Water Quality Analysis in Mountain Freshwater: Poiana Uzului Reservoir in the Eastern Carpathians

GHEORGHE ROMANESCU[1], DELIA MIFTODE[1], ALIN MIHU PINTILIE[2], CRISTIAN CONSTANTIN STOLERIU[1], ION SANDU[3,4]*

[1]Alexandru Ioan Cuza University of Iasi, Faculty of Geography and Geology, Department of Geography, 20A Carol I Blvd., 700505, Iasi, Romania

[2]Alexandru Ioan Cuza University of Iasi, Interdisciplinary Research Department – Field Science, 54 Lascar Catargi Str., 700107, Iasi, Romania

[3]Alexandru Ioan Cuza University of Iasi, ARHEOINVEST – Interdisciplinary Platform, Laboratory of Scientific Investigation & Conservation, 22 Carol I, Blvd., Corp G, 700506, Iasi, Romania

[4] Romanian Inventors Forum, 3 Sf. Petru Movila Str., 700089, Iasi, Romania

Water demand has increased, while water resources have decreased. The most important aspect of water is quality. For this reason, mountainous waters are captured for drinking water supply, because they are cleaner and their flow is more constant. The great dams constructed in Romania also have the role of preserving water resources. Poiana Uzului Reservoir comprises waters ranked in the first and the second water quality class, because the physicochemical parameters range within normal limits. For this reason, the reservoir supplies water for the towns of Darmanesti, Comanesti, Moinesti, Tg. Ocna, Onesti and Bacau. Only the amount of total suspended materials is greater, but it does not exceed normal limits. This study analyzes the physicochemical parameters of Poiana Uzului Reservoir waters, in order to highlight their qualitative status.

Keywords: anthropic activity, freshwater supply, physicochemical parameters, water quality index, pollution

The analysis of water quality within reservoirs used for drinking water supply in localities has been a topic of major interest for human society. The contamination of these water reserves with polluting substances can affect significantly the socioeconomic context, by altering irremediably the aquatic ecosystem and the health status of local or regional population. From this viewpoint, Poiana Uzului Reservoir represents a subject of study at regional level, because it supplies water for most of the population inhabiting the Curvature Carpathians area. The physico-chemical parameters specific to waters within large reservoirs vary greatly in time and space, while the risk of contaminating water with polluting elements is determined by a multitude of factors: lithology, wastewater dumping, use of chemical or natural fertilizers, etc. National and international scientific literature underscores the qualities of captured waters distributed through reservoirs for the supply of human settlements [1-16].

This study conducts a descriptive and statistical analysis of 22 chemical and physicochemical parameters highlighting the water quality index within Poiana Uzului Reservoir. The water resource in the Curvature Carpathians area is distributed outside this region, which most often suffers from acute lack of water. In the mountainous sector, precipitations are relatively scarce because this sector is influenced by the foehn, which is a warm dry wind [17-20].

Experiemntal part

Study area

Poiana Uzului Reservoir is situated in the Nemira Mountains Nature Reserve, in the Eastern Carpathians. It is placed on the Uz stream, which is a right tributary of River Trotus (in its turn discharging into River Siret, namely the most important river on the Romanian territory). On the right, its tributaries are the creeks of Secatura, Izvorul Alb, Groza and Tulburea, while on the left Rachitis, Paraul Plopilor, Plopul and Alunul. The distance from the Uz dam to the confluence with River Trotus is 13 km. In the upstream sector of the reservoir, there is the locality of Cremenea, while the downstream sector includes the locality of Darmanesti (County of Bacau). Its limits are as follows: to the north - 46°20'17"N; to the south - 46°19'17"N; to the west - 26°20'26"E; to the east - 26°23'55"E (fig. 1).

The dam was built in the period 1956-1972. It is a buttress dam; for its construction, the villages of Poiana and Pivniceri – comprising 260 dwellings on 150 ha - had to be relocated. At the same time, five ha of woods were deforested. The dam provoked discontinuities in the evolution of the Uz riverbed and of adjacent slopes [21]. The reservoir occupies a rocky sector of the former River Uz, while at the narrow end of the lake a locally important wetland is in development [22-24].

Poiana Uzului Reservoir was built to supply water for the localities of Darmanesti, Comanesti, Moinesti, Tg. Ocna, Onesti, Bacau and for some villages that do not benefit from water supply facilities. The dam has a drinking water intake, an industrial water intake and a micro-hydropower station (5MW installed power). During higher waters, the reservoir covers 334 ha; it is 3.75 km long, its volume reaches $98x10^6$ m^3 and its depth 64.7 m [21]. During droughty periods, the flow ensured for drinking water is 1.5 m^3/s, while for industrial water it is 6.5 m^3/s (table 1).

