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CHARACTERIZATION OF OLT RIVER WATER QUALITY USING ANALYTICAL METHODS

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Abstract. In this work are presented experimental results obtained by investigation of water samples collected from different zones of Olt River (Superior Hydrographic Basin – Fagaras Depression, Romania) in order to characterize the quality of water. Total Dissolved Solids (TDS), electrical conductivity, salinity, and other physicochemical indicators of samples including NO_3^-, pH, turbidity, and total hardness were investigated in the order to establish the real pollution degree of Olt River. The heavy metals concentrations including Pb, Cd, Zn, Ni, Cr, Mn, and Fe were determined by Flame Atomic Absorption Spectrometry (FAAS). The results demonstrated that heavy metals are originated from various pollutant sources; however, the main anthropogenic sources were industrial waters (e.g. effluents of Chemical Factories from studied area), municipal wastewaters and run-off waters from agricultural fields.

Key words: Olt River, pollution, heavy metal, FAAS.

1. INTRODUCTION

It is well known [1–5] that certain changes in water quality occur naturally along the length of a river, and most of changes may be significantly influenced by anthropogenic activities. The water quality can be affected mostly by industries, agriculture and urban settlements which can produce sewage effluent, fertilizers, and other poisonous substances.

The toxic action of a water pollutant, its intensity and velocity with which that pollutants affect the aquatic organisms depends on many factors: internal (species of organisms that are present in water, the development and the physiological stage of organism, etc.) and external (temperature, turbidity, pH, dissolved oxygen, etc.) [6].

Some heavy metals (*e.g.* Mn, Ni, Cr, Zn and Fe) occur naturally in the environment and in small concentrations are essential for all life forms including humans and other (*i.e.* Pb and Cd) are toxics. The main problem is represented by the heavy metals accumulation and related diseases, as well as, the impossibility of human body to remove these toxic elements through natural processes [7].

The aim of this current study was to determine the heavy metal concentrations (*e.g.* Pb, Cd, Zn, Ni, Cr, Mn, and Fe) of some water samples collected from Olt River (Superior Hydrographic Basin - Fagaras Depression, Romania) by using Flame Atomic Absorption Spectrometry [8-13]. These results were interpreted in relation with the main physicochemical indicators including total dissolved solids, electrical conductivity, salinity, turbidity, NO_3^-, pH, and total hardness in order to establish the water quality of Olt River and their classification in a specified category according with the Romanian Regulation (*i.e.* Order 161/2006 [14]).

2. METHOD AND MATERIALS

In Olt hydrographic basin have been identified 622 rivers (with surfaces higher than 10 km^2) and 33 accumulation lakes (with surfaces higher than 50 ha), and Olt River is one of the important affluent of Danube. Determination of the pollution degree of Olt River in Fagaras Depression, between Fagaras City and Victoria City where was developed important chemical industrial activities, was the subject of this study (Fig. 1). All samples have been collected in April 2012, on a distance of about 30 km (Table 1 and Fig. 2).

The water samples were collected, preserved, handled and transported, according with ISO 5667-3:2012 "Water quality - Sampling - Part 3: Preservation and handling of water samples" [15].

Table 1

Geographical coordinates of collection points

Samples	**Collection points**	**Coordinates**	
		Longitude E	**Latitude N**
S_1	Mandra Hidropower plant (barrage)	25.05178	45.84759
S_2	Berivoi Creek	24.96581	45.83003
S_3	Beclean Creek	24.92121	45.83531
S_4	Voila Hidropower plant (barrage)	24.89262	45.84315
S_5	Voila Creek	24.83864	45.80351
S_6	Sambata Creek	24.82224	45.76312
S_7	Oltet Creek	24.77175	45.79198
S_8	Vistea Hidropower plant (barrage)	24.75552	45.80674
S_9	Corbul Ucii Creek	24.69223	45.73933
S_{10}	Ucea Creek	24.66189	45.76570
S_{11}	Ghirlotel-Arpas Creek	24.65744	45.79865
S_{12}	Arpas Hidropower plant (barrage)	24.59633	45.79518

