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VALUATION OF WATER FOR DRINKING AND DOMESTIC PURPOSES USING (WQI). CASE STUDY : GROUNDWATER OF ABU-WAGNAH VILLAGE, TAL-AFAR DISTRICT, IRAQ.

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Abstract

The current study came to assess the quality of groundwater for the village of Abu- Wajnah, Tal Afar District, Nineveh Governorate, for drinking and domestic uses, as water samples were collected from fourteen wells scattered in the study area during the spring and summer seasons to conduct physical and chemical analyzes based on international standard methods and the use of the overall index of pollution (OIP**)** model. The results of the overall index of pollution (OIP) indicated that the studied groundwater was suitable for drinking and domestic uses, as the values of the overall index of pollution (OIP) ranged between (0.65 to 1.26). However, the quality of the water studied is of excellent water quality (Class C_1).

Key words: *Groundwater quality, Abu-wagnah village, Overall index of pollution*.

Introduction

Water chemistry in any aquatic ecosystem depends on the different lithological characteristics, weathering of rocks in the geological layers that water passes through, human activities such as wastewater and agricultural activity that play a role in the deterioration of the water quality, which affects the quality of water and thus affects the health and safety of citizens, livestock, poultry, and the productivity of irrigated plants, so the quantity and quality of water is one of the vital factors affecting the human being and its development and economy (Al-Saffawi *et al.,* 2018a; Al-Asaaf *et al.,* 2020).

Therefore, water has become a precious resource due to climatic changes and scarce rainfall, especially in arid and semi-arid regions. The demand for water has increased in recent decades, which has led to water scarcity in many regions of the world as is the case in some African countries. As for the Iraqi country, which suffers from the water problem, especially the central and southern parts of the country, as a result of the water policies of neighbouring countries (Turkey and Iran), such as the construction of giant dams in Turkey, which affected the amount of water discharged to it. Therefore, this issue must be taken seriously and use the proper management of water resources and periodic follow-up of water quality with the use of modern methods in evaluation to stand at any unsound condition, such as the use of mathematical models (Al-Saffawi, 2018a; Talat and Al-Saffawi, 2019).

The idea of a water quality index to determine water quality for different uses was proposed by Horten in 1965, as it reflects the overlapping effects of the characteristics studied in determining water quality and is one of the most influential methods for monitoring surface and groundwater pollution .It gives one value instead of a large number of data that confuses the reader, thus it is understandable to the specialist and non-specialist (Al-Hamdany and Al-Saffawi, 2018). The studies conducted in Nineveh Governorate to assess the groundwater quality using the water quality index are limited compared to other regions in the world, and work has started in this field significantly in the last ten years, including the study of Al-Saffawi *et al.,* (2018) for the groundwater quality in the village of Gleewkhan in northeastern Iraq using WQI as an important source of water in the village, the results indicated that the water quality was unfit for drinking and domestic uses, as well as a study of Al-Saffawi & Al -Sardar (2018) of the groundwater situation in the villages of Abu Jarboua and Al-Daraweesh of the sub-district of Bashiqa and the results of the WQI values indicated that the water is not suitable for drinking and

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civil uses. Also, the study of Al-Safawi (2019) for the quality of water wells of Al-Nimrod sub-district, south of Mosul city, for drinking purpose using (CCMEWQI). The results of the study indicated high levels of most of the studied characteristics, which reflected negatively on the values of CCME WQI, where 70% of them were classified as poor water quality for drinking and domestic purposes. The study recommended periodic monitoring of water quality with water treatment processes before using it for drinking. Finally, Talaat *et al.,* (2019) also studied the assessment of groundwater quality in Al-Gameaa and Al-Zeraee quarter in Mosul city, Iraq for drinking and domestic purposes using WQI, the results showed that the quality of the studied groundwater is not suitable for use. They attributed this deterioration in water quality to higher levels of electrical conductivity, total hardness, sulfate ions and bacterial contamination.

Therefore, the current study came to evaluate the groundwater for the village of Abu Wajnah, Tal Afar district for civil and drinking uses. As a major source of water in the region and away from surface water.

