WATER QUALITY INDEX FOR ASSESSMENT OF DRINKING WATER SOURCES FROM MEDIAŞ TOWN, SIBIU COUNTY

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ABSTRACT. **Water Quality Index for assessment of drinking water sources from Mediaş Town, Sibiu County.** The purpose of this study was to evaluate the drinking water sources quality from Mediaş Town, Sibiu County. In November 2013, 6 water samples were taken from different drinking water sources and each water sample was analysed to determinate physico-chemical parameters (using a portable multiparameter WTW 320i major ions (using DIONEX ICS1500 ion chromatograph and heavy metals (using Atomic Absorption Spectrophotometer model ZENIT 700 Analytik Jena). The investigated physico-chemical parameters were: temperature, salinity, electrical conductivity (EC), pH, total dissolved solids (TDS) and redox potential (ORP). The analysed major ions were: lithium (Li^+), sodium (Na^+), potassium (K^+), magnesium (Mg^{2+}), calcium (Ca^{2+}), fluoride(F^-), chloride (Cl^-), bromide (Br^-), nitrite (NO_2^-), nitrate (NO_3^-), phosphate (PO_4^{3-}) and sulphate (SO_4^{2-}). The investigated heavy metals were: lead (Pb), zinc (Zn), cooper (Cu), iron (Fe), cadmium (Cd), nickel (Ni), chromium (Cr) and arsenic (As). The Water Quality Index (WQI) was calculated using the analysed water quality parameters and it ranged from 76 (very poor water quality) to 375 (unsuitable for drinking).

Keywords: drinking water, physical-chemical parameters, major ions, heavy metals, Mediaş Town.

1. INTRODUCTION

The water should be managed carefully and be protected. It is not just a consumer product, it is a precious natural resource, it is vital for both future generation and for our own generation. The life cannot perpetuate without water.

Water is a finite resource and it becomes a rare benefit in many parts of the worlds. In those countries where the water is a limited resource, the competition between agriculture, industry and domestic use, which are limited by water, represent a constraining factor for economic development (Anitha et al, 2012).

Because the groundwater flows slowly through the subsoil, the human activities impact may affect the groundwater for a long time. This means that the

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pollution which occurred decades ago may still threaten water quality nowadays and in some cases will continue to do so for several generations.

Groundwater is considered to be “a hidden resource” which is quantitatively more important that surface water and for which the pollution prevention, monitoring and rehabilitation are more difficult than for surface water due to their inaccessibility (Timothy et al, 2011).

2. STUDY AREA

Mediaş Town is located in the middle basin of the Târnava Mare River. It is one of the oldest towns from Târnava valley. It is located at a distance of 39 km to Sighisoara town, 13 km to Copşa Mica town and 41 km to Blaj town.

The town has a population of about 44170 people (2011 census) and it has existed for more than seven centuries. It was first mentioned in a historical document in 1267 and it is one of the oldest towns in Romania.

Mediaş Town is situated on the Târnava Mare terraces (especially on the ones on the left side) at the confluence with the Mosna Valley. The soils present in the Târnava Mare corridor are varied: molisoils, clay-alluvial soils and hydromorphic soils (Horhoi, 2001; Reti et all, 2007, www.primariamedias.ro)

The climate is continental temperate with cool and wet weather. In Mediaş Town the air multiannual average temperature is 8.6 °C.

The extreme temperatures which are recorded in the area are common for the hilly regions from Romania (-24°C in winter and 32°C in summer). The first frost is registered around on October 8 and the last around on April 2. The average duration of the interval without frost is about 170 days. The days with positive medium temperatures are numerous, 300-310 days per year and only 30-45 days per year are below 0°C (Horhoi, 2001; www.primariamedias.ro)

The population from Mediaş uses natural springs for drinking water.

The aim of this study is to know and to assess the drinking water quality by sampling water from 5 natural springs and a pump, which are used by people like safe water sources but there are very few investigations to determine their chemical composition.

The objectives of this study were to determine the physico-chemical parameters, the major dissolved ions and the heavy metals for the collected drinking water samples, and to interpret the obtained data using water quality index (WQI).

3. EXPERIMENTAL

Drinking water samples were collected from 6 different springs in November 2013. The water samples were collected from five natural springs from Mediaş Town and from a pump.

Fig. 1. The study area with the sampling points

Water samples were analysed for 28 water quality parameters: pH, electrical conductivity (EC), total dissolved solids (TDS), turbidity, dissolved oxygen (OD), oxidation-reduction potential (ORP), salinity, F^-, Cl^-, NO_2^-, NO_3^-, Br^-, PO_4^{3-}, SO_4^{2-}, Li^+, Na^+, Mg^{2+}, Ca^{2+}, K^+, Cr, Mn, Fe, Ni, Cu, Zn, As, Cd and Pb.