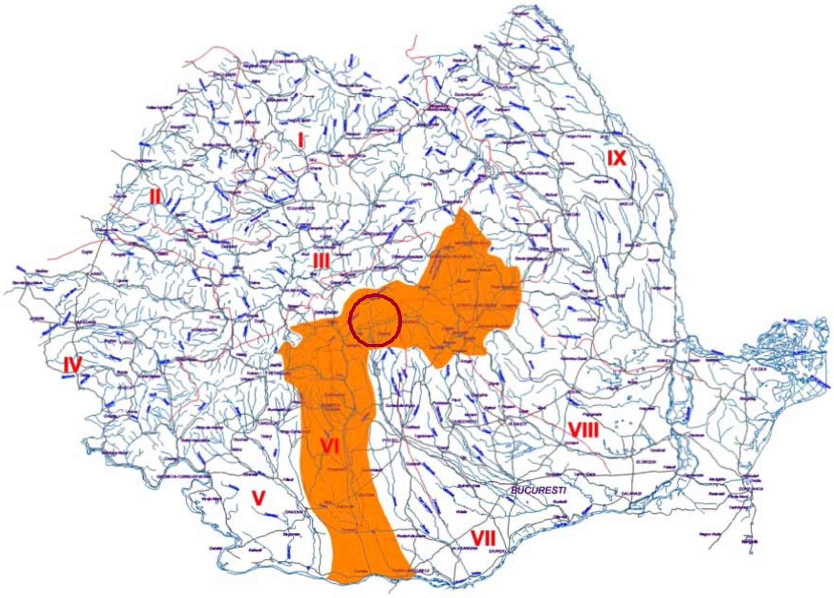

Fig. 1 – Olt Hydrographic Basin (Orange zone), and the collection area (red circle).

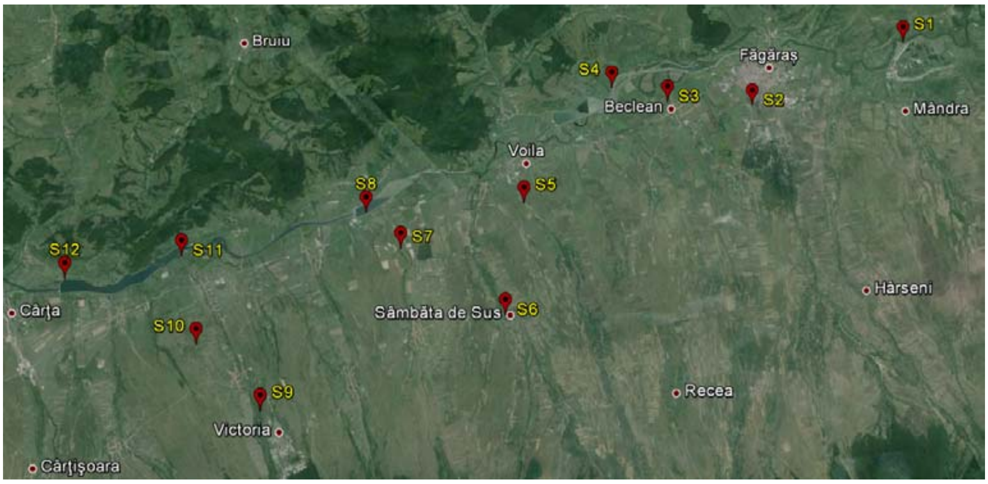

Fig. 2 – Geographic localization of collection points.

The nitrates from samples were determinate in according with SR ISO 7890/1-98 [16] and pH was achieved in according with SR ISO 10523-97 [17]. For FAAS analysis all samples were mineralized with aqua regia (*i.e.* using 2.5 mL HNO_3 67% and 7.5 mL HCl 37%) by using Bergof MWS-2 Digester. The heavy metal concentrations obtained by Flame Atomic Absorption Spectrometry are presented in Table 3.