Materials and Methods

Description of the study area:

The village of Abu-Wajnah (also called Burqaid) is located in the northwest of the city of Mosul, 90 km away and belonging to the Zammar sub-district, Tal Afar district, Nineveh governorate, on longitude (36°41'28") N and latitude (42°37'22") E and the atmosphere is hot dry summers and cold, rainy winters. The average annual rainfall is 450 mm (Atiyah, 2018) and most of its residents work in agriculture and livestock breeding. As a result of their distance from rivers, people depend on groundwater for use for different purposes. As fourteen wells scattered in the village were randomly identified in the study area, whose depth ranges between (18-30) meters and that nine of them are from deep wells and the rest of the surface type (Al-Shanona *et al.,* 2018) as shown in Fig. 1.

Geology of the region:

Several geological formations are spread in the region, such as Plaspi formation (Middle-upper Eocene) containing limestone and Al-Fa'tha formation (Middle-Miocene) containing limestone and gypsum rocks ($CaSO_4.2H_2O$), anhydrite ($CaSO_4$) and evaporated salts as well as yellow marl with sandy, alluvial or clay layers, the formation of Injana (Upper-Miocene) consisting of successive sandy and alluvial layers and sometimes clay and the formation of Miqdadiya (Pliocene) and appear in the region the quaternary era deposits consisting of gravel, sand, silt and clay, which covers the formations of the Al-Fa'tha and Injana irregularly. (Salim and Abdul-Qader, 2008; Al-Hamdany and Al-Saffawi, 2018). Thus, the main reactions that occur in the geological layers are those that control the quality of groundwater, such as the Dolomitization process, which includes the dissolution of the dolomite, which encourages the dissolution of anhydrite.

Sampling and Methodology:

Water samples were collected during the spring and summer seasons (4 replications per well), using clean polyethene bottles with a note of the colour and smell of water samples to record observations in an emergency using the standard methods of collecting and analyzing samples (APHA, 1998, 2017). The pH, Total dissolved solid and Total Alkalinity, Total hardness, calcium, magnesium, sodium, chlorides, and sulfates ions were determined.

Calculation of overall index of pollution (OIP):

Estimating the water quality index, the overall index of pollution (OIP) was chosen, this model shows the health status of water when used for drinking and domestic purposes under Iraqi environmental conditions, and The OIP was applied using nine properties (pH, TDS, T. Hard. T. Alk., Ca, Mg, Na, Cl and SO_4) as in the following equations (Kamboj and Kamboj, 2019):

$$OIP = \frac{1}{n}\sum_{i=1}^{n} Pi$$

$$Pi = \frac{Vt(Tested\ value\ of\ the\ parameter)}{Vs(Standard\ limit\ of\ the\ parameter)}$$

Where, Pi: The pollution index value of i^{th} parameter., n: The total number of parameters used in the model.

Then the water quality is classified according to the OIP values into five categories (Sargaonkar and Deshpande, 2003): When the value of OIP is less than <1.9, the water quality is an excellent category and it is in the class of C_1, and if it is less than 3.9 and greater than 1.9, the quality is an acceptable category and it is in the class C_2. If the OIP values < 7.9, < 15.9 and > 16 are Slightly polluted Category (Class, C_3), Polluted category (class, C_4), Severe Polluted category (class, C_5) consecutively.

Results and Discussion

Groundwater quality information is vital to meet the needs of the region's residents and to preserve the lives and health of consumers. The current study was conducted to evaluate the quality of groundwater for the village of Abu-Wajnah using the overall index pollution (OIP) model. Nine physical and chemical properties were analyzed. Fortunately, the quality of the studied groundwater was suitable for drinking and civilian uses, and according to the characteristics studied, as shown in the table 1. It is noted from the table that the overall index pollution (OIP) values ranged between (0.65 to 1.26). However, the quality of the water studied is from the category of excellent quality water (Class C_1). This difference in the (OIP) values of the studied groundwater is due to the differences in the concentrations of the specific properties of the water quality. It is also noted from the table that the most parameters affecting the water quality in our current study, which had a greater value of the pollution index (Pi) than other parameters are the pH, TDS, T. Alkalinity and Total Hardness.

