the maximum value of the Algerian standard for surface waters of each parameter in mg/l except for pH, T°C and electrical conductivity. Then, a quality assessment scale (Qi) is calculated for each parameter by dividing the concentration by the standard of said parameter and multiplying the whole by 100 as in the following formula:

$$Q_{\mathrm{i}} = \left(\frac{C_i}{S_i}\right) \times 100 \tag{3}$$

Q_i: quality assessment scale for each parameter.
C_i: the concentration of each parameter in mg/L

Finally, the overall water quality index is calculated by the following equation:

$$IQE = \sum_{i=1}^{n} Q_i \times W_i \Big/ \sum_{i=1}^{n} W_i \tag{4}$$

Five quality classes can be identified according to the values of the water quality index IQE (Table 2).

Table 2: Classification and possible use of water according to the WQI (Aher et al., 2016; Brown et al., 1972; Chatterji and Raziuddin, 2002)

IQE class	*Type of water*	*Possible use*
0 – 25	Excellent quality	Drinking water, irrigation and industry
>25 - 50	Good quality	Drinking water, irrigation and industry
>50 – 75	Bad quality	Irrigation and industry
>75 – 100	Very bad quality	Irrigation
>100	No-drinkable water	Appropriate treatment required before use.

Results and Discussion

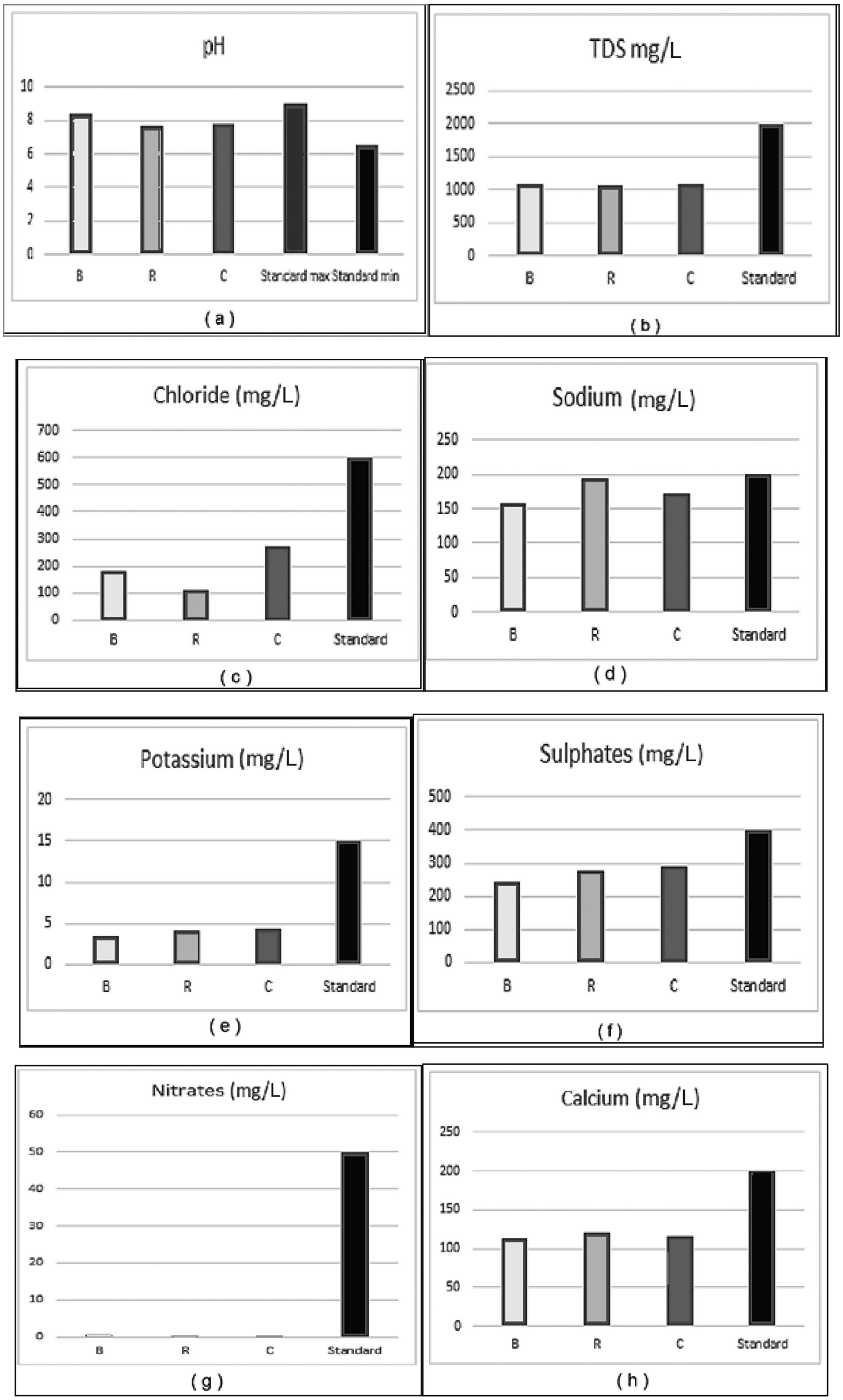
In order to study the quality of the water circulating along the chain (dam–reservoir-consumer), we compared our results with Algerian standards (Table 3).