The physico-chemical parameters were measured by a portable multiparameter WTW 320 i and a turbidimeter. The major dissolved ions were analysed using an ion chromatograph (DIONEX ICS1500) and the heavy metals were determined using an atomic absorption spectrophotometer (ZENIT 700 Analytik Jena).

In this study we used different water quality parameters for each water samples, to calculate the WQI depending on the chemical composition of each collected drinking water samples. For sample point 1 (S1) we used the following parameters to calculate WQI: pH, EC, TDS, Turbidity, Ca^{2+}, Mg^{2+}, Na^+, F^-, NO_3^-, SO_4^{2-}, Cl^-, Fe, Zn. WQI was calculated for sample point 2 (S2) using the water quality parameters like: pH, EC, TDS, Turbidity, Ca^{2+}, Mg^{2+}, Na^+, F^-, NO_3^-, SO_4^{2-}, Cl^-, Fe, Ni. To determine the WQI for sampling point 3 (S3) we used pH, EC, TDS, Turbidity, Ca^{2+}, Mg^{2+}, Na^+, F^-, NO_3^-, SO_4^{2-}, Cl^-, Fe, Zn. The WQI for sampling point 4 (S4) was obtained using the pH, EC, TDS, Turbidity, Ca^{2+}, Mg^{2+}, Na^+, F^-, NO_3^-, NO_2^-, SO_4^{2-}, Cl^-, Fe, Ni. For sampling point 5 (S5) WQI was determined using the parameters like: pH, EC, TDS, Turbidity, Ca^{2+}, Mg^{2+}, Na^+, SO_4^{2-}, Cl^-, Fe, Cu. For the sample point 6 which is a pump (P6) the WQI was obtained using the water quality parameters such as: pH, EC, TDS, Turbidity, Ca^{2+}, Mg^{2+}, Na^+, F^-, NO_3^-, SO_4^{2-}, Cl^-, Fe, Ni, Cu, Zn.

Relying on several water quality parameters we can obtain a single number which characterizes the overall quality of the water. To calculate the WQI we have used different water quality parameters for every spring, depending on the chemical composition determined for each water sample.

The equation (1) was used to calculate the WQI:

$$WQI = \frac{\sum_{i=1}^{n} q_i \cdot W_i}{\sum_{i=1}^{n} W_i} \quad (1)$$

where: *Wi* is weightage factor (see equation 2); *K* is a constant value and it is calculated using the following formula K=1/Σ(1/Si); S_i is the standard value of the i^{th} water quality parameter*;* *n* is the total number of water quality parameters; q_i is the quality rating for the i^{th} water quality parameter and is calculated using the equation (3)

$$W_i = \frac{K}{S_i} \quad (2) \qquad ; \qquad q_i = \frac{Va - Vi}{S_i - Vi} \cdot 100 \quad (3)$$

V_a represents the value of the i^{th} water quality parameter determinate experimentally, V_i is the ideal value of the i^{th} water quality (V_i for pH = 7, for OD is 14.6 mg/L and for the other parameter the V_i value is 0 (Kumar and Dua, 2009; Amadi et all, 2010; Yisa and Jimoh, 2010; Srinivas P. et all., 2011; Iticescu et al, 2013).

4. RESULTS AND DISCUSSIONS

The levels of the measured physico-chemical and chemical parameters for the drinking water samples are presented in Tables 1 and 2.

In the Romanian legislation (Law 458/2002) there are not mentioned maximum concentration levels for Ca^{2+}, Mg^{2+}, K^+, Li^+, while in the international legislation (BC Health Act Safe Drinking Water Regulation – BC Reg 230/92 Canada; World Health Organisation – WHO 1996) there are set maximum concentration levels for these parameters.

For Na^+ the maximum concentration level set by Romanian legislation (Law 458/2002) is 200 mg/L but none of our samples exceeded this limit.

Table 1. Physico-chemical parameters analysed for the drinking water samples

Spring	**T** (°C)	**pH**	**ORP** (mV)	**EC** (µS/cm)	**TDS** (mg/L)	**Sal** (‰)	**Turbidity** (NTU)	**OD** (mg/L)
S1	14.1	7.98	1.4	691	443	**0.1**	0.03	6.11
S2	14.3	7.81	10.1	777	497	**0.1**	0.01	6.07
S3	13.9	7.78	11.6	828	**530**	**0.2**	0.11	5.95
S4	13.1	7.95	2.4	749	479	**0.1**	0.01	5.89
S5	12.9	7.81	-47.1	1094	**702**	**0.3**	0.08	5.88
P6	12.9	7.22	-12.3	779	498	**0.1**	1.2	6.1
MCL	-	**6.5-9.5**	-	**2500**	**500**	**0.0**	**5**	-

