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GROUNDWATER POLLUTION ASSESSMENT IN A RURAL AREA BASED ON WATER QUALITY INDEX. CASE STUDY: COTU-VAMEŞ VILLAGE, NEAMȚ COUNTY, ROMANIA

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ABSTRACT. This paper presents a comprehensive study regarding the pollution of the groundwater, in a rural area. Drinking water samples have been collected from ten wells from Cotu-Vameş village, Neamţ County for two years (2011 and 2013). These drinking water samples were analyzed for pH, electrical conductivity (EC), total dissolved solids (TDS), ammonium (NH_4^+), nitrite (NO_2^-), nitrate (NO_3^-), chloride (Cl^-), color, smell, oxidability, turbidity, coliform bacteria, *Escherichia coli*, enterococci and total number of germs.

Three of the wells had a large number of coliform bacteria over the maximum permissible values according to the Romanian legislation for drinking water (LAW 311/2004; 458/2002).

Water quality index (WQI) was calculated in order to evaluate the overall quality of groundwater and its values ranged between 22 (excellent quality) and 84 (very poor quality).

Key words: *groundwater, village, nitrite, coliform bacteria, WQI*

INTRODUCTION

Water is considered to be an indispensabile factor for human body and for animal body, as well (Cical et al., 2007).

We use water for almost everything like basic needs, drinking, food preparation, washing (Rojannschi, 1996) (Cical et al., 2006).

The drinking water sources in rural areas from Romania are represented mostly by wells and natural springs. These drinking water resources are used for human consumption or animal consumption without a good knowing about physico-chemical and microbiological composition of these resources (Sucuturdean and Muică, 2009; www.epa.gov).

Drinking water monitoring, from rural areas, has to be a priority because about 50 % of our population lives in rural areas and as a sources of drinking water they depend on these wells or natural springs (Nerţan and Roşu, 2008).

STUDY AREA

Cotu Vames village is located in the eastern part of Neamt County, at the confluence of Neamt and Moldova rivers. It is situated at a distance of about 2 km from the Roman city and at a distance of about 48 km the Piatra Neamt city. The Cotu Vames village is bordered to the North with Roman city and Cordun village, to the East with Sagna village, to the West with Trifesti village and to the South and South-West with Ion Creanga village. Currently, the village population is around 3254 inhabitants.

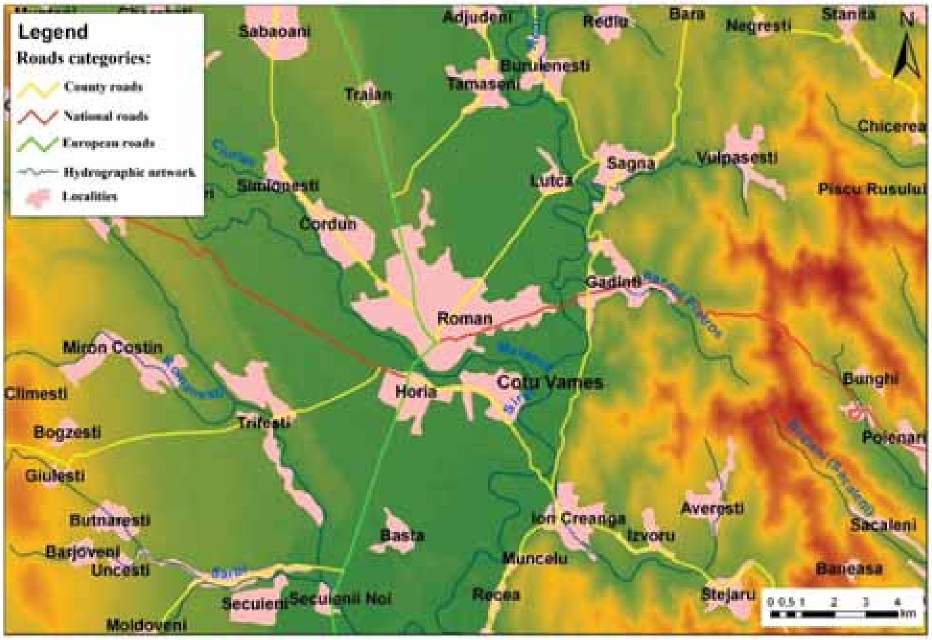

Fig. 1. *Location of the Cotu Vames village*

Among the important underground resources of the investigated area it should be mentioned the gasified field, discovered 30 years ago.