3. RESULTS AND DISCUSSION

The values of quality indicators of samples collected from Olt River (pH, conductivity, salinity, turbidity, and TDS) are presented in Table 2.

Table 2

Physicochemical indicators of surface water samples collected from Olt River

No	Quality indicators						
	NO_3^- [mg/L]	**pH**	**Conductivity [mS/cm]**	**Salinity [‰]**	**Turbidity [NTU]**	**TDS [mg/mL]**	**GH [ºG]**
S_1	17.93	7.38	304	0.1	15.1	144	19.1
S_2	15	6.83	128.9	0.1	0.07	61	13.2
S_3	21.62	6.04	96.3	0	0.4	46	12.1
S_4	36.28	7.5	309	0.1	5.7	147	19.7
S_5	31.6	6.24	118.1	0.1	0	56	12.3
S_6	21.86	6.33	108.1	0.1	5.39	51	11.8
S_7	30.5	7.23	101.5	0	0.28	48	11.4
S_8	35.2	7.52	329	0.2	14.42	157	19.7
S_9	46.7	7.68	348.2	0.2	11.24	170	18.7
S_{10}	21.3	6.78	78.8	0	0	37	12.1
S_{11}	23.03	6.23	75	0	0	35	11.8
S_{12}	36.44	7.10	345	0.2	11.07	164	20.1
QC-I	5	6.5-8.5	-	-	-	-	-
QC-II	15						
QC-III	25						
QC-IV	50						

It was observed high nitrate concentrations between 15.00 mg/L (S_2 Berivoi Creek) and 46.70 mg/L (S_9 Corbul Ucii Creek). The highest value recorded in S_9 can be explained by the presence of Chemical Factory from Victoria City and agricultural activities as well.

In the Fig. 3 is represented the nitrates content related to pH values. Therefore, it can be observed a high nitrates concentration and a weak acid pH – under the minimum admitted limit, 6.5 (the red rectangle) in S_3, S_4, S_5, and S_9 samples. The pink rectangle including S_7, S_8, and S_{12} samples show a high nitrates concentration and a pH value according with Order 161/2006 (Romanian legislation). The green rectangle including S1, S2, S6, S10, S11 samples show a low nitrates concentration and a pH value in conformity with Romanian Regulation.

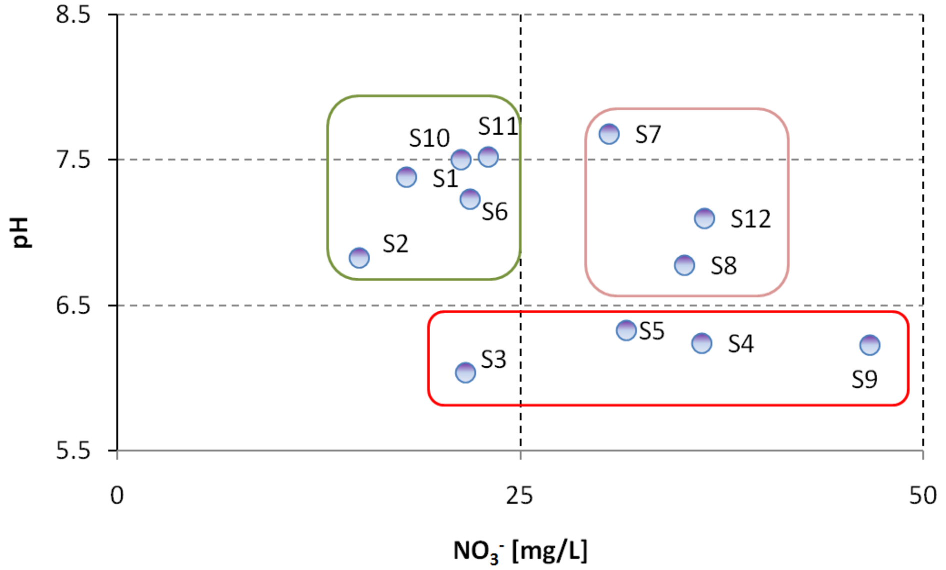

Fig. 3 – Nitrates content related to pH.