Methodology

For Poiana Uzului Reservoir, three water sampling sites were selected: S.1 Upper area of Poiana Uzului Reservoir; S.2 Middle area of Poiana Uzului Reservoir (2.5 km distance from the dam); S.3 Lower area of Poiana Uzului Reservoir (0.2 km distance from the dam). The water samples were collected in conformity with the water monitoring system manual drafted by the specialists with the Siret Water Basin Administration, Bacau (fig. 1). The monitoring period

* email: sandu_i03@yahoo.com

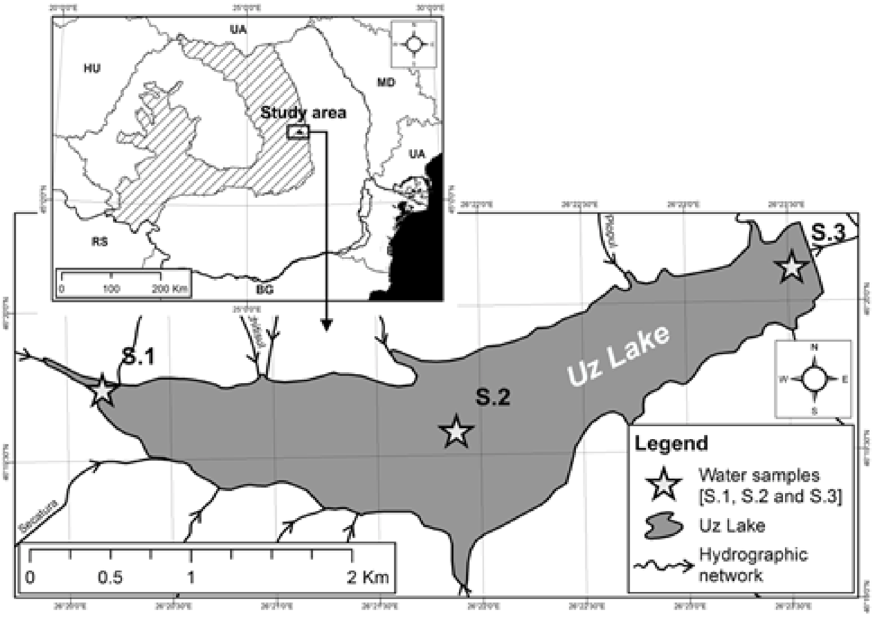

Fig. 1. Geographic position of Poiana Uzului Reservoir in the Eastern Carpathians (Romanian territory) and the water sampling sites

Table 1
CHARACTERISTICS OF POIANA UZULUI RESERVOIR

Placement	On River Uz
Dam type	Buttresses
Building period	1956–1972
Purpose of dam building	Water supply – main purpose; electric power production – secondary purpose
Inauguration of partial exploitation	1970
Inauguration of exploitation within designed parameters	1972
Maximum dam height	80 m
Length of dam crest	500 m
Reservoir volume	$90x10^6 m^3$
Maximum reservoir volume (during higher waters)	$98x10^6 m^3$
Maximum reservoir length (during higher waters)	3.75 km

consisted of four samplings/ year. Water samples were collected from three representative areas. Water quality was assessed pursuant to the quality standards issued by the Order of the Ministry of Environment and Water Management no. 161/2006. A second method was used for evaluating water quality (statistical method) in order to determine the weighting of the 22 chemical and physicochemical parameters.

The data collecting method led to the determination of the 22 chemical and physicochemical parameters: Thermal regime and acidifying -Air and water temperature (°C), pH (pH units) and alkalinity (mmol/L); Oxygen regime - Dissolved oxygen (mg O_2/L), Dissolved oxygen saturation (%), Biochemical oxygen demand (mg O_2/L) and Chemical oxygen demand (mg O_2/L); Nutrients- Ammonium (mg N/L), Nitrites (mg N/L), Nitrates (mg N/L), Total nitrogen (mg N/L), Soluble orthophosphates (mg P/L) and Total phosphorus (mg P/L); Salinity - Fixed residue (mg/L), Conductivity (μS/cm), Chlorides (mg/L), Sulfates (mg/L), Calcium (mg/L), Magnesium (mg/L), Bicarbonates (mg/L), Dissolved iron (mg/L) and Total manganese (mg/L); Other chemical indicators- Total suspended materials (mg/L). The pinpointing of chemical characteristics and of water quality - at the end of one-year monitoring cycle - is based on the interpretation of descriptive statistical parameters: Med., Min., Max., Q1 - Quartile 1 (25%), Q3 - Quartile 3 (75%) and S.D. - Standard Deviation (tables 2, 3

Table 2
DESCRIPTIVE STATISTICS FOR 22 ELEMENTS, CHEMICAL AND PHYSICO-CHEMICAL PARAMETERS ANALYZED IN [S.1] – UPPER AREA OF POIANA UZULUI RESERVOIR

Water sample [S.1] – Upper area of Poiana Uzului Reservoir									
Water quality indicators	Elements, chemical and physicochemical indicators	Count	Med.	Min.	Max.	Q1	Q3	S.D.
Thermal regime and acidifying	Air temperature (°C)	4	19.25	14	24	15.2	21.75	4.27
	Water temperature (°C)	4	13.25	7.00	21.00	7.30	18.00	6.85
	pH (pH units)	4	7.67	7.51	7.83	7.54	7.74	0.13
	Alkalinity (mmol/L)	4	2.45	1.60	3.50	1.74	2.83	0.81
Oxygen regime	Dissolved oxygen (mg O_2/L)	4	9.08	8.01	10.37	8.23	9.47	0.99
	Dissolved oxygen saturation (%)	4	88.50	85.00	92.00	85.90	89.75	2.89
	Biochemical oxygen demand (mg O_2/L)	4	2.02	1.30	2.54	1.54	2.23	0.52
	Chemical oxygen demand (mg O_2/L)	4	35.71	5.00	103.00	8.00	40.63	45.28