Physical and Chemical Parameters

- B: Dam
- A: Reservoir
- C: Consumer
- The pH values of the waters studied B, R and C are between 7.69 and 8.39, referring to the drinking water quality standards, the pH values of the waters studied comply with the Algerian standards whose values are set from 6.5 to 9. This explains why the water does not undergo any contact with oxidants or reducers during its journey. There is not a great variation for the 3 sampling areas (Figure 3a).
- The TDS levels measured show varying values between 1071 mg/L and 1085 mg/L, so the results do not exceed the Algerian standards of 1500 mg/L (Figure 3b).

Table 3: The values of (Qi) of each parameter of the three stations

Parameter	*pH*	*TDS*	NO_3^-	Cl^-	NO_4^{2-}	HCO_3^-	Ca^{2+}	Na^+	K^+	Mg^{2+}
Dam	93,22	72,33	0,8	30,5	61,25	44,22	56,5	25,06	79,5	23,33
Reservoir	85,44	71,4	0,5	18,68	69,25	23,3	60,5	26,1	96,5	28
Consumer	85,88	71,66	0,76	45,1	72,75	62,01	58	26,01	85,5	28


pH
10
8
6
4
2
0
B
R
C
Standard max
Standard min
(a)
TDS mg/L
2500
2000
1500
1000
500
0
B
R
C
Standard
(b)
Chloride (mg/L)
700
600
500
400
300
200
100
0
B
R
C
Standard
(c)
Sodium (mg/L)
250
200
150
100
50
0
B
R
C
Standard
(d)
Potassium (mg/L)
20
15
10
5
0
B
R
C
Standard
(e)
Sulphates (mg/L)
500
400
300
200
100
0
B
R
C
Standard
(f)
Nitrates (mg/L)
60
50
40
30
20
10
0
B
R
C
Standard
(g)
Calcium (mg/L)
250
200
150
100
50
0
B
R
C
Standard
(h)

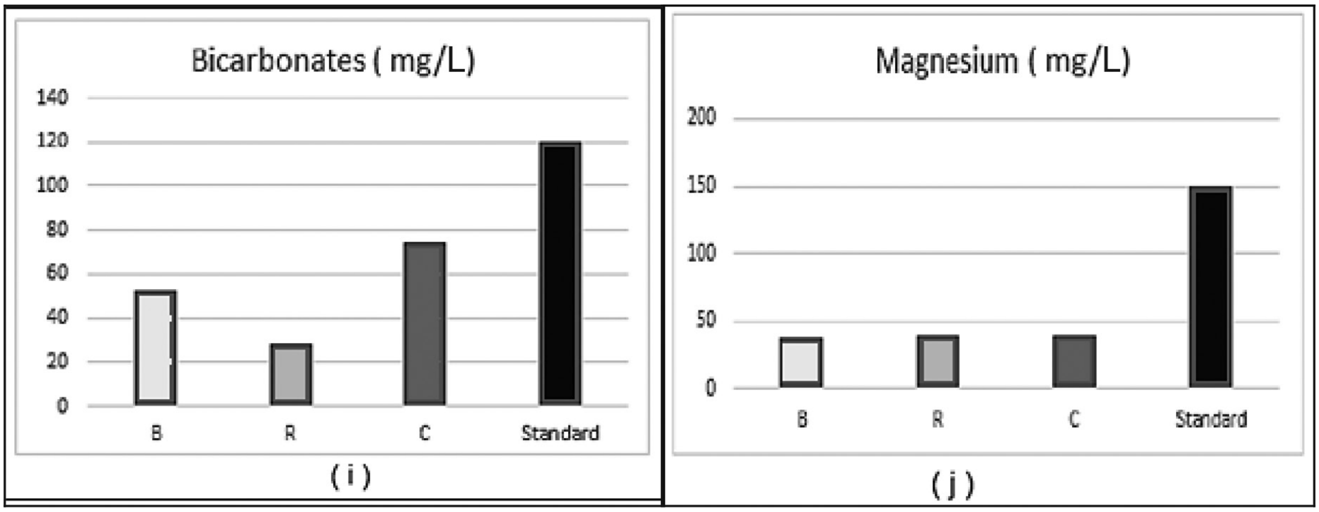


Figure 3: Results of the physico-chemical analysis along the chain (D: dam – R: reservoir-C: consumer).