MCL – Maximum contaminant level

Table 2. Heavy metals values in drinking water samples

Spring	**Cr** (µg/L)	**Mn** (µg/L)	**Fe** (µg/L)	**Ni** (µg/L)	**Cu** (µg/L)	**Zn** (µg/L)	**As** (µg/L)	**Cd** (µg/L)	**Pb** (µg/L)
S1	<1	<1	8.8	<1	<1	47.7	<1	<1	<1
S2	<1	<1	32.3	1.8	<1	<1	<1	<1	<1
S3	<1	<1	17.8	<1	<1	27.4	<1	<1	<1
S4	<1	<1	51.9	1,3	<1	<1	<1	<1	<1
S5	<1	<1	40.1	<1	1.3	<1	<1	<1	<1
P6	<1	<1	**282.4**	2.0	1.4	353.8	<1	<1	<1
MCL	**50**	**50**	**200**	**20**	**100**	**5000**	**10**	**5**	**10**

MCL – Maximum contaminant level

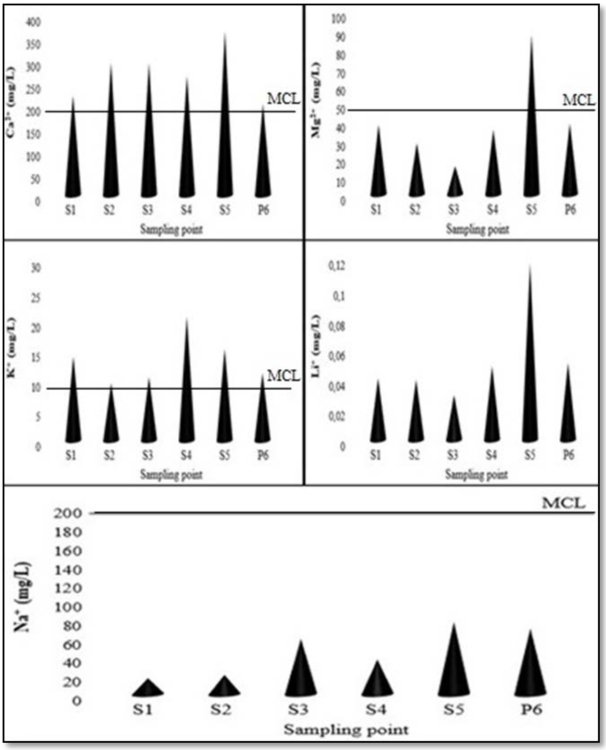

Fig. 2. The level of major dissolved cations

As it can be seen in Fig. 2 all the analysed water samples proved to have low concentration for sodium and lithium, while for calcium, magnesium and potassium the maximum allowed concentration was exceeded (BC Health Act Safe Drinking Water Regulation – BC Reg 230/92 Canada; World Health Organisation – WHO 1996).

Fig. 3 shows the values of major dissolved anions. As we can observe the nitrite was detected only in one sample (S4) and it was higher than maximum contamination level.

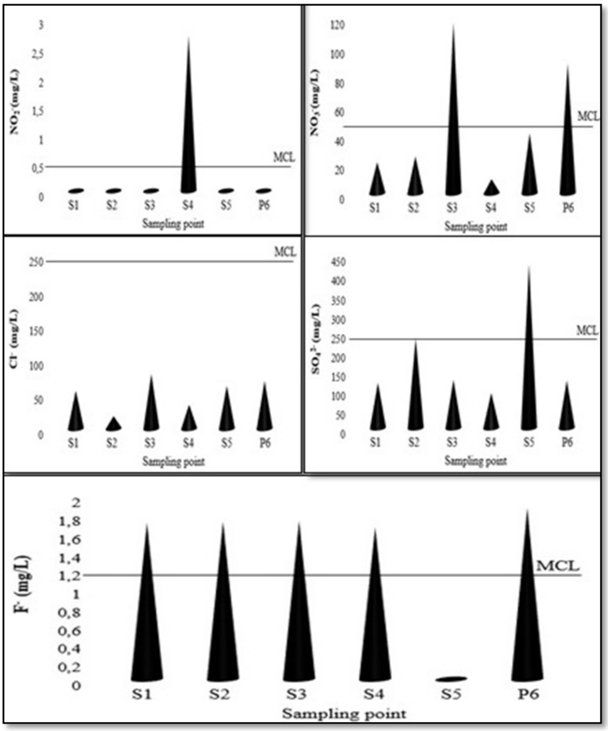

Fig. 3. The level of major dissolved anions

For NO_3^- the maximum allowed limit was exceeded for two samples (S3 which is a natural spring and P6 which is a pump). The high level of NO_2^- and NO_3^- from sampling point S3 and S4 can be correlated with the location of those natural springs near the two parks where fertilizer are used for the growth of vegetation.