Nutrients	Ammonium, N-NH_4^+, (mg N/L)	4	0.21	0.02	0.75	0.02	0.22	0.36
	Nitrites, N-NO_2^-, (mg N/L)	4	0.02	0.00	0.04	0.00	0.02	0.01
	Nitrates, N-NO_3^-, (mg N/L)	4	0.38	0.31	0.46	0.32	0.42	0.06
	Total nitrogen, N, (mg N/L)	4	0.86	0.75	1.20	0.75	0.86	0.22
	Soluble orthophosphates, P-PO_4^{3-}, (mg P/L)	4	0.01	0.01	0.04	0.01	0.01	0.01
	Total phosphorus (mg P/L)	4	0.01	0.01	0.04	0.01	0.01	0.01
Salinity	Fixed residue (mg/L)	4	110.50	97.00	128.00	98.80	117.50	13.63
	Conductivity (µS/cm)	4	170.50	149.00	199.00	151.70	181.75	22.07
	Chlorides, Cl^-, (mg/L)	1	2.50	2.50	2.50	2.50	2.50	-
	Sulphates, SO_4^{2-}, (mg/L)	1	3.55	3.55	3.55	3.55	3.55	-
	Calcium, Ca^{2+}, (mg/L)	2	31.35	29.09	33.60	29.54	32.47	3.19
	Magnesium, Mg^{2+}, (mg/L)	2	4.43	2.92	5.95	3.22	5.19	2.14
	Bicarbonates, HCO_3^- (mg/L)	4	149.50	98.00	214.0	106.7	172.75	49.70
	Dissolved iron, $Fe^{2+} + Fe^{3+}$, (mg/L)	1	0.02	0.02	0.02	0.02	0.02	-
	Total manganese, $Mn^{2+} + Mn^{7+}$, (mg/L)	3	0.02	0.01	0.03	0.01	0.02	0.01
Other chemical indicators	Total suspended materials (mg/L)	4	21.33	5.30	35.00	9.41	28.25	12.53

Table 3

DESCRIPTIVE STATISTICS FOR 22 ELEMENTS, CHEMICAL AND PHYSICO-CHEMICAL PARAMETERS ANALYZED IN [S.2] - MIDDLE AREA OF POIANA UZULUI RESERVOIR (2.5 Km DISTANCE FROM THE DAM)

Water sample [S.2] – Middle area of Poiana Uzului Reservoir (2.5 km distance from the dam)								
Water quality indicators	Elements, chemical and physicochemical indicators	Count	Med.	Min.	Max.	Q1	Q3	S.D.
Thermal regime and acidifying	Air temperature (°C)	4	19.50	14.00	24.00	15.20	22.50	4.43
	Water temperature (°C)	4	13.75	7.00	21.00	7.60	18.75	6.80
	pH (pH units)	4	7.63	7.49	7.76	7.53	7.68	0.11
	Alkalinity (mmol/L)	4	1.99	1.50	2.29	1.64	2.22	0.35
Oxygen regime	Dissolved oxygen (mg O_2/L)	4	8.95	8.09	10.06	8.16	9.52	0.92
	Dissolved oxygen saturation (%)	4	88.25	83.00	93.00	84.20	90.75	4.27
	Biochemical oxygen demand (mg O_2/L)	4	1.91	1.35	2.78	1.41	2.16	0.63
	Chemical oxygen demand (mg O_2/L)	4	15.18	13.99	16.64	14.29	15.46	1.09
Nutrients	Ammonium, N-NH_4^+ (mg N/L)	4	0.19	0.02	0.70	0.02	0.19	0.34
	Nitrites, N-NO_2^-, (mg N/L)	4	0.01	0.01	0.01	0.01	0.01	0.00
	Nitrates, N-NO_3^-, (mg N/L)	4	0.42	0.35	0.49	0.37	0.44	0.06
	Total nitrogen, N, (mg N/L)	4	0.84	0.75	1.12	0.75	0.84	0.18
	Soluble orthophosphates, P-PO_4^{3-}, (mg P/L)	4	0.01	0.01	0.01	0.01	0.01	0.00
	Total phosphorus, (mg P/L)	4	0.01	0.01	0.02	0.01	0.01	0.01
Salinity	Fixed residue, (mg/L)	3	173.67	146.00	191.00	153.60	187.50	24.21
	Conductivity, (µS/cm)	3	173.67	146.00	191.00	153.60	187.50	24.21
	Chlorides, Cl^-, (mg/L)	1	6.32	6.32	6.32	6.32	6.32	-
	Sulphates, SO_4^{2-}, (mg/L)	1	1.50	1.50	1.50	1.50	1.50	-
	Calcium, Ca^{2+}, (mg/L)	1	36.80	36.80	36.80	36.80	36.80	-
	Magnesium, Mg^{2+}, (mg/L)	1	1.95	1.95	1.95	1.95	1.95	-
	Bicarbonates, mg/L,	3	131.67	121.00	140.00	123.60	137.00	9.71
	Dissolved iron, $Fe^{2+} + Fe^{3+}$, (mg/L)	1	0.02	0.02	0.02	0.02	0.02	-
	Total manganese, $Mn^{2+} + Mn^{7+}$, (mg/L)	3	0.02	0.02	0.03	0.02	0.03	0.01
Other chemical indicators	Total suspended materials (mg/L)	3	29.60	7.80	45.00	13.44	40.50	19.41