Moldova River crosses the Cotu Vames village over a distance of 11.5 km (the width is around 300 m) and the Siret River crosses Cotu Vames village over a distance of 13.1 km (the width is 400 m). Their hydrologic regime is characterized by larges variations regarding the flows and levels. These flows and levels increases produce flood, silting and erosion of riverbeds. These phenomena occur in spring after snowmelt and summer rainfall.

The wells from floodplain terrace of the Moldova are supplied from a single water table which is influenced by precipitates regime. The water table roof is mostly constituted from soil with loamy sand.

In Cotu Vames village people use as water supply exclusively well waters, because they don't have other sources (Horia village General Urban Plan, 2007; General Memoir). In Cotu Vames village there are 110 wells with a depth between 5 and 20 meters. The water from wells is used both in household and in public institutions. The industrial activities are inexistent.

The aims of this study were: (1) to analyze the physico-chemical and bacteriological parameters of several drinking water samples; (2) to assess the drinking water quality from Cotu Vames village by calculating the water quality index (WQI); (3) to investigate the annually fluctuation of the analyzed water quality parameters. 20 drinking water samples were taken from 10 different wells from the Cotu Vames village for two years (2011 and 2013).

EXPERIMENTAL

A total of 20 drinking water samples were taken, in 2011 and 2013, from 10 wells from Cotu Vames village. The location of the investigated wells is presented in Fig. 2.

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

Each drinking water sample was analyzed for 15 parameters: pH, electrical conductivity (EC), total dissolved solids (TDS), ammonium (NH_4^+), chloride (Cl^-), nitrite (NO_2^-), nitrate (NO_3^-), oxidability, turbidity, color, smell, coliform bacteria, *Escherichia coli*, enterococci and total number of germs.

Water quality index (WQI)

Using water quality index (WQI) we can get a single number which characterizes the total quality of the water, based on several water quality parameters (Khan et al., 2005; Kumar and Dua, 2009).

In this research for calculating the water quality index (WQI) we used nine water quality parameters: pH, EC, TDS, NH_4^+, Cl^-, NO_2^-, NO_3^-, oxidability and turbidity.

The following equation was used to calculate the water quality index (WQI):

WQI = $(\sum_{i=1}^{n} qiWi \,/\, \sum_{i=1}^{n} Wi)$
Wi = Weightage factor
Wi = K/Si
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
qi = $\{[(Va - Vi)/(Si - Vi)]x100\}$
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 al., 2011).

RESULTS AND DISCUSSION

The results are presented in the figures 3 - 11.

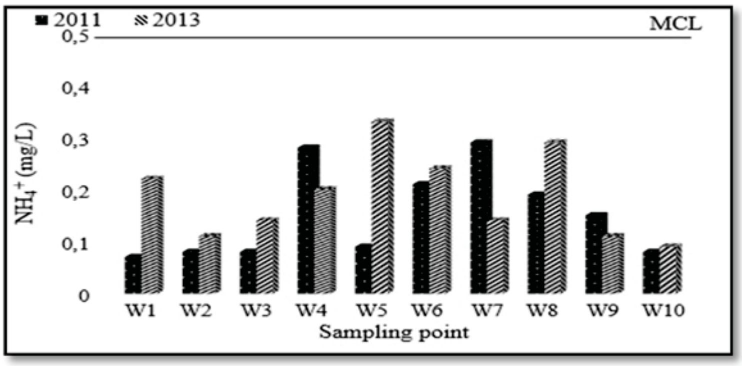

Fig. 3. *Comparing NH_4^+ (mg/L) values in 2011 to its values in 2013, depending on the sampling point*

As we can see in Fig. 3 the concentrations for ammonium don't exceed the maximum concentration level for drinking water. 60% from sampling points have a higher value for ammonium in 2013 than in 2011, which indicates that the wells water quality decreased during 2013.

