As water is one of essential environmental factors that sustains life, the quality of drinking water represents a very important aspect for human health. A recent study shows that the unsafe water is the leading health risk factor in the world causing millions of deaths [1, 2]. In less developed countries the presence of pathogens is the most critical risk factor [3] and the usage of materials with antibacterial effects as silver [4], is increasing for various applications. The chemical contamination, including high toxicity heavy metals, has more relevance in developed, industrialized countries [1, 3].

Heavy metals that are normally present in nature are not dangerous to environment or health because they have very small concentrations, but because heavy metals are present in every area of modern life (constructions, pluming, cosmetics, appliances and so on) their concentrations are growing to a point where they become harmful [5-7], especially for vulnerable groups of population as aged people and children [8]. Heavy metals in water can occur due to natural sources including volcanic activities, erosions and weathering and due to human activities such as mining, waste disposal, agriculture, municipal or industrial effluents [3, 8]. For example lead and copper leach into water supplies through corrosion of house plumbing, pipes, fittings, a source of arsenic contamination can be the runoff from orchards, cadmium occurs in association with zinc from the corrosion of galvanized pipes and fittings [9, 10]. Some of the heavy metals are necessary for the body in small amounts but they become toxic if they are in excess in drinking water, the long term exposure can lead to damaged or reduced mental and central nervous functions, irregularity in blood composition, kidney, lungs and liver damage, cancer, death [7, 11, 12].

From the various sources of drinking water commonly used in rural areas, like rivers, wells, lakes, ponds [13], in this paper the drinking water from wells represents the subject of study. The chemical fertilizers, herbicides and pesticides used for agricultural purposes, also the municipal and industrial wastes have entered the soil, infiltrating in some aquifers and damaging the ground-water quality [14, 15].

Organization like the World Health Organization, the European Commission, US Environmental Protection Agency and the legislative assembly of countries have set guidelines for drinking water quality and limits for heavy metals and other toxic elements, also for the protection of human health. Nowadays, in Romania, the loss of important industries in the city leads to an increase in the rural population, due especially to the return of retired population from cities back to villages and also to the development of new activities like tourism and agro tourism. That means more interest in the quality of water in the rural area and a motivation for both kinds of investigations: the identification of pollutants - which is the aim of the present paper - and their removal [16].

Inductively coupled plasma-mass spectrometry (ICP-MS) was used to determine the concentration of 12 heavy metals and other toxic elements as - aluminium (Al), arsenic (As), chromium (Cr), cadmium (Cd), copper (Cu), iron (Fe), nickel (Ni), manganese (Mn), lead (Pb), selenium (Se), uranium (U, radioactive metal as well) and zinc (Zn) - in samples of drinking water collected from wells in 4 rural areas of Romania.

**Experimental part**

**Sampling.** The drinking water samples were collected from wells located in 4 localities from rural areas of Olt, Ialomita, Botosani and Giurgiu Countries, Romania, as is represented in figure 1. The sampling procedure was in compliance with the Romanian standard regarding ground water sampling, SR ISO 5667-11. The total number of samples...
was 48, 12 samples for each area studied. The collected samples were filtered, then acidified with nitric acid, from Merck, and stored in 0.5 L polyethylene recipients. The samples were then kept at a temperature of 4°C till the analyses were performed.

**Instrument.**

A Perkin Elmer Sciex ELAN DRC-e ICP-mass spectrometer, with the operating conditions summarized in the table 1, was used for all measurements.

**Procedure**

The analyses were performed in compliance with the Romanian standard regarding water quality analysis using inductively coupled plasma-mass spectrometry, SR EN ISO 17294-1. A multi-element standard reference solution of 10 μg/mL was used as internal standard for all the metals analysed.

**Results and discussions**

The concentrations of aluminium, arsenic, cadmium, chromium, copper, iron, manganese, nickel, lead, selenium, uranium and zinc in samples of drinking water were determined using ICP-MS. The results obtained were compared with the limits set by the Romanian Law 458/2002 [17], based on the European Council Directive 98/83/EC [18] and WHO guidelines [19], which is presented in table 2. According to Law 458/2002 parameters like the concentrations of Al and Fe are mandatory for the control monitoring and the concentrations of the other metals are mandatory for the audit monitoring.