Table 4

DESCRIPTIVE STATISTICS FOR 22 ELEMENTS, CHEMICAL AND PHYSICO-CHEMICAL PARAMETERS ANALYZED IN [S.3] - LOWER AREA OF POIANA UZULUI RESERVOIR (0.2 KM DISTANCE FROM THE DAM)

Water sample [S.3] – Lower area of Poiana Uzului Reservoir (0.2 km distance from the dam)								
Water quality indicators	Elements, chemical and physicochemical indicators	Count	Med.	Min.	Max.	Q1	Q3	S.D.
Thermal regime and acidifying	Air temperature (°C)	11	13.18	1.00	24.00	4.00	19.00	7.45
	Water temperature (°C)	11	9.45	1.00	20.00	2.00	14.50	6.95
	pH (pH units)	11	7.61	7.03	7.88	7.48	7.77	0.23
	Alkalinity (mmol/L)	10	1.66	1.20	1.98	1.38	1.85	0.25
Oxygen regime	Dissolved oxygen (mg O_2/L)	11	8.77	0.20	12.00	7.45	10.31	3.16
	Dissolved oxygen saturation (%)	11	85.36	80.00	93.00	80.00	89.00	4.76
	Biochemical oxygen demand (mg O_2/L)	11	2.80	0.98	14.35	1.10	1.98	3.86
	Chemical oxygen demand (mg O_2/L)	11	14.83	5.00	27.90	5.00	15.00	6.44
Nutrients	Ammonium, N-NH_4^+ (mg N/L)	11	0.04	0.02	0.20	0.02	0.02	0.06
	Nitrites, N-NO_2^-, (mg N/L)	11	0.01	0.00	0.02	0.00	0.01	0.00
	Nitrates, N-NO_3^-, (mg N/L)	11	0.44	0.14	0.68	0.34	0.57	0.16
	Total nitrogen, N, (mg N/L)	10	0.70	0.36	0.75	0.59	0.75	0.12
	Soluble orthophosphates, P-PO_4^{3-}, (mg P/L)	11	0.01	0.01	0.02	0.01	0.01	0.00
	Total phosphorus, (mg P/L)	11	0.01	0.01	0.02	0.01	0.02	0.01
Salinity	Fixed residue, (mg/L)	11	133.91	78.00	366.00	90.00	123.50	79.55
	Conductivity, (µS/cm)	11	203.27	120.00	564.00	138.00	190.00	122.33
	Chlorides, Cl^-, (mg/L)	11	3.08	2.50	6.32	2.50	2.50	1.31
	Sulphates, SO_4^{2-}, (mg/L)	11	3.69	1.50	8.96	1.50	5.17	2.47
	Calcium, Ca^{2+}, (mg/L)	8	32.00	24.24	40.00	25.19	34.90	5.71
	Magnesium, Mg^{2+}, (mg/L)	8	4.89	2.92	11.79	2.92	4.61	3.05
	Bicarbonates, mg/L,	10	101.10	73.00	121.00	83.80	113.25	15.61
	Dissolved iron, Fe^{2+} + Fe^{3+}, (mg/L)	9	0.07	0.02	0.15	0.02	0.10	0.05
	Total manganese, Mn^{2+} + Mn^{4+}, (mg/L)	9	0.03	0.01	0.06	0.01	0.03	0.01
Other chemical indicators	Total suspended materials (mg/L)	11	20.06	10.00	49.00	10.00	22.85	13.22

and 4). Data interpretation was also based on the analysis of previously edited thematic papers [25-44].

Results and discussions

Thermal regime and acidifying

The thermal regime of Poiana Uzului Reservoir waters is influenced directly by air temperature regime. While taking water samples, the average air temperature varied between 13.25 and 19.50°C. The great difference in thermal amplitude is provided by the fact that samples were collected in different days. In this case, the difference between the thermal regime of air and water must be calculated separately. For the S.1 sample, the average thermal amplitude between air and water is 6°C. For S.2 samples, a difference of 5.55°C was recorded, while for S.3 the difference was 3.73°C. The temperature difference drops from upstream to downstream, with a constancy of around 1°C for the three collection points. The difference is induced by the variation of water depth and aquatic surface under the direct influence of sun radiation. Water temperature has different values, by season. Thermal amplitude is provided by intervals: S.1 -7÷21°C; S.2- 7÷21°C; S.3 -1÷20°C. In summertime, water temperature ranges between 20 and 21°C, while in wintertime it ranges between 1 and 7°C. During spring and autumn, temperature has different oscillations because of the thermal mixture with runoff waters from ice melting or from precipitations, (significantly reducing the altitude influence of sun radiation) (fig. 2).