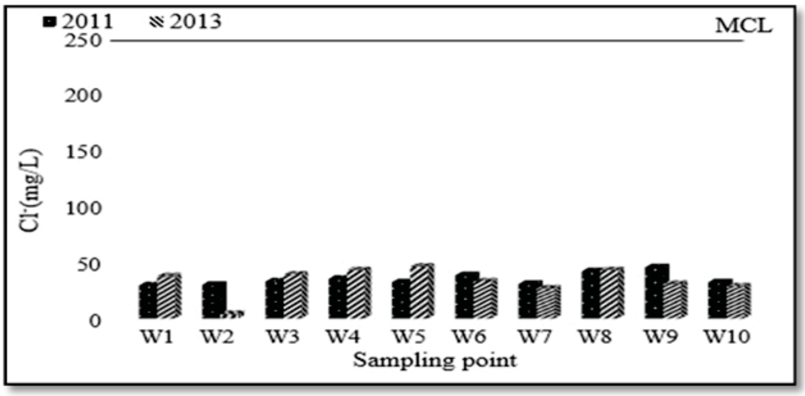

Fig. 4. *Comparing Cl^- (mg/L) values in 2011 with its values in 2013, depending on the sampling point.*

The analyzed water samples proved to have low levels of chloride. This parameter was below the maximum permissible limit for all the investigated water sources (Fig.4). 50% from sampling point present higher values of chloride during 2013.

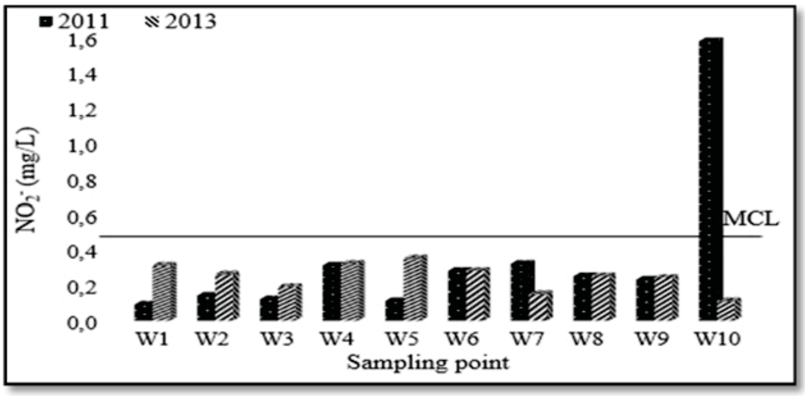

Fig. 5. *Comparing NO_2^- (mg/L) values in 2011 with its values in 2013, depending on the sampling point*

With the exception of sample W10 (during 2011), all the analyzed samples had a low level of nitrite, below the maximum permissible limit for drinking water (0.5 mg/l). During 2011, well number 10 proved to have a significantly high level of nitrite, being three times higher than maximum permissible limit (Fig.5). The annually fluctuation indicated that during 2013, 70% of the investigated wells had higher levels of nitrite than those registered during 2011.

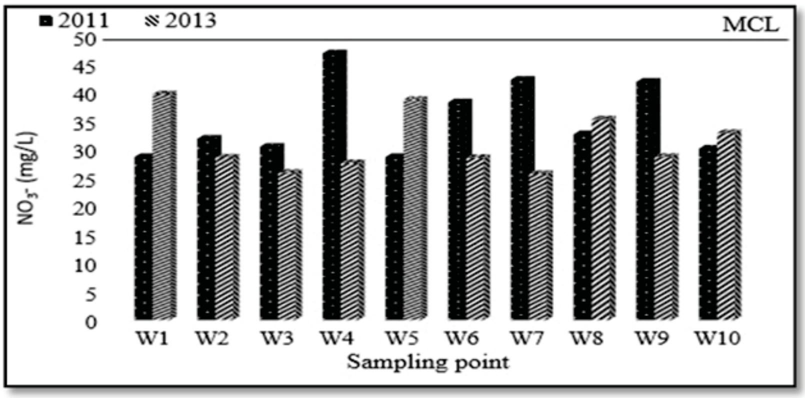

Fig. 6. *Comparing NO_3^- (mg/L) values with its values in 2013, depending on the sampling point*

As it is shown in Fig.6, the nitrates values are below the maximum concentration level for all the investigated wells. 60% of water samples have higher nitrates values in 2011 than in 2013.