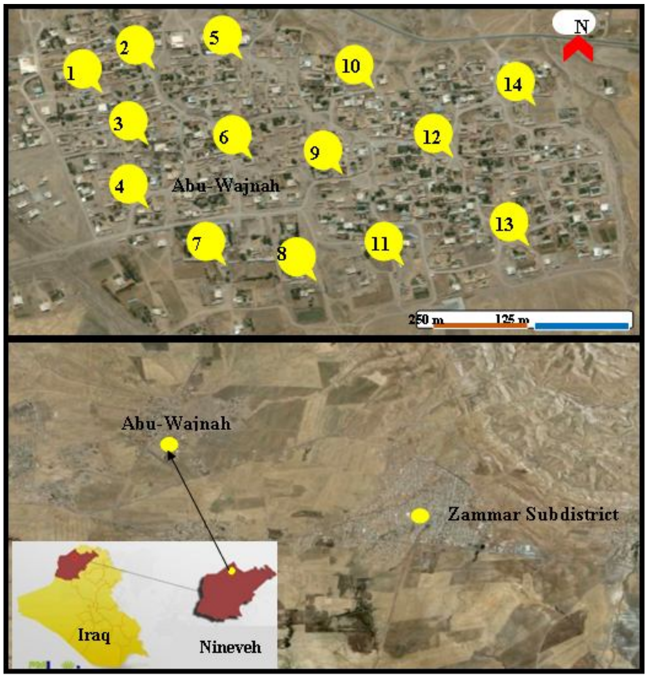

Fig. 1: Groundwater collection sites for Abu-Wajnah village, Zammar district.

Table 1: The values of the pollution index (Pi) and the Overall pollution index (OIP) of groundwater for the village of Abu-Wajnah.

Pollution index for the parameters (Pi)												
Sits	pH	TDS	T.A	T.H	Ca	Mg	Na	Cl	SO_4	©Pi	OIP	Class
1	1.08	1.10	2.55	1.26	0.48	0.65	0.87	0.53	0.30	8.82	0.98	C_1
2	1.10	1.25	2.63	1.36	0.47	0.77	0.90	0.64	0.35	9.47	1.05	C_1
3	1.07	1.14	2.52	1.27	0.45	0.67	0.78	0.53	0.36	8.79	0.98	C_1
4	1.11	0.96	2.66	1.15	0.40	0.61	0.72	0.34	0.33	8.28	0.92	C_1
5	1.09	0.85	2.63	1.13	0.41	0.59	0.45	0.92	0.25	7.69	0.85	C_1
6	1.09	1.49	2.56	1.59	0.55	0.85	1.13	0.61	0.60	10.5	1.17	C_1
7	1.13	0.81	2.53	1.08	0.41	0.57	0.50	0.35	0.39	7.77	0.89	C_1
8	1.09	0.86	2.50	1.16	0.42	0.62	0.50	0.28	0.40	7.83	0.87	C_1
9	1.12	0.62	2.24	0.90	0.29	0.33	0.36	0.12	0.25	6.23	0.69	C_1
10	1.12	0.83	1.00	1.11	0.38	0.56	0.42	0.24	0.35	6.01	0.67	C_1
11	1.11	0.66	2.30	0.91	0.32	0.56	0.42	0.24	0.23	6.75	0.75	C_1
12	1.15	0.75	2.58	1.02	0.37	0.53	0.46	0.19	0.35	7.40	0.82	C_1
13	1.13	1.61	2.42	1.61	0.65	0.77	1.23	0.69	1.27	11.4	1.26	C_1
14	1.09	0.84	2.57	1.02	0.33	0.92	0.56	0.21	0.31	5.85	0.65	C_1
Vs	6.5	1000	200	500	200	150	200	250	400			

T.A: Total Alkalinity., T.H: Total Hardness., Vs: Standard value (ppm).

The pH shows the acidity and basicity of aqueous samples. It is noted from table 2 that the pH values were close to the parity state, and the values varied between (6.98-7.46) that this decrease in a fluctuation of values, which did not exceed 0.48, is due to the presence of bicarbonate ions Likewise, the existence of calcium and magnesium carbonate in the geological layers of the area that dissolves in the presence of carbonic acid, as shown in the following equations (Al-Asaaf *et al.*, 2020).