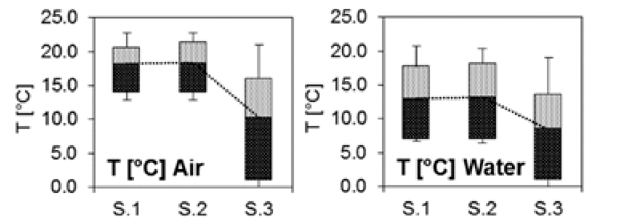

Fig. 2. Thermal regime

Temperature also regulates the water-acidifying regime, through both seasonal distribution and the cycle of day and night. *p*H records a great variation gap during the day because of photosynthesis and breathing of aquatic organisms [26-28, 32]. *p*H has a relatively even distribution, recording the following average value at the three sampling points: S.1 - 7.67; S.2 - 7.63; S.3 -7.61. The maximum pH value was recorded for sample S.3 - 7.88. A weakly alkaline concentration was measured in the spillway area at the dam level. PH level is directly related to water alkalinity, ranging between 1.20 and 3.50 mmol/L. This is typical behaviour for a lake situated in a mountainous area. Most of the year, waters are alkaline, except for the spring shock, when acidity increases due to rapid snow melting (fig. 2).

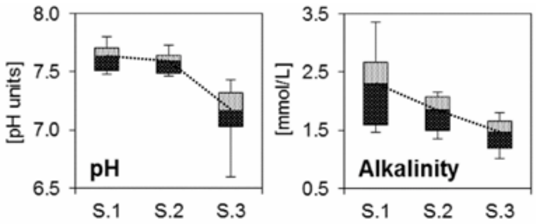

Fig. 3. Acidifying conditions

Oxygen regime

Oxygen is important for the breathing of organisms (biodiversity maintenance). The necessary amount of dissolved oxygen for economically important ichthyofauna to survive must not drop below 3–5 mg O_2/L. Oxygen decrease below this value indicates the presence of an oxygen-replacing mechanism [26-28]. The average value of dissolved oxygen (DO) within Poiana Uzului Reservoir ranges between 8.77 and 9.08 mg O_2/L. The DO amount drops from upstream to downstream due to water turbidity. As for samples S.1 and S.2, the average value of DO is >0.25 mg O_2/L. Concerning sample S.3, minimum DO value is 0.20 mg O_2/L. The phenomenon is closely connected to water dynamic, because water stagnates for a longer period in the dam area. The maximum values of DO range between 10.06 and 12.00 mg O_2/L. DO% saturation indicates descending average values from upstream to downstream: S.1 – 88.50%, S.2 – 88.25%, S.3 – 85.36%. The maximum values of saturation in dissolved oxygen range between 92 and 93%, while the minimum between 80 and 85% (fig. 3).

The seasonal regime of dissolved oxygen (DO) increased significantly during winter and decreased in summertime. The correlation between DO and water temperature is negative and values are inversely proportional. Seasonal differences are due to algae.

Biochemical oxygen demand (BOD_5) represents the amount of dissolved oxygen (DO) necessary for aerobic organisms to decompose organic matter in the water [26-28, 45]. A high level of BOD_5 may indicate high organic carbon contents from natural sources and contamination with wastewater from anthropic sources (containing a significant amount of faecal matters). BOD_5 value varies as follows: S.1 - 1.3÷2.54 mg O_2/L; S.2 - 1.35÷2.78 mg O_2/L; S.3 - 0.98÷14.35 mg O_2/L. The great amplitude of BOD_5 for S.3 sample is due to the accumulation of non-decomposed organic matter within the dam area. Maximum value corresponds to a time interval where water was not evacuated and organic matter was already decomposed. Minimum value corresponds to periods with intense water circulation. Average values of BOD_5 - at the level of the entire water body – vary between 1.9 and 2.8 mg O_2/L. Chemical oxygen demand (COD) is an indicator that determines the oxygen demand of water mass bacteria (it takes less to be determined). For this reason, only 60–70% of the organic substances present in the water mass were identified. The variation of COD values is the following: S.1 - 5.00÷103.00 mg O_2/L; S.2 - 13.99÷16.64 mg O_2/L; S.3 - 5.00÷27.9 mg O_2/L. Average values ale COD - at the level of the entire water body - vary between 14.83 and 35.71 mg O_2/L (fig. 4).

High forestation degree and the lack of agrozootechnical and industrial infrastructures within the catchment basin of the lake reflect in the low values of BOD_5 and COD indicators. The values of these indicators increase in summertime, when the amount of organic substances is great due to the vegetative season of plants. The sudden increase in chemical and biochemical oxygen demand also occurs after periods with high amounts of precipitations, due to the great quantities of non-

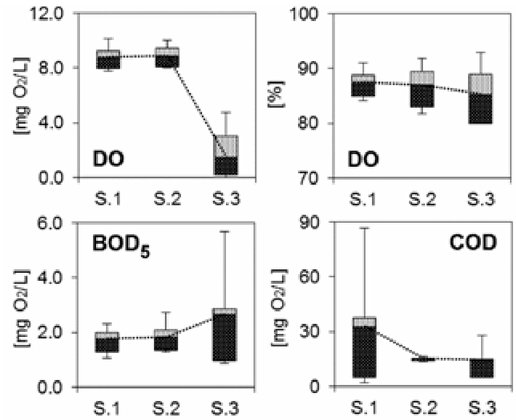

Fig. 4. Oxygen regime

decomposed organic matters, transported and deposited by high waters [25-32].

