ASSESSMENT OF GROUND WATER QUALITY STATUS BY USING WATER QUALITY INDEX (WQI) METHOD IN TURENI VILLAGE, CLUJ COUNTY

CRISTINA ROŞU [1], IOANA PIŞTEA[1], MIHAELA CĂLUGĂR [1], ILDIKO MARTONOŞ[1], A. OZUNU [1]

ABSTRACT. - Assessment of ground water quality status by using water quality index (WQI) method in Tureni Village, Cluj County. The rural population from Romania is dealing even today with the absence of access to a sure drinking water source. Therefore in 2002 only 65% of the Romanian population had access to drinking water, distributed in 90% from the urban environment and 33% from the rural one (www.recensamant2002.ro).
This work presents a case study referring to a 3 month (April-May-June 2011) monitoring of weekly samples of the quality of well water (10 samples) from Tureni village, Cluj County.
A portable multiparameter model WTW 720 Germany was used to measure the pH, total dissolved solids (TDS), electrical conductivity (EC), temperature, oxidation-reduction potential and salinity of the collected water samples (these tests were done on site). In laboratory, using the photometric method (RQ Flex instrument, Merck) we determined : Ca^{2+}, Mg^{2+}, SO_4^{2-}, Cl^- and NO_3^- (C. Nertan et C. Rosu, 2008). The analyzed well water samples have values over the legally admitted limits by the Romanian legislation for the drinking waters (L 458/2002) in the calcium cation, the nitrate and sulfate anion, but also in the global parameters: salinity and TDS.

Keywords: Groundwater, WQI, Minerals in groundwater, Nitrates in water, Tureni village

1. INTRODUCTION

Water resource becomes more and more demanding in everyday life, based on the population growth, the production rate of food stocks and in the evolving industry.

The most important fresh water source in the world, based on stability and importance, is the groundwater (or subterranean waters) (Neag G., 2000).

In the present day, it has become a necessity to protect the groundwater resources against pollution (natural or anthropic), because they could have negative effects on the human health (Caliman et al., 2010; P. Srinivas et al., 2011). In the developing countries ~1.8 million people, especially children die every day, because of the contaminated groundwater (Akoteyon I.S. et al., 2011).

[1] "Babes Bolyai" University Faculty of Environmental Sciences and Engineering, 30 Fântânele Street, RO - 400294, Cluj-Napoca, Romania, 0040(0)264307030, cristina.rosu@ubbcluj.ro

2. STUDY AREA

Tureni commune is situated in the southern part of Cluj County, ~20 km from Cluj-Napoca (Fig. 1). The commune consist of 5 villages: Ceanu Mic, Comşeşti, Mărtineşti, Miceşti and Tureni. From total surface of the commune (5.34 km^2), from which Tureni occupies 2.06 km^2.

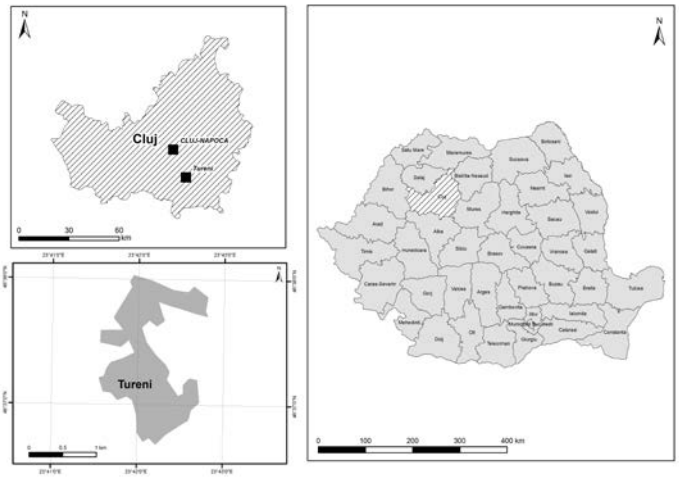

Fig. 1. ***Location of the study area***

Mineral resources include limestone (primarily operated in Tureni career until two decades ago). On leaving the village, towards Miceşti we can found several salt springs, the place was named "Marat Valley".

Regarding the spectrographic structure, the main of the Trascau Mountain is formed mainly from limestone, which has a major effect on the relief. Due to the presence of limestone, we can observe intense karst formations (gorges, plateaus, caves, etc.). Besides limestone we can find: crystalline schists and Cretaceous flysch; which give rise to a specific relief. Noteworthy is also the presence of ophiolites (magmatic rocks formed in intrusions), which can be found in isolated areas.