$$CO_2+H_2O \longrightarrow H_2CO_3$$

$$H_2CO_3+CaCO_3 \longrightarrow Ca(HCO_3)_2$$

$$CaMg(CO_3)_2+2H_2CO_3 \longrightarrow Ca(HCO_3)_2+Mg(HCO_3)_2$$

Without the Acid Neutralization Capacity (ANC), the decrease in values would have been significant and thus increase the negative effects on humans, livestock and plants due to the increase in the dissolution of heavy mineral elements from the rocks through which the water passes (Kamboj and Kamboj, 2019; Al-Saffawi and Al-Maathidi, 2017), for the same reasons shown in the above equations, the levels of total alkalinity levels rise to reach the highest average to 525 ppm so, that it exceeds the limits allowed for drinking and domestic use WHO, 2011). For the same reasons, the concentrations of the total dissolved solids (TDS) ranged between (622 to 1614) ppm, and this difference in values is due to the nature of the geological formations that the groundwater passes through. Such as the formation of Al-Fatha, consisting of evaporated salts, gypsum, dolomite, and the formation of Injana consisting of sequences of sandstone and siltstone, etc. These differences are reflected in the quality of the water passing through it (Al-Yousbakey *et al.*, 2018). Overall, 64% of the results were within the permissible limits for drinking (WHO, 2011).

These results are relatively comparable to the results reached by Al-Safawi *et al.,* (2018b), with the highest average (1799) ppm when studying the groundwater of Abu Maria village, Tal Afar district, Iraq and the results of the Al-Saffawi (2018) study on the groundwater of Sinjar district, Nineveh Governorate, with the highest average

Table 2: Average* and standard deviation of the specific characteristics of groundwater for the village of Abu-Wajna (ppm).

Wells No.		pH	TDS	T.A.	T.H.	Ca	Mg	Na	Cl	SO_4
1	*Mean± Sd*	7.030.18	110428.7	51022.5	62918.2	9520	9817	17421	1337.7	12120.1
2	*Mean± Sd*	7.120.12	124549.4	52623.3	68138.1	944.5	1152.8	17913.4	15918.3	14123.6
3	*Mean± Sd*	6.980.14	1143102	50411.6	63418.5	895.5	1005.6	1557.15	1326.06	14312.1
4	*Mean± Sd*	7.210.16	96127.5	51221.2	57515.0	8011	914.9	1435.02	863.8	13115.0
5	*Mean± Sd*	7.050.16	84819.7	52517.8	56421.6	815.5	882.7	893.5	736.7	9830
6	*Mean± Sd*	7.050.04	149055.2	51114.4	79536.4	1106.1	1277.7	22514.9	1522.05	23912.0
7	*Mean± Sd*	7.340.25	81442.4	50514.3	53930.1	812.1	856.0	1008.0	8730	15412.0
8	*Mean± Sd*	7.100.02	86033.9	50014.1	58136.5	834.9	936.7	1005.6	718.5	16010.2
9	*Mean± Sd*	7.260.01	62222.1	4472.45	44842.9	578.7	5020	726.3	293.3	9929
10	*Mean± Sd*	7.270.15	82555.7	50114.8	55616.4	756.6	8413	842.7	594.0	14140.1
11	*Mean± Sd*	7.210.07	66222.2	46013.3	45520.6	636.3	734.7	827.7	334.0	93.012.4
12	*Mean± Sd*	7.460.22	74585.8	5159.6	51043.0	748.0	797.5	915.4	4812	14126.6
13	*Mean± Sd*	7.360.17	161483.8	48462.7	80317.0	13044	11623	2468.96	1722.4	50621.7
14	*Mean± Sd*	7.060.02	8424.48	5135.72	5108.16	668.2	1387.0	1122.16	521.3	12512.3

*Mean of four replications., T.A.: Total Alkalinity., T.H.: Total Hardness

(1671) ppm, but it was less than the results obtained by Al-Saffawi *et al.,* (2020) for groundwater in Al-Kasik region, Tal-Afar district, which rates ranged between (1981 to 2313) ppm. This is due to the differences nature of the geological formations of the Kasik region, compared to the village of Abu-Wajnah.

As for the total hardness and its causes (calcium and magnesium ions) in the water, it plays a protective role to reduce the toxic effects of some toxic substances, such as the toxic heavy metal elements, the reproduction and corrections of the DNA and the mechanical inhibition of the effect of some carcinogens on the human body (Al-Saffawi, 2018). Despite its negative impact on the taste and the formation of crusts in boilers etc. when their concentrations are higher than the permissible limits.