Nutrients

The analysis of nutrients was conducted by pointing out the concentration of ammonium ion (N-NH_4^+), of nitrites (N-NO_2^-), nitrates (N-NO_3^-) and soluble phosphorus (P-PO_4^{3-}). Whereas their toxicity is low, their presence within water mass can be considered an indicator of anthropic pollution. The average concentration of ammonium ion (N-NH_4^+) varies between 0.04 and 0.21 mg N/L. The maximum value of 0.75 mg N/L was recorded for the S.1 sample at the narrow end of the lake. This concentration occurs in the spring and it is correlated with the emergence of floods. The lowest values were recorded for the middle sector (S.2) and the dam area (S.3), but they do not drop below 0.02 mg N/L. The low values of ammonium ion concentrations correlate with the lack of agrozootechnical and industrial activities within the lake area (the result of natural contaminations) (fig. 5).

The distribution of the amounts of nitrites (N-NO_2^-) and nitrates (N-NO_3^-) shows a reduced value of contamination. The concentration of nitrites ranges between 0.01 and 0.04 mg N/L, while the concentration of nitrates between 0.14 and 0.68 mg N/L. The higher value of nitrates is due to the use of nitrogen-based chemical fertilizers and manures to fertilize agricultural fields. Transportation to the lake is done through the drainage network, while the accumulation of nutrients in the dam area is a consequence of water

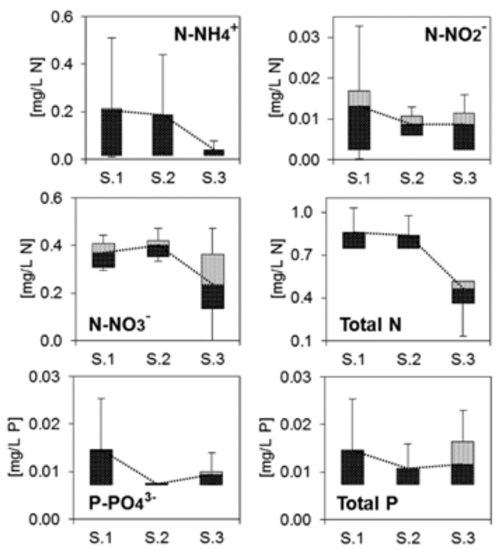

Fig. 5. Nutrient concentrations

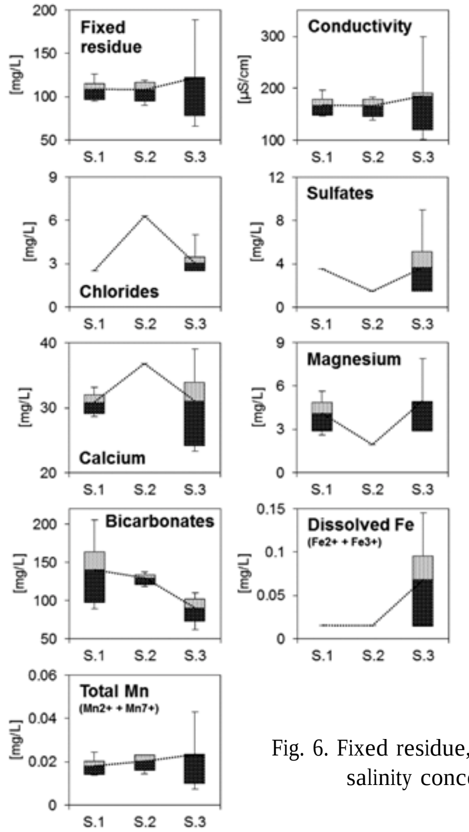

Fig. 6. Fixed residue, conductivity and salinity concentrations

dynamic. For this reason, the highest value of average annual concentration of nitrates corresponds to S.3 sample - 0.44 mg N/L. The average value of total nitrogen indicates a quantitative decrease from upstream to downstream: S.1 -0.86 mg N/L; S.2- 0.84 mg N/L; S.3 -0.70 mg N/L. The phenomenon is due to water depth and to the emergence of vegetation that settles the nitrogen for a long period (in the wetland at the narrow end of the lake and on banks with low declivity) [46]. Water contamination with nitrites and nitrates is still low, due to natural conditions and less to anthropic conditions.

The increase in phosphorus content is usually a consequence of anthropic pressure (faulty storage of animal wastes and use of phosphates-based fertilizers) [26-28]. The average concentration of soluble phosphorus ($P\text{-}PO_4^{3-}$) and total phosphorus is 0.01 mg P/L. The most important seasonal variation was recorded for S.1 sample, where the concentration amplitude of phosphorus is situated within the interval 0.01-0.04 mg N/L. As for samples S.2 and S.3, the maximum value of soluble phosphorus ($P\text{-}PO_4^{3-}$) concentration does not exceed 0.02 mg P/L. Phosphorus distribution indicates low contamination in the area where Uz discharges into the lake (fig. 5).