The Turenilor keys are the result of karst phenomena manifested in Jurassic limestones (tithonical). The reservation aspect is that of a karstic canyon, V-shaped, the limestone walls with heights raging from 20 m (in the right part of the Tureni career on the entrance keys) and 105 m keys on the route itself.

The carbonate succession is mainly represented by gravity-induced deposits (debris flows, grain flows, mass flows) in Turenilor Keys area. Moreover, hemipelagic limestones exist also in the basal part of the succession, whereas in the middle and upper part coral there are bioconstructions with sponges and stromatoporoids, this indicating an open marine environment below normal wave basis (Sasaran et al., 2001).

Average temperatures in January are between +3 and -4 º C and 16-18 º C. Freezing phenomenon occurs around the 1st of November and the last day of frost on or around May 1 (Gergely E. et al., 2002).

Currently, the village population is around 1053 inhabitants, with 453 buildings. The inhabitants of this village face lack of access to safe drinking water.

The population uses primary wells or natural springs nearby, without knowing the chemical composition of these sources and, in most cases, Tureni water wells are characterized by high mineralization and often due to anthropogenic activity are contaminated with nitrates, chlorides and oil residues, barium, manganese or iron.

The purpose of this paper is to know and to evaluate drinking water quality by sampling water from ten wells from Tureni village, analyzing physical-chemical parameters, and major ions.

The objectives of this study were the weekly monitoring of the water quality parameters of the water samples. Water samples were taken from wells for three months. From the data provided from the laboratory analysis we interpreted the results using the water quality index (WQI).

3. EXPERIMENTAL

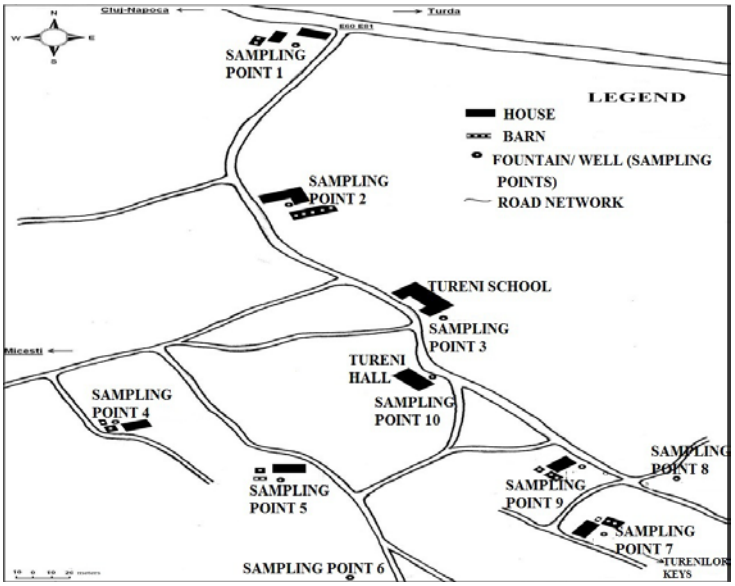

Fig. 2. ***The study area with sampling locations***

120 water samples were taken from different wells in the village of Tureni (Fig. 2), for three months (April, May and June 2011). Water samples were collected weekly from 10 wells, selected to cover a large part of the village and especially the interests they represent, namely the frequency of use of these waters.

Each water sample was analyzed for 10 parameters: pH, oxidation reduction potential, electrical conductivity (EC), total dissolved solids (TDS), salinity, calcium, magnesium, sulfate, chloride and nitrate.

Water samples from the wells were analyzed using a portable multiparameter model WTW 720 Germany to measure the pH, oxidation-reduction potential, total dissolved solids, electrical conductivity, temperature, and salinity of the collected water samples (these tests were done on site).

Using the photometric method (RQ Flex instrument, Merck) we determined in the laboratory: Ca^{2+}, Mg^{2+}, SO_4^{2-}, Cl^- and NO_3^-. Were aspirated 30 ml of sample with a syringe and filtered through a cellulose membrane of 0,45 μm. The filtrate was kept in a refrigerator at 5 °C until the next day; when the Merck RQ flex plus was used to determine five ions. They were determined after calibration with standard solutions of the specific instrument. (Nerţan C. et Roşu C., 2008).