The results are shown in table 3 indicate that the average concentrations of total hardness and calcium and magnesium ions reached to 803, 130 and 138 ppm consecutively. Generally, 86% of the total hardness values of the studied water exceed the internationally accepted high limits (WHO, 2011). This rise in concentrations is due to the dissolution of the dolomite and limestone in the rocks through which the waters pass (Jaafer and Al-Saffawi, 2020). Sodium ions are also important for public health because of their relationship with blood pressure, in addition to that high concentrations of sodium ions stimulate the occurrence of cancerous tumours when exposed to carcinogens (WHO, 2003), and the results indicate that the values of values ranged between 72 to 246 ppm. Fortunately, 87% of the values were within the limits permitted by the WHO.

The high levels of chlorides and sulfates in drinking water (> 250 $mg.L^{-1}$) give water an unpleasant aftertaste to people unfamiliar with high concentrations as well as laxative effects as well as negative effects on animals and plants (Al-Saffawi and Alshuuchi, 2018). The results ranged between (33 to 172) and (98 to 506) ppm, consecutively and 93% of the samples within the permissible sulfate limits. Likewise, all chloride values are within the limits permitted by the WHO. These high concentrations are due to the possibility that they pass in the composition of Al-Fatha formation which containing gypsum, anhydrite and evaporated salts (Al-Sanjari *et al.,* 2019).

Conclusions and Recommendations

The groundwater of Abu-Wajnah village was distinguished by the fact that the overall index of pollution (OIP) values were from the category of excellent water quality (class C_I) for drinking and civil uses, despite the presence of relatively high concentrations of both T. alkalinity, T. hardness and TDS, so we recommend periodic checks to know the reality of water and take the necessary solutions when needed.

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References

Al-Sinjari, W.E., A.Y.T. Al-Saffawi and Y.A.J. Al-Taee (2019). Application of WQI model to assessment of water for irrigation and livestock drinking purpose: The Case study:

groundwater quality of Gleewkhan village southeastern of Mosul city Iraq. *J. of Eng. and Appl. Sci.,* **14(9):** 10706-10710.

Al-Asaaf, A.Y.R., R.A. Talat, and A.Y.T. Al-Saffawi (2020). Suitability of water for irrigation purpose using IWQI model: The case study groundwater quality of some quarters in Mosul city, Iraq. *Plant Archives,* **20(1):** 1797-1802.

Al-Assaf, A.Y.R., R.A. Talat and A.Y.T. Al-Saffawi (2020). Suitability of water for irrigation and livestock watering purpose using IWQI Model: The case study, groundwater quality of some quarters of Mosul city, Iraq. Plant Archives, **20(1):** 1797-1802.

Al-Hamdany, A.S. and A.Y.T. Al-Saffawi (2018). Evaluation of the groundwater quality of the right side of Mosul city for drinking purposes using the water quality index (WQI (Proceeding of the 1st Int. Conf. and Scientific 3rd of coll. Of Sci. Univ. Of Tikrit Iraq., 17-18 Dec. 2018 (P-3), pp: 23-32.

Al-Hamdany, A.S. and A.Y.T. Al-Saffawi (2018). Evaluation of the groundwater quality of the right side of Mosul city for drinking purposes using the water quality index (WQI). Proceed. of the 1st int. and 3rd sci. Conf. of the Faculty of Sci. Tikrit Uni, Iraq, 17-18 December 2018 (part 9): 23-32.

Al-Saffawi, A.Y.T. (2018a). Assessment of groundwater for irrigation and domestic suitability by using (WQI) in Singiar district eastern of Mosul city. *Iraq. Mesopo. Environ. J.* Special Issue, 75-84. *www.bumej.com*.

Al-Saffawi, A.Y.T., R.A.A. Shanona and N.M.S. Al-Sardar (2018b). Assessment of water quality characteristics and calculation index (WQI) for some water sources In the village of Abu Maria, Tal Afar District / Nineveh Governorate. *Educat. J. for pure sci.,* **27(3):** 81-98. *https://www.iasj.net/iasj*.