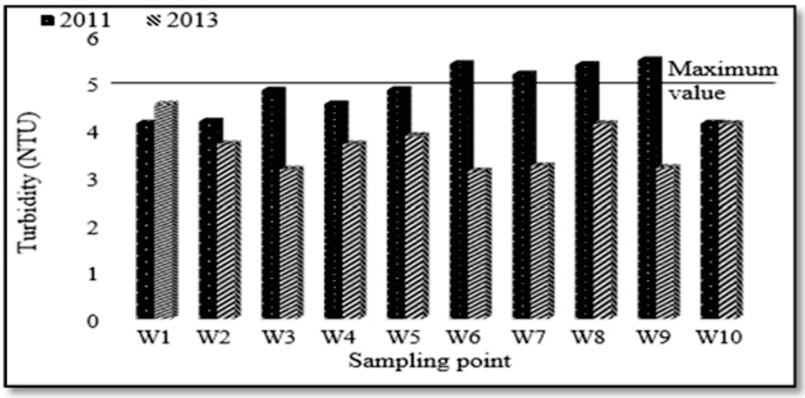

Fig. 7. *Comparing turbidity (NTU) values in 2011 with its values in 2013, depending on the sampling point*

During 2011, a total of 40% of samples had higher values of turbidity than the maximum allowable value (5 NTU) (Fig.7). With the exception of well number 1, for the rest of the investigated wells, the turbidity decreased during 2013 comparing to 2011.

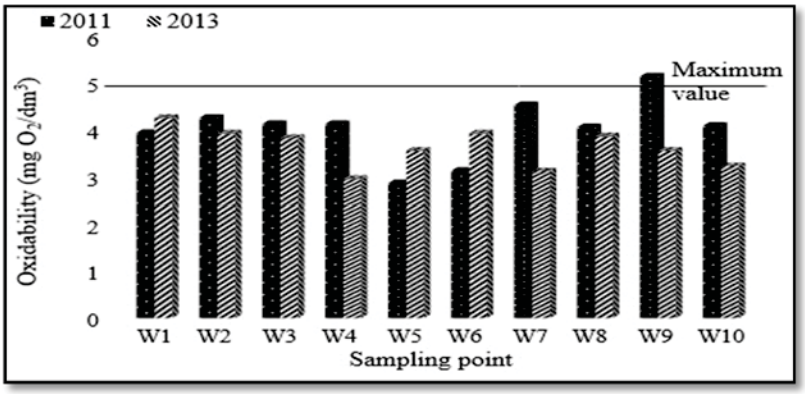

Fig. 8. *Comparing oxidability (mg O_2/dm^3) values in 2011 with its values in 2013, depending on the sampling point*

As it is shown in Fig. 8, the analyzed water samples proved to have low levels of oxidability; only one sample (W9 during 2011) was over the maximum permissible limit. A total of 70% of drinking water samples have higher oxidability levels during 2011 than during 2013.

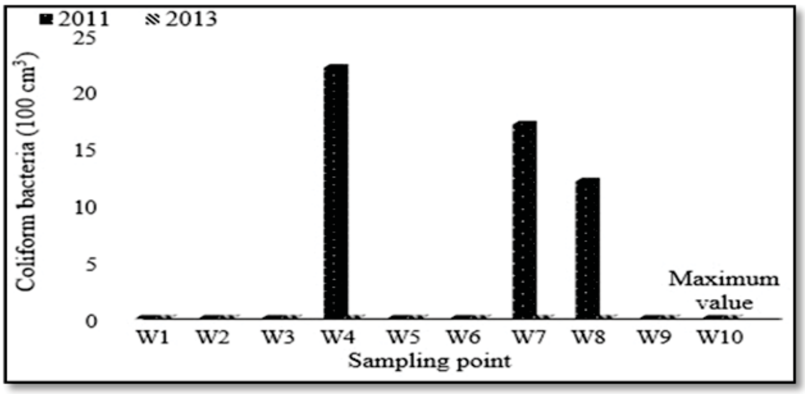

Fig. 9. *Comparing coliform bacteria (100 cm^3) values in 2011 with its values in 2013, depending on the sampling point*

As it is shown in Fig. 9, with the exception of wells W4, W7 and W8 (during 2011), the analyzed water samples had low levels of coliform bacteria. A total of 30% of water samples taken in 2011 exceed maximum permissible limit. This exceeding may cause severe health problems (cramps or diarrhea) if the water sources are used continuously as drinking water source (www.healthvermont.gov).