Maximum permissible limit for SO_4^{2-} has to be 250 mg/L but sampling point S5 has a higher value (426 mg/L). High levels of SO_4^{2-} or organic materials and deficient oxygen conditions can lead to high levels of H2S which is a threat for the health.

With the exception of the sampling point S5, where the fluoride was not detected, the other analysed water samples proved to have high level of F^-, exceeding the maximum admissible limit (Fig.3). Fluoride is a naturally occurring element found in drinking water sources. Bedrock wells are at greater risk for high levels of fluoride. Fluoride may also be discharged as by-products from fertilizer.

Based on the laboratory results, the WQI was calculated for each of the investigated water sources. Table 3 provides an example of how the WQI was calculated for sampling point S1.

As we can observe in Fig. 4, the Water Quality Index (WQI) ranged from 76 to 375. Only one drinking water sample (S5) has a very poor quality and all others are unsuitable for drinking. The majority (83.33 %) of the collected water samples are not recommended for consumption.

Table 3. An example of how the WQI was calculated for sampling point S1.

Parameter	Wi	q_i	Wi x q_i
pH	0.81/7.5 = 0.108	[(7.98-7)/(7.5-7)] x 100 = 7.84	0.84
EC	0.81/2500 = 0.0003	(691/2500) x 100 = 27.64	0.0082
TDS	0.81/500 = 0.001	(443/500) x 100 = 88.6	0.088
Turbidity	0.81/5 = 0.162	(0.03/5) x 100 = 0.6	0.0972
Ca^{2+}	0.81/200 = 0.004	(221.8/200) x 100 = 110.9	0.443
Mg^{2+}	0.81/50 = 0.016	(38.26/50) x 100 = 76.5	1.22
Na^{+}	0.81/200 = 0.004	(17.19/200) x 100 = 8.595	0.0343
F^{-}	0.81/1,2 = 0.678	(1.71/1.2) x 100 = 142.5	96.6
NO_3^{-}	0.81/50 = 0.016	(21.23/50) x 100 = 42.48	0.679
SO_4^{2-}	0.81/250 = 0.003	(118.3/250) x 100 = 47.32	0.141
Cl^{-}	0.81/250 = 0.003	(54.99/250) x 100 = 21.99	0.065
Fe	0.81/200 = 0.004	(8.8/200) x 100 = 4.4	0.017
Zn	0.81/5000 = 0.0001	(47.5/5000) x 100 = 0.954	0.00009
	$\sum W_i = 0.994$		$\sum Wi \cdot qi = 100.23$

$$WQI = \frac{\sum Wi \cdot qi}{\sum W_i} = \frac{100.23}{0.994} = 100.8$$

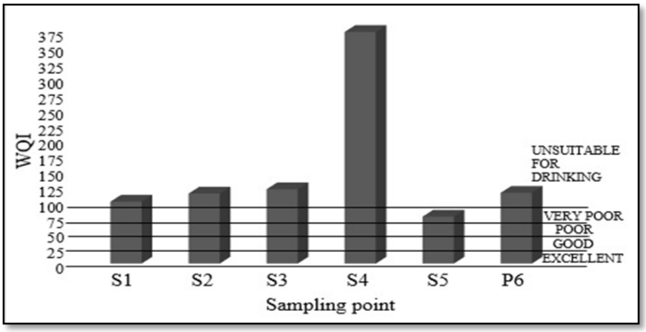

Fig. 4. Water quality index (WQI) values for drinking water samples

5. CONCLUSIONS

All the analysed water samples proved to have low concentration for sodium and lithium. With the exception of iron, the other heavy metals were under the maximum allowed limit according to Romanian legislation. The chemical parameters that exceeded the maximum limits were Ca^{2+}, Mg^{2+}, K^{+}, NO_3^{-}, NO_2^{-}, SO_4^{2-} and F^{-}. The laboratory analyses proved that the water from sampling point S1 is rich in calcium, potassium and lithium salts; the water from sampling point S2 is rich in calcium, potassium and lithium salts and sulphates; the water from point S3 is rich in calcium, potassium and lithium salts and nitrite (correlated with the location of the spring near the park where fertilizer are used for the growth of vegetation); the water from point S4 proved to have high levels of calcium, potassium and lithium salts and nitrate (may be due to close vicinity of the park where fertilizer are used); the water from point S5 has high concentrations of calcium, magnesium and potassium salts and sulphates; while the water from sampling point P6 (pump) contains elevated levels of calcium, lithium, potassium, iron (due to water stagnation in the pipe) and nitrates.

As a consequence the water quality index (WQI) indicated that five of the six investigated water sources are unsuitable for drinking, while the water for one spring (S5) has a very poor quality. The present study showed that the pollution with nitrate, nitrite, sulphate and fluoride in the area may pose high potential health risks to local residents, especially for those who consume the water from spring S4 as drinking water. Therefore it is mandatory to carefully monitories these water sources.

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