Al-Saffawi, A.Y.T. (2018c). Application of the CCME WQI to evaluate water quality for drinking purpose: A case study for groundwater quality of Al-Mahalibiya Sub-district, Nineveh Province. *Iraq. Rafidain J. of Sci.,* **27(5):** 193-202. *https://www.iasj.net/iasj*.

Al-Saffawi, A.Y.T., B.S.U. Ibn Abubakar and L.Y. Abbass (2020). Assessment of groundwater quality for potential irrigation purposes using water quality index in Al-Kasik subdistrict, Iraq. Accepted for publication in the *Nigerian J. of Eng. Sci.,* **39(2):** April 2020.

Al-Saffawi, A.A.Y.T., W.E. Al sinjari and Y.A.J. AL-Taee (2018b). Assessment of groundwater quality using (WQI) in Gleewkhan village northeastern of Iraq. *Int. J. Enhanced Res. In Sci.,Tech. and Engin.,* **7(5):** 1-7.

Al-Saffawi, A.Y.T. (2018a). Assessment of groundwater for irrigation and domestic suitability by using (WQI) in Singiar district eastern of Mosul city. Iraq. Mesopo. *Environ. J., Special Issue F.*, 75-84. *http: www.bumej.com.*

Al-Saffawi, A.Y.T. (2019). Water quality index assessment of ground water in Al- Nimrud district of Southeastern Mosul City. Iraq. *Pak. J. Anal. Environ. Chem.,* **20(1):** 75-81.

Al-Saffawi, A.Y.T., W.A. Al-Sinjari and Y.A.J. Al-Taee (2018a). Assessment of groundwater quality using (WQI) in Gleewkhan village northeastern of Iraq *Int. J. Enhanced Res. In Sci., Techno. and Engin.,* 7(5): 1-7. http://www.erpublications.com.

Al-Shanona, R.A.A., N.M. Sadeq and A.Y.T. Al-Saffawi (2018). Water quality assessment for irrigation and livestock drinking in Abu Maria village/ district of Tall-Afar-Iraq. *J. of Environmental Studies JES.,* **18:** 9-14.

Al-Yousbakey, K.T., A.M. Sulaiman and D.A. Ismaeel (2018). The evalution of chemical characterization for selected wells water in Mosul-Bahshiqa-Shalalat areas, Ninivah governorate, Northern Iraq. The 9th periodical Sci. Conf. of dam and water resources Res. Center. Mosul Univ. Iraq. 28-29 Nov. 2018, 201-216.

APHA, AWWA and WCPE (1998). "Stand Method for Examination of water and wastewater American public Health Association," 20th ed., Washington DC, USA.

APHA, AWWA and WCPE (2017). "Stand Method for Examination of water and wastewater American public Health Association," 23th ed., Washington DC, USA.

Atiyah, K.S. (2018). Trends in climate change in the characteristics of Nineveh climate elements. The 9th periodic sci. Conf. of the Dams and Water Reso. Res. Center. November 28-29. Mosul University, Iraq: 229-248.

Ghalib, H., M. Yaqub and A. Alaa Al-Abadi (2018). Hydrogeochemical modeling and isotopic assessment of the quaternary aquifer at Ali al-Garbi area in Misaan Governorate, South of Iraq. Proc. of the 1st Springer Conf. of the Arabian J. of Geosciences (CAJG-1), Tunisia 2018: 121-124. *https://doi.org/10.1007/978-3-030-01572-5_30*.

Jaafer, A.J.A. and Al-Saffawi (2020). Application the logarithmic water quality index (WQI) to evaluate the wells water in Al-Rashidiya area, north Mosul, for drinking and civilian uses. accepted for publication *Plant archives,* **20(1):** 2020.

Saim, T.H. and U.N. Abdul-Qader (2008). Determination of hydraulic properties of Injana aquifer of Al-Shimal dis, district Sinjar, northern Iraq. *Iraqi J. of Earth Sci.,* **8(2):** 18-31.

Sargaonkar, A. and V. Deshpande (2003). Development of an overall index of pollution for surface water based on a general classification scheme in Indian context. *Enviro. Monit. and Asses.,* **89:** 43-67.

WHO. (2003). Sodium in drinking water, Guide for drinking water quality. World health organization. Geneva. Switzerland, 11.

WHO. (2011). Guidelines for drinking-water quality - 4th ed. chronicle, 38, 104-108.