- According to the results obtained, the chloride contents of the waters studied vary between 112.1 mg/L and 183.07 mg/L, these chloride concentrations are less than 600 mg/L According to Algerian standards, therefore the quality of the waters studied is acceptable (Figure 3c).
- The concentrations of sodium, comply with the prescribed standards of 200 mg/L. Their contents vary between 159 mg/L and 193 mg/L (Figure 3d).
- The potassium concentrations of the samples analyzed are between 3.5 mg/L and 4.3 mg/L. the potassium content is still within the prescribed standard 15 mg/L (Figure 3e).
- According to the results obtained, the concentrations of sulphates vary between 248 mg/L and 291 mg/L These sulphate contents comply with the limit values determined by Algerian standards 400 mg/L (Figure 3f).
- According to the results obtained, the nitrate concentrations vary between 0.25 mg/L and 0.40 mg/L. These nitrate levels comply with the limit values determined by the Algerian standards 50 mg/L (Figure 3g).
- The calcium contents vary between 113 mg/L and 121 mg/L and its contents are well below the Algerian standard which is 200 mg/L (Figure 3h).
- During the analyses carried out, the content of the bicarbonates found in the three samples varied from 28.06 to 74.42 mg/L conforming to potability standards (Figure 3i).
- There is not a big difference between the different values obtained, 37.6 mg/L in B and 39.2 mg/L in R and C, they are all within the range of Algerian standards which set the rate of magnesium at 150 mg/L (Figure 3j).

The water quality index IQE during the company of February 2022 indicates that the two stations (B and R) or 90% of the stations, remain of good quality (0 <IQE ≤47,93). The remaining station, representing 10% of each of all stations, also remains without seasonal change with Bad quality (50 <IQE ≤75) for station C of the municipality of Sendjas. However, the class of excellent quality remains absent (Table 4 and Figure 4). The increasing degree of water degradation at station C is linked to the degradation of drinking water distribution networks in the municipality of Sendjas

Table 4: IQE calculation results for the waters studied

Parameter	*Sample*		
	B	*R*	*C*
pH	7,5	6,92	6,9
TDS	9,4	9,2	9,31
NO_3^-	0,1	0,065	0,09
Cl^-	3,96	2,4	5,86
SO_4^{2-}	7,96	9	9,4
HCO_3^-	1,19	0,6	1,6
Ca^{2+}	3,051	3,2	3,1
Na^+	3,25	3,3	3,3
K^+	10,33	12,5	11,1
Mg^{2+}	0,62	0,75	0,75
IQE	47,36	47,93	51,41
Class IQE	Good quality	Good quality	Bad quality

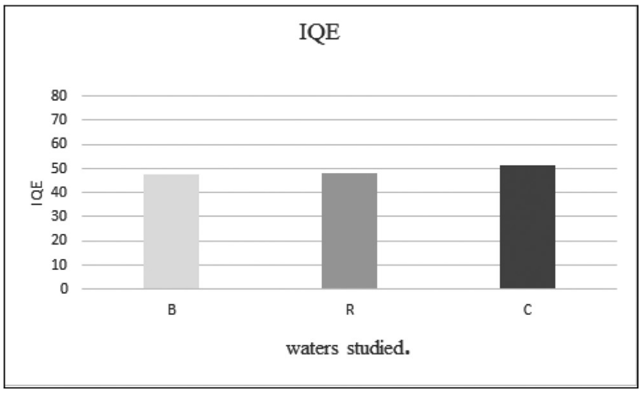


Figure 4: The variation in IQE of the waters studied (D: dam – R: reservoir-C: consumer).

thus to the high contents of certain physico-chemical parameters (chloride, sulphate and bicarbonate) (Figure 4).

Conclusion

Before any water consumption, it is necessary to check the physicochemical quality of the water. Neglecting this control can cause waterborne diseases to the population, in case of consumption of polluted water. To reduce the resulting diseases, awareness campaigns must be launched among the population living in sanitary conditions that do not comply with international standards.