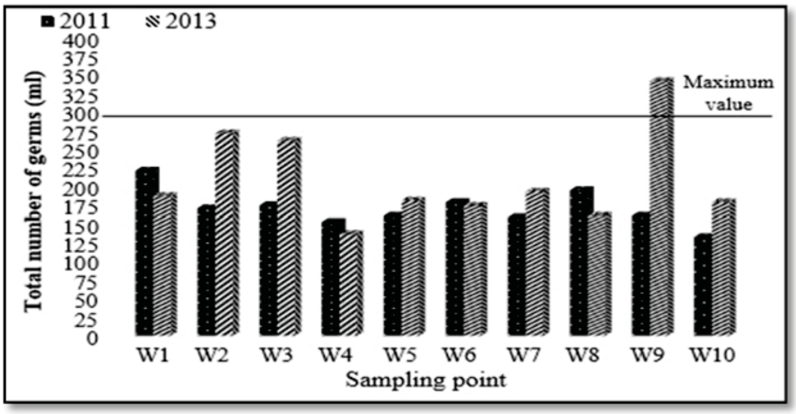

Fig. 10. *Comparing total number of germs (ml) values in 2011 with their values in 2013, depending on the sampling point*

With the exception of water sampled from W9 during 2013, the investigated wells had low levels of total germs (Fig. 10). 60% of water samples show higher values of the total number of germs in 2011 than in 2013.

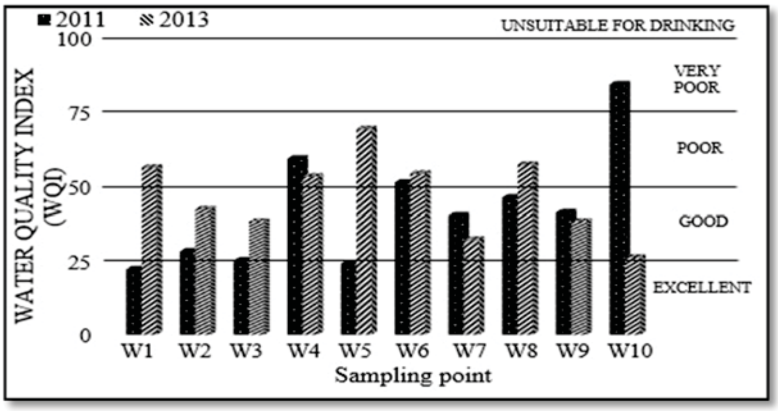

Fig. 11. *Comparing water quality index (WQI) values in 2011 with their values in 2013, depending on the sampling point*

By calculating the WQI, the obtained data indicated that during 2011, a total of 20% of investigated water samples had an excellent quality, having WQI lower than 25, while 50% of samples had a good quality having WQI lower than 50, a total of 20% had a poor quality (WQI<75) and 10% have a very poor quality (WQI<100). During 2013, the water quality improved considerably, as a consequence a total of 50% of water samples had a good quality and 50% have a poor quality.

The annually fluctuation indicated that 60% of drinking water samples have water quality index values higher in 2013 than their values in 2011.

CONCLUSIONS

The analyzed waters proved to have low levels of ammonium, chloride, nitrite (exception W10 during 2011), nitrate, oxidability (exception W9 during 2011) and total number of germs (exception W9 during 2013).

During 2011, some water quality parameters like nitrite, turbidity, oxidability, coliform bacteria and total number of germs exceeded the maximum permissible limit set by national legislation for drinking water. The presence of high levels of coliform bacteria can cause gastrointestinal distress like cramps or diarrhea.

In general the drinking water quality from Cotu Vames village (Neamt County) has a good quality. Generally the investigated water quality parameters had lower values during 2013 comparing to 2011, proving that the water quality has improved during 2013. In 2011 we found three wells with an excellent water quality. The annually fluctuation indicated that 60% of drinking water samples have water quality index values higher in 2013 than their values in 2011.

These drinking water sources should be further monitored because the population from Cotu Vames village doesn’t have another safe water source and they use the water from those wells both for drinking and cooking.

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