Water quality index (WQI)

With water quality index, we can obtain a number that expresses the overall quality of water, based on several quality parameters (Khan A.A. et al., 2005; Kumar A. et Dua A. 2009).

In this study for the calculation of water quality index we used eight important parameters like: pH, electrical conductivity EC (μS/cm), total dissolved solids TDS (mg/L), calcium (mg/L), magnesium (mg/L), chloride (mg/L), sulfate (mg/L) and nitrate (mg/L) (Thakor F.J. et al, 2011; Yogendra K. et Puttaiah E.T., 2008).

Water quality index was determined using the following equation:

WQI = $(\sum_{i=1}^{n} qiWi / \sum_{i=1}^{n} Wi)$

Wi = *Weightage factor* calculate using the equation Wi = K/Si

Where *K = proportionality constant, and his value is 1; Si = Standard value of the* i^{th} *water quality parameter; n = the total number of water quality parameters*; *qi = quality rating fot the* i^{th} *water quality parameter* and is calculated using the following equation

qi = $\{[(Va - Vi)/(Si - Vi)]x100\}$

Where *Va= the value of the* i^{th} *water quality parameter determinate in laboratory, Vi = ideal value of the* i^{th} *water quality parameter obtained from standard tables*, Vi for pH = 7 and for the other parameter the Vi value is 0 (Srinivas P. et all., 2011).

4. RESULTS AND DISCUSSIONS

pH is one of the most important indicator of the quality of water. pH of drinking water is normally between 6.5 to 9.5. In the present study pH values ranged from 8.95 at well 2 to 9.47 at well 8 (Table 1.) (Shah D.G. et Trivedi P.M., 2011)

Electrical conductivity (**EC**) is a measure to the capacity of water to conduct electrical current. It is a versatile physicochemical parameter in the identification of water mineralization degree (the ionic dissolved substances). In the study area electrical conductivity values ranged from 497.5 μS/cm at well 7 to 2193 μS/cm at well 1 (Table 1.)

Table 1. ***Values determined for the monitored parameters***

PLACE	**pH**	**ORP** (mV)	**T** (˚C)	**EC** (μS/cm)	**TDS** (mg/L)	**Salinity** (‰)	**Ca^{2+}** mg/L	**Mg^{2+}** mg/L	**SO_4^{2-}** mg/L	**Cl^-** mg/L	**NO_3^-** mg/L
1	9.0	-118	8.4	2193	**1404**	**0.96**	**231.5**	17.5	**487**	**464.5**	**162.5**
2	8.9	-116	9.3	1994	**1297**	**0.83**	**205.2**	17	**435.5**	**380**	**138.5**
3	9.1	-129.3	9.3	2022	**1295.3**	**0.86**	**218.5**	12	**460**	**403.5**	**151**
4	9.1	-127.6	8.4	1086	**694**	**0.30**	116.2	10	217	217	**85**
5	9.1	-125.6	8.6	988.3	**632.6**	**0.26**	55	9.5	229.5	209	**79.5**
6	9.2	-137	9.1	678.6	433.3	**0.10**	71.5	7.5	149.5	133	**50.5**
7	9.2	-130.3	8.7	497.3	482.6	**0.33**	80.75	5	172	148	**50.5**
8	9.4	-145.6	9.2	766	489.6	**0.16**	73	5.5	154.5	159	**52**
9	8.9	-136.3	9.4	950	**614**	**0.23**	79	6	100	150.5	**63**
10	9.2	-101.3	9.6	1679	**1073.6**	**0.66**	180.5	14.5	**325**	**340.5**	**139.5**
MCL	**6.5 - 9.5**			**2500**	**500**	**0.0**	**200**	**50**	**250**	**250**	**50**

MCL – Maximum contaminant level

Total Dissolved Solids (TDS) is a measure of all dissolved substances in water. In the present study TDS values ranged from 433.3 mg/L at well 6 to 1404 mg/L at well 1 (Table 1.), while TDS value for drinking water should be less than 500 mg/L (70% from sampling points exceed this limit).

Salinity is an important parameter which help us to make a difference between the soft waters and the salts ones. It is a measure of the amount of salts in the water. In the study area salinity values ranged from 0.1‰ at well 6 to 0.96 at well 1 (100% from sampling points exceed this limit) (Table 1.).