Our results are summarized in tables 3-6, were the average values, standard deviation, minimum and maximum values are shown. In addition the concentration of each metal in different water samples compared with the tolerable limits set by the Romanian law and WHO guidelines are presented in figure 2.

All the water samples collected from Olt County had concentrations of cadmium and nickel below the detection limit and they are not presented in the table.

From both, the table 3 and figure 2, it can be observed that the mean values and the maximum values for Al and Fe are higher than the tolerable limits, the maximum concentration of iron being 14 times higher than the limit.
The concentrations of As, Pb, Se, Zn are by far lower than the limits and so is the concentration of Cu compared with WHO guidelines.

The analysis results for the drinking water collected from Ialomita County are similar with those from Olt County, regarding the concentration of cadmium and nickel. Values higher than the limits are recorded for the mean concentrations of iron and aluminium, but there are some samples for which the concentration of selenium is higher as well.

In addition the concentration of uranium in some samples is near the limit while the concentration of manganese is higher than the limit set by Law 458/2002. The concentrations of the other metals are far below the limits.

The concentrations of Cd and Ni of the samples collected from Botosani County are below the detection limits.

The mean concentrations of Al and Fe are higher than the limits, also the maximum concentration of iron is 6 times higher than the limit and the maximum concentration of manganese is 7 times higher than the limit set by Law 458/2002. The concentrations of the other metals are below the tolerable limits.

Similar to the samples collected from the other areas, the water samples from Giurgiu County present concentrations of Ni and Cd below the detection limits; moreover the concentrations of Pb in all samples, except one, are also below the detection limit. The mean concentrations of Fe and Mn are higher than the tolerable limits and the maximum concentration of Mn is 5 times higher than the limit set by WHO guidelines and 44 times higher than the limit set by Law 458/2002. The concentrations of the other metals are far below the limits.

Fig. 2. Metals and other toxic elements concentration in different drinking water samples from all the studied areas and the tolerable limits.
L, the highest concentration of Cr - 36.601µg/L, the highest concentration of Se - 11.08µg/L and the highest concentration of U - 13.038µg/L.

In the samples from Olt County can be found the highest concentration of As - 3.693µg/L, the highest concentration of Cu - 63.613µg/L, and the highest concentration of Fe - 2861.826µg/L. In the samples from Botosani County can be found the highest concentration of Pb - 4.878µg/L, and the highest concentration of Mn - 509.867µg/L.

From all 4 areas studied it seems that Ialomita County recorded higher concentrations than the limits set by Law 458/2002 - in Giurgiu County.

The metals for which there were recorded concentrations that exceeded the tolerable limits are Al, Fe and Mn in Giurgiu County; Pb in Olt County and Mn in Giurgiu County.

The heavy metals for which there were recorded concentrations that exceeded the tolerable limits are Al, Fe, Mn and Se, the effects of oral exposure (water ingestion) being presented in the following section.

The exposure to aluminium can affect the nervous system causing Alzheimer’s disease and possibly other neurotoxic effects, the exposure to iron and manganese are associated with Alzheimer type II astrocytosis, Parkinson disease, ataxia and liver diseases and the exposure to selenium can cause from nausea, vomiting and diarrhea to selenosis.

**Conclusions**

The amounts of heavy metals and other toxic elements in wells drinking water from 4 rural areas of Romania were investigated in this paper. The technique of analysis was the ICP-MS which is very suitable for small concentrations. The results show that the values for the majority of the studied heavy metals and other toxic elements were below the limits set by the guidelines; moreover the concentrations for Cd and Ni were below the detection limits for all 4 areas. The metals for which exceeded values were recorded were Al, Fe, Mn and Se. Alarming concentrations were recorded for iron - 2861.826µg/L, 14 times higher than the limit set by the Law 458/2002 - in Olt County, and for manganese - 2232.793µg/L, 5 times higher than the limit set by WHO guidelines and 44 times higher than the limit set by Law 458/2002 - in Giurgiu County. Also in Ialomita county were recorded exceeded values for 3 metals, but their concentrations are not much higher than the limits.

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