A linear correlation between TDS and electrical conductivity (Fig. 4, $R^2 = 0.999$) and total hardness and conductivity (Fig. 5, $R^2 = 0.970$) was observed.

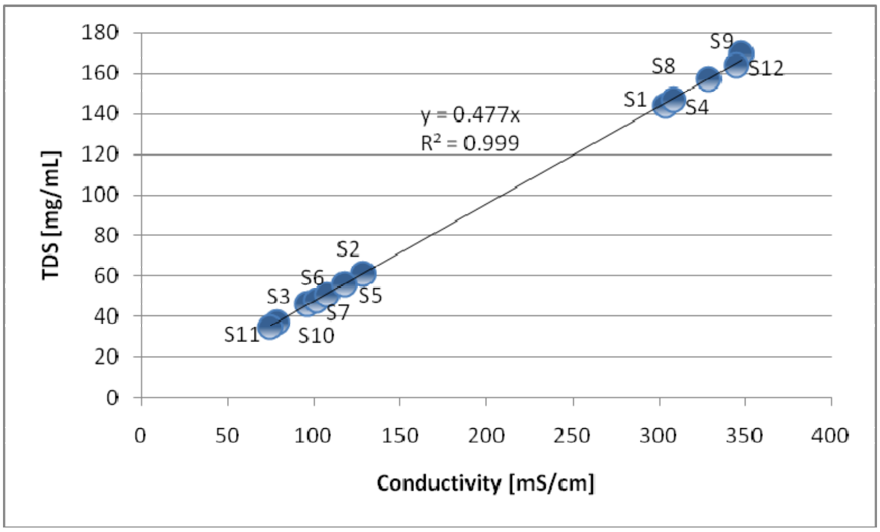

Fig. 4 – Linear correlation between TDS and conductivity.

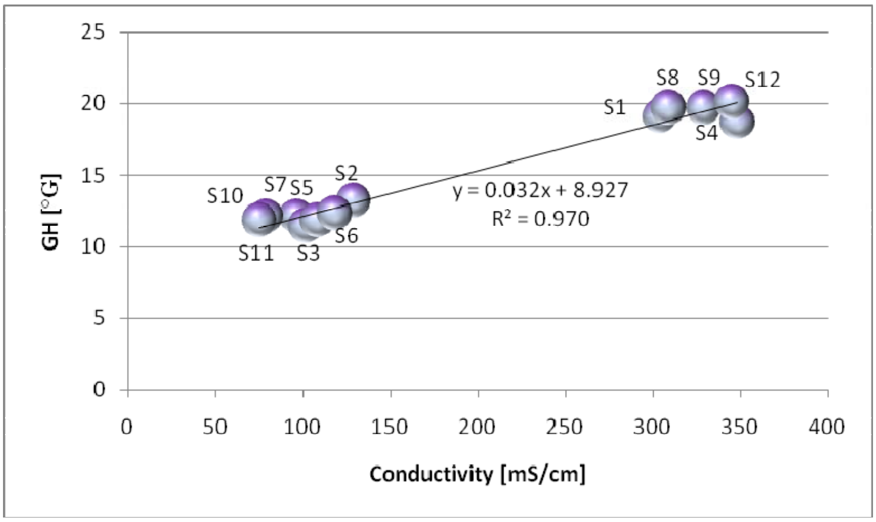

Fig. 5 – Linear correlation between total hardness and conductivity.

As can be shown in Figs. 4 and 5, the water samples collected from Olt River are grouped in two categories: * Low conductivity and low TDS and total hardness (S_2, S_3, S_5, S_6, S_7, S_{10}, and S_{11}); * High conductivity and high TDS and total hardness (S_1, S_4, S_8, S_{12}, and S_9). In first category are included all creeks (Berivoi, Beclean, Voila, Sambata, Oltet, Ucea, Ghirlotel-Arpas), and in second category are included all waters barrages (Mandra, Voila, Vistea, Arpas) and Corbul Ucii Creek – which passes the land of Victoria Industrial Factory.