Calcium in the present study has the values ranged from 55 mg/L at well 7 to 231.5 mg/L at well 1 (Table 1.) while calcium value for drinking water should be less than 200 mg/L (30% from sampling points exceed this limit).

Magnesium in the study area has the values ranged from 5 mg/L at well 7 to 17.5 mg/L at well 1 (Table 1.). The magnesium and calcium quantities in groundwater depends upon the type of rocks (Akoteyon I.S. et al., 2011).

Sulfate may be found naturally in groundwater from the dissolving of minerals like gypsum and anhydrite. In study area sulfate concentration ranged from 100 mg/L at well 9 to 487 mg/L at well 1 (Table 1.). The maximum value for SO_4^{2-} should be less than 250 mg/L, but 40% from sampling points exceed this limit. A high level of sulfate, in drinking water, may induce diarrhea (www.epa.gov; www.who.int), (40% from sampling points exceed this limit).

Nitrate is an important parameter in water quality assessment. It may be found naturally in groundwater or due to the human activities such leaching of animal manure or chemical fertilizer (www.env.gov.bc.ca). In the present study NO_3^- values ranged from 50.5 mg/L at well 6 and well 7 to 162.5 mg/L at well 1 (Table 1). Nitrate concentration should be less than 50 mg/L in drinking water (100% from sampling points exceed this limit).

Chloride can be found naturally in groundwater through the weathering of rocks and soil or due to the human activities such leachate from dumps or landfills (www.gov.ns.ca.). In the present study Cl^- values ranged from 133 mg/L at well 6 to 464.5 mg/L at well 1(Table 1.), while concentration of chloride should be less than 250 mg/L (40% from sampling points exceed this limit).

Table 2. ***Water Quality Parameters, Standard Values, Ideal Values and Weightage Factors of Water Quality Parameters***

Parameter	Standard Value (Si)	Ideal Value (Vi)	Weightage Factor (Wi)
pH	7.5	7	0.133
Electrical conductivity (µS/cm)	2500	0	0.0004
Total Dissolved Solids (mg/L)	500	0	0.002
Calcium (mg/L)	200	0	0.005
Magnesium (mg/L)	50	0	0.02
Chloride (mg/L)	250	0	0.004
Sulphate (mg/L)	250	0	0.004
Nitrate (mg/L)	50	0	0.02

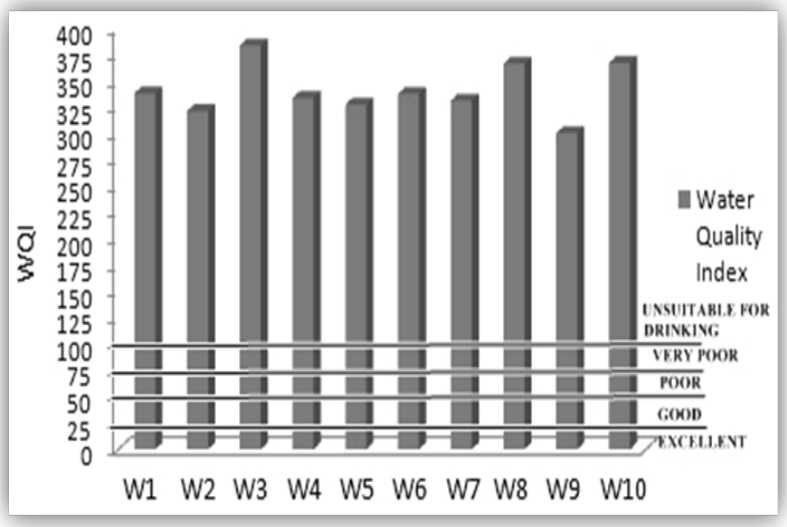

Fig. 3. ***Water Quality Index Values for Collected Groundwater Samples***

As we can notice in this Fig. 3, following the water quality index calculation of the waters in the wells from Tureni, presenting high values (WQI >100), it results that this water cannot be consumed as drinking water.

5. CONCLUSIONS

Because of the fact that the inhabitants from Tureni do not have another source of drinking water than the fountain one, it is very important that the monitoring of these waters to become a priority.

The laboratory analysis, to determine the physico-chemical parameters of major ions concentration, of the water samples taken from the wells of the village Tureni relieved the presence of hard water in this region. This thing can be mainly caused by the mineral resources composition, in this area the limestone being predominant.