Salinity

Chemism is influenced directly by the geological conditions within the catchment basin. The presence of friable sediment deposits – specific to Palaeogene flysch – determines the accumulation of relatively important amounts of mineral substances. The average value of fixed residue within the water mass indicates a relatively high erosion capacity at the level of the catchment basin: S.1 – 110.50 mg/L; S.2- 173.67 mg/L; S.3 - 133.91 mg/L. The high concentration of fixed residue within S.2 sample indicates significant erosion activity conducted by tributaries on the sides. Annual salinity regime is reflected in the total concentration of suspended materials. The annual average of this parameter is the following: S.1 - 21.33 mg/L; S.2 - 29.6 mg/L; S.3-20.06 mg/L. The presence of a significant amount of salts is also illustrated by the value of water conductivity, which varies as follows: S.1 – 149÷199 µS/cm; S.2 - 146÷191 µS/cm; S.3 - 120÷564 µS/cm. The high value of conductivity in S.3 sample is due to solid transportation and to the accumulation of mineral substances in the dam area (fig. 6).

The maximum concentration of chlorides (Cl^-) increases from upstream to downstream, from S.1 -2.5 mg/L to S.3 - 6.32 mg/L. Total sulphates (SO_4^{2+}) increase from S.1- 3.55 mg/L to S.3 - 8.96 mg/L. The value of maximum total calcium (Ca^{2+}) increases from S.1 - 33 mg/L to S.3 -40 mg/L, and magnesium contents (Mg^{2+}) from S.1 - 5.95 mg/L to S.3 -11.49 mg/L. Bicarbonates feature a reverse distribution compared to previously mentioned mineral substances. The value of maximum concentration drops from upstream to downstream from S.1- 214 mg/L to S.3 - 121 mg/L. The presence of dissolved iron (Fe^{2+} + Fe^{3+}) is due to geological context, but it can also be an anthropic consequence (mining, water use). Average values of dissolved iron vary between 0.02 and 0.07 mg/L (fig. 6).

The frequency of maximum salinity values is higher during winter. This value can also be high during the autumn or spring. High values are specific to cold season because during this interval the lowest water flow rate was recorded. Ice bridge emergence represents a factor of control. The distribution type of lake salinity is specific to most reservoirs [25-32].

Water quality

Two methods were used for water quality index. The first is the determination of water quality by the value of concentrations for the 22 chemical and physicochemical parameters analyzed, in conformity with freshwater quality standards [21, 25, 26, 33, 43]. The parameters were grouped into five categories (thermal regime and acidifying, oxygen regime, nutrients, salinity and other chemical indicators) (table 5).

For thermal regime and acidifying, all three samples (S.1, S.2 and S.3) are included in the first quality class. The even value of the *p*H is the main argument for this parameter. Oxygen regime includes S.2 and S.3 samples in the first quality class, while S.1 sample in the second quality class (due to higher BOD_5 and COD values at the narrow end of the lake, where there is a human settlement). The low concentration of nutrients indicates higher water quality (first quality class). Salinity within S.1 and S.2 samples includes water in the first quality class, while S.3 sample in the second quality class (due to the accumulation of mineral substances at the level of the dam). The total concentration of suspended materials classifies the Poiana Uzului Reservoir waters in the second quality class.

The second evaluation method for water quality was conducted using statistical methods consisting of calculating the weighting of the 22 chemical and physicochemical parameters. The arithmetic value of water quality index was obtained using the following formula:

$$WQ_i = \Sigma WQ_i / \Sigma W_i$$

where:

Q_i is calculated for each parameter analyzed using the formula $WQ_i = 100[(V_i - V_o)/(S_i - V_o)]$ and W_i is calculated for each parameter analyzed through the formula $W_i = K/S_i$ where: $K = 1/\Sigma(1/S_i)$; Q_i- quality rating scale; W_i - weight unit; V_i - the estimated concentration of the parameter in water; V_o - the ideal value of the parameter, $V_o = 0$ (except for *p*H = 7.0 and DO = 14.6 mg/L); S_i - the recommended

Table 5
ELEMENTS, CHEMICAL AND PHYSICAL STANDARDS OF QUALITY IN THE FRESHWATER WITHIN THE WATER QUALITY CLASSES OF POIANA UZULUI RESERVOIR