The results obtained by Flame Atomic Absorption Spectrometry (FAAS), regarding the heavy metal concentrations, are presented in Table 3.

Table 3

Heavy metals concentration of surface water samples collected from Olt River

No	Heavy metals [mg/l]						
	Pb	**Cd**	**Zn**	**Ni**	**Cr**	**Mn**	**Fe**
S_1	10.153±0.5	0.954±0.2	257.077±7.2	12.154±1.2	4.973±0.2	37.830±3.3	351.63±5.2
S_2	8.216±0.1	0.025±0.01	230.441±6.8	5.525±1.1	4.783±0.2	22.285±3.5	471.71±7.2
S_3	6.211±3.5	0.901±1.2	234.567±6.7	11.901±1.0	1.857±0.6	34.032±3.4	440.31±4.6
S_4	9.540±3.6	0.082±0.01	232.781±6.7	4.982±1.1	5.758±0.1	33.027±3.2	460.11±4.5
S_5	3.112±1.9	0.112±1.0	220.803±6.9	10.112±1.0	1.723±0.5	29.394±3.1	311.22±4.5
S_6	6.353±0.01	0.092±0.02	238.365±7.0	3.892±0.9	1.745±0.3	13.815±2.7	241.19±4.3
S_7	7.889±1.2	0.873±0.1	229.890±6.5	9.873±1.0	3.601±0.2	22.228±2.8	349.12±4.5
S_8	10.487±0.2	0.032±0.01	226.095±6.5	8.932±0.9	4.452±0.1	31.777±2.5	399.59±4.3
S_9	9.366±0.9	0.761±0.1	242.697±6.3	7.761±0.8	3.092±0.1	21.098±2.5	381.34±8.0
S_{10}	6.208±0.2	0.052±0.02	231.190±6.3	1.652±0.8	0.532±0.2	10.821±2.5	372.55±5.0
S_{11}	5.159±0.9	0.542±0.3	226.921±6.2	7.542±0.7	3.201±0.7	30.126±2.4	321.20±3.7
S_{12}	9.399±0.08	0.091±0.01	223.632±5.5	0.691±0.8	4.306±0.8	30.892±2.4	351.37±3.8

Table 4

Quality classes (QC) of surface waters – Order 161/2006 [mg/l] [8]

	Heavy metals [mg/l]						
QC	**Pb**	**Cd**	**Zn**	**Ni**	**Cr**	**Mn**	**Fe**
I	5	0.5	100	10	25	50	300
II	10	1	200	25	50	100	500
III	20	2	500	50	100	300	1000
IV	50	5	1000	100	250	1000	2000
V	>50	>5	>1000	>100	>250	>1000	>2000

A comparison between Pb, Cd, Zn, Ni, and Fe concentrations and QC values of surface waters – Order 161/2006 (Table 4) was achieved (Figs. 6–10).

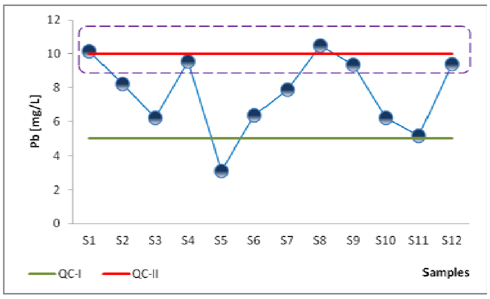

Fig. 6 – Lead concentration in surface water samples collected from Olt River.

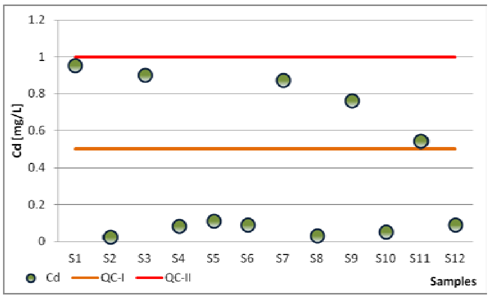

Fig. 7 – Cadmium concentration in surface water samples collected from Olt River.