The calcium and magnesium ions presence in the water make the water to be hard. The salts that give hardness to the water are not harmful to the human body than in very small quantities. For the calcium ions we have determined values up to 309 mg/L, while the maximum admitted value is 100 mg/L. In May seven of the ten samples have calcium ions concentrations which exceed MCL, while in June only four of ten samples exceed these values.

The present nitrates in the well water from the village Tureni are firstly due to a historical agricultural pollution but also due to inappropriate location of stables and other annexes, the drains coming from these ones going into the underground water. If the maximum admitted values for nitrates by the actual legislation is 50 mg/L, in the case of samples number 1, 2, 3, 4, 5 and 10 this value is exceeded, going even up to 116 mg/L. Higher values of nitrates have been observed in the samples from June, all the ten samples having values that have exceeded the maximum admitted limits for the drinking water. This thing is due to the agricultural activities. The high nitrate concentrations from the drinking water can affect children's health (infants cyanosis), but without secondary effects for adults.

It has been observed very high values of the sulfate ions concentration, which can lead to serious health problems, such as kidneys incrustation.

Therefore, the wells from the village Tureni, Cluj County, are strongly and medium mineralized. The main problems appear in the case of samples 1, 2, 3 and 10 (strongly mineralized).

REFERNCES

1. Akoteyon I.S., Omotayo A.O., Soladoye O., Olaoye H.O. (2011), *Determination of Water Quality Index and Suitability of Urban River for Municipal Water Supply in Lagos-Nigeria,* European Journal of Scientific Research, Volume 54, No.2, 263-271.
2. Caliman A.F., Robu M.B., Smaranda C., Pavel L.V., Gavrilescu M. (2011), *Soil and groundwater cleanup: benefits and limits of emerging technologies*, Clean Techn Environmental Policy, Volume 13, No.2, 241-268.
3. Gergely E., Todea V., Surd Gh. (2002), Tureni : monographic study (In Romanian), Cartea Cărţii de Ştiinţă, Cluj-Napoca.
4. Khan, A.A, Tobin, A., Paterson, R., Khan H., Wareen, R. (2005), *Application of CCME Procedures for Deriving Site-Specific Water Quality Guidelines for the*

CCME Water Quality Index, Water Qual. Res. J. Canada, Volume 40, No.4, 448-456.
5. Kumar, A., Dua, A. (2009) *Water Quality Index for assessment of water quality of river Ravi at Madhopur (India)*, Global Journal of Environmental Science, Volume 8, No.1, 49-57.
6. Neag G. (2000), *Soil and groundwater remediation* (In Romanian), Cartea Cartii de Stiinţă, Cluj-Napoca.
7. Nertan C., Rosu C. (2008), *The quality of fountain water from Salaj county*, National Symposium with national participation "Scientific contributions in technologies and equipments for the environment evaluation and protection" - IVth edition, 26-28 September 2008 Arcalia (Bistrita-Nasaud), 36-37.
8. Sasaran E., Bucur I. I., Prica I. (2001), *Microfacies and Microfossils in Upper Jurassic limestones from Cheile Turenilor*, Studia Universitatis Babes-Bolyai, Geologia, XLVI, 2, 35-52.
9. Shah D.G., Trivedi P.M. (2011), *Physicochemical Analysis of Bore Wells and Open Wells Drinking Water of Kathalal Region*, Current World Environment, Volume 6, No.2, 287-290.
10. Srinivas P., Pradeep Kumar G.N., Srinivatas Prasad A., Hemalatha T. (2011), *Generation of Groundwater Quality Index Map- A case study*, Civil and Environmental Research, Volume 1, No.2, 9-21.
11. Thakov F.J., Bhoi D.K., Dabhi H.R., Pandya S.N., Nikitaraj Chauhan B. (2011), *Water quality Index (W.Q.I.) of Pariyej Lake Dist. Kheda-Gujarat*, Current World Environment, Volume 6, No.2, 225-231.
12. Yogendra K., Puttaiah (2008), *Determination of Water Quality Index and Suitability of an Urban Water body in Shimoga Town, Karnataka*, Proceedings of Taal 2007: The 12th World Lake Conference, 342-346.
13. www.epa.gov accessed on December 20, 2012.
14. www.gov.ns.ca accessed on 11 December, 2012.
15. www.mmediu.ro/legislatie accessed on November, 19, 2012
16. www.recensamant2002.ro accesed on November 15, 2012.
17. www.who.int accessed on December 20, 2012.