This study made it possible to evaluate the physico-chemical quality of water in the Sendjas region, using the IQE water quality index, which makes it possible to know the quality of water in the area of study, hence the results of the analysis carried out for certain physico-chemical parameters of the three consecutive stations (Sidi Yakoub Dam, Reservoir 500 and Consumer) in the study region. The results of the analyses obtained during our work show that there is a slight difference in the latter, but the quality of the physico-chemical water remains good and consumable at the level of two stations (Sidi Yakoub Dam, Reservoir 500) and bad quality of the station which represents the municipality of Sendjas, the latter is due to the high content of chloride and the degradation of distribution networks. The analysis of water is still necessary to protect the consumer. In perspective, it will be interesting to do the analysis of water in all regions and when it will be distributed to consumers to avoid diseases and serious consequences on human health.

References

Aher, D.N., Kele, V.D., Malwade, K.D. and M.D. Shelke (2016). Lake water quality indexing to identify suitable sites for household utility: A case study Jambhulwadi Lake; Pune (MS). *Int. Journal of Engineering Research and Applications*, **6(5):** 16-21.

ANBT (2021). L'Agence National des Barrages et Transferts 2021.

Ayenuddin, H., Abu Sayed, J. and S. Papia (2019). Assessment of physicochemical and bacteriological parameters in surface water of Padma River, Bangladesh. *Applied Water Science*, **9:** 10. DOI: 10.1007/s13201-018-0885-5

Brown, R.M., McClelland, N.I., Deininger, R.A. and M.F. O'Connor (1972). A water quality index - crashing the psychological barrier. *In:* Thomas W.A. (eds). Indicators of Environmental Quality. *Environmental Science Research*, **1:** 173-182. Springer, Boston, MA. https://doi.org/10.1007/978-1-4684-2856-8_15 .

Brown, R.M., McClelland, N.I., Deininger, R.A. and R.G. Tozer (1970). A water quality index- Do we dare? *Water and Sewage Works*, **117:** 339-343.

Chatterji, C. and M. Raziuddin (2002). Determination of water quality index of a degraded river in Asanol Industrial area, Raniganj, Burdwan, West Bengal. *Nature, Environment and Pollution Technology*, **1(2):** 181-189.

Dhawde, R., Surve, N., Macaden, R., Wennberg, A.Ch., Seifert-Dähnn, I., Ghadge, A. and T. Birdi (2019). Physicochemical and bacteriological analysis of water quality in drought prone areas of Pune and Satara Districts of Maharashtra, India. Environments. https://doi.org/10.3390/environments5050061.

GWP (Global Water Partnership) (2014). Towards a water secure world: Water & urbanisation, water & climate change. Available from:https://www.gwp.org/en/CRITICALCHALLENGES1/Water-and-Urbanisation/

Horton, R.K. (1965). An index number system for rating water quality. *Journal of Water Pollution Control Federation*, **37(3):** 300-306.

Myers, D.N. (2015). Foundations of Water Quality Monitoring and Assessment in the United States. Elsevier Inc. p. 21-92.

Normatov, P.I., Armstrong, R., Normatov, I.S., Narzulloev N., Russ. Meteorol. (2015). Hydro+. **40:** 347-354.

Orelien and Frantzy (2017). Etude de la qualité de l'eau destinée à la consommation humaine dans le sousbassin versant de Ravine Diable (Anse-a-Veau) [Study of the quality of water intended for human consumption in the Ravine Devil subwatershed (Ansea-Veau)]. Master's degree in Environmental Science and Management in Developing Countries. University of Liège, Belgium. http://hdl.handle.net/2268.2/3245

Palamuleni, L. and M. Akoth (2015). Physico-chemical and microbial analysis of selected borehole water in Mahikeng, South Africa. *Environmental Research and Public Health*, **12(8):** 8619-8630. https://doi.org/10.3390/ijerph120808619.

Remini, B. (2010) :La problématique de l'eau en Algérie du nord.Lary. J. 08

Rodier, J. (2009). L'analyse de l'eau, 9e édition. DUNOD (éditeur), Paris, France.1579 p.

Sila Onesmus, N. (2019) Physico-chemical and bacteriological quality of water sources in rural settings, a case study of Kenya, Africa. Scientific African. **2:** e00018, https://doi.org/10.1016/j.sciaf.2018.e00018.

Tampo, L., Gnazou, M., Akpataku, V., Bawa, L. and G. et Djaneyé-Boundjou (2015). Application des méthodes statistiques à l'étude hydrochimique des eaux d'un hydrosystème tropical: Cas du bassin versant de la rivière Zio (Togo). *European Scientific Journal*, **11(4):** 204-225.

Yidana, S.M. and A. Yidana (2010). Assessing water quality using water quality index and multivariate analysis. *Environmental Earth Sciences*, **59(7):** 1461-1473. . https://doi.org/10.1007/s12665-009-0132-3.

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