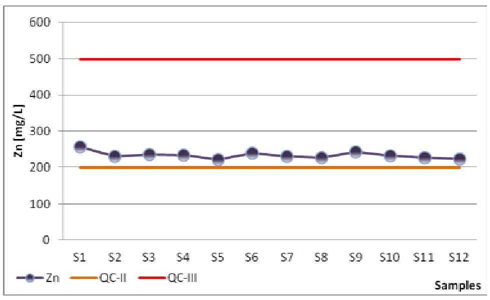

Fig. 8 – Zinc concentration in surface water samples collected from Olt River.

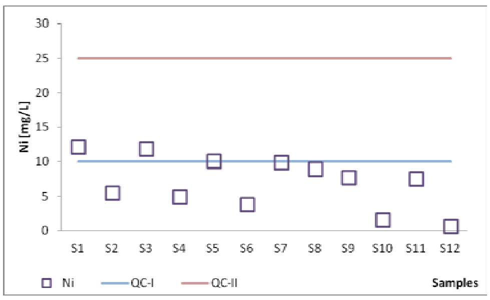

Fig. 9 – Nickel concentration in surface water samples collected from Olt River.

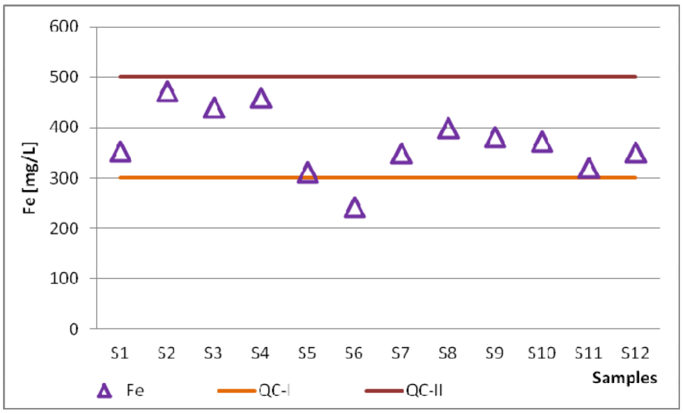

Fig. 10 – Iron concentration in surface water samples collected from Olt River.

Lead concentrations for S1 and S8 samples exceed the QC-II values, and for the samples S2, S3, S4, S5, S6, S7, S9, S10, S11 and S12 were between the QC-I and QC-II values. Only S4 samples was included in QC-I.

Cadmium concentrations for S1, S3, S7, S9, and S11 samples were between the QC-I and QC-II values and all the other samples were included in QC-I.

Zinc concentrations for all the samples were slightly higher that QC-II values.

Nickel concentrations for S1 and S3 samples were slightly higher that QC-I values and all the other samples were included in QC-I.

Iron concentrations for all samples were between the QC-I and QC-II values except the S6 sample which was included in QC-I.

4. CONCLUSIONS

In accordance with the Framework Directive 96/61/EC (IPPC Directive), the requirements of Directive 2006/11/EC which replaced Directive 76/464/EEC on pollution caused by dangerous substances discharged into the aquatic environment of the Community and the Implementation Plan of Directive 91/271/EEC concerning urban wastewater, the present study aimed to determine the pollution degree of the Olt River, on Fagaras – Victoria sector.

Concerning the nitrates concentrations can conclude that the water of Olt River (Superior Hydrographic Basin – Fagaras Depression, Romania) may be included in QC-II and QC-III, except water from Voila Hidropower plant (S4), Vistea Hidropower plant (S8), Corbul Ucii Creek (S9) and Arpas Hidropower plant (S12) which is included in QC-IV.

Concerning the heavy metal concentrations can conclude that the water of Olt River (Superior Hydrographic Basin – Fagaras Depression, Romania) may be included in QC-I and QC-II.

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