Water quality indicators	Elements, chemical and physicochemical indicators	Standard classes of water quality					Poiana Uzului Reservoir		
		I	II	III	IV	V	S.1	S.2	S.3
Thermal regime and acidifying	Air temperature (°C)	No norms					I	I	I
	Water temperature (°C)	No norms							
	pH (pH units)	6.5–8.5							
	Alkalinity (mmol/L)	-							
Oxygen regime	Dissolved oxygen (mg O_2/L)	9	7	5	4	<4	II	I	I
	Dissolved oxygen saturation (%)	90–70	70–50	50–30	30–10	<10			
	Biochemical oxygen demand (mg O_2/L)	3	5	7	20	>20			
	Chemical oxygen demand (mg O_2/L)	10	25	50	125	>125			
Nutrients	Ammonium, N-NH_4^+ (mg N/L)	0.4	0.8	1.2	3.2	>3.2	I	I	I
	Nitrites, N-NO_2^-, (mg N/L)	0.01	0.03	0.06	0.3	>0.3			
	Nitrates, N-NO_3^-, (mg N/L)	1	3	5.6	11.2	>11.2			
	Total nitrogen, N, (mg N/L)	1.5	7	12	16	>16			
	Soluble orthophosphates, P-PO_4^{3-}, (mg P/L)	0.01	0.02	0.04	0.19	>0.19			
	Total phosphorus, (mg P/L)	0.015	0.04	0.075	1.2	>1.2			
Salinity	Fixed residue, (mg/L)	500	750	1000	1300	>1300	I	I	II
	Conductivity, (µS/cm)	-	-	-	-	-			
	Chlorides, Cl^-, (mg/L)	25	50	250	300	>300			
	Sulphates, SO_4^{2-}, (mg/L)	60	120	250	300	>300			
	Calcium, Ca^{2+}, (mg/L)	50	100	200	300	>300			
	Magnesium, Mg^{2+}, (mg/L)	12	50	100	200	>200			
	Bicarbonates, mg/L,	-							
	Dissolved iron, $Fe^{2+}+Fe^{3+}$, (mg/L)	0.3	0.5	1	2	>2			
	Total manganese, $Mn^{2+}+Mn^{7+}$, (mg/L)	0.05	0.1	0.3	1	>1			
Other chemical indicators	Total suspended materials (mg/L)	-					II	II	II
Total water quality							II	II	II

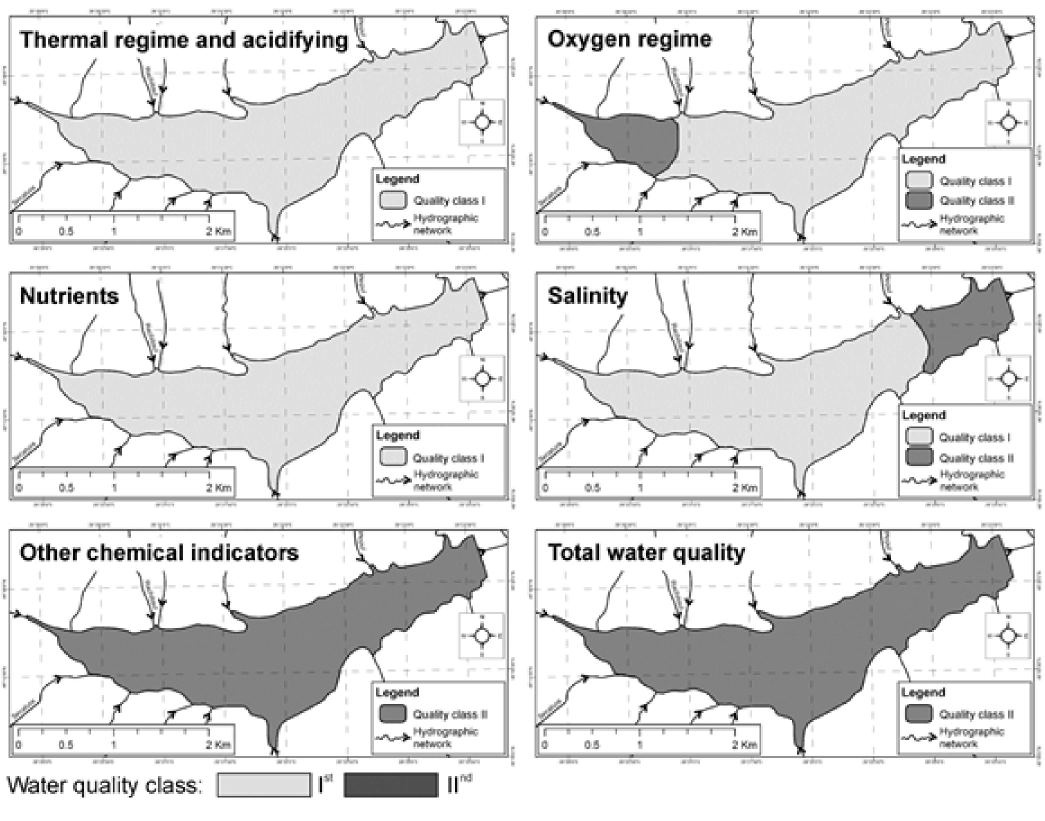

Fig. 7. Spatial distributions of water quality index [WQI] in Poiana Uzului Reservoir

standard value of the parameter; K = the proportionality constant.

In the first phase, the purpose was to determine the water quality index [WQI] by season, but the amount of data was low, which made it impossible to obtain a relevant result. For this reason, WQI was calculated based on annual average values for each of the 22 parameters under analysis. In this case, the result led to the classification of water into a specific quality class, depending on the section where the sampling was done. According to the calculation of the value ascribed to physicochemical parameters used in the calculation formula for WQI, the dominant parameters for establishing the quality class are as follows: BOD_5, COD, water salinity and the amount of suspended materials. From this viewpoint, oxygen regime at the narrow end of the lake (S.1 sample) and the accumulation of mineral substances in the dam area (S.3 sample) determines the decrease from the first quality class to the second quality class. The total amount of suspended materials is very important for the calculation formula of WQI. High values determine the decrease from the first quality class to the second quality class for all samples. The statistical method highlights the existence of second-quality water, which corresponds to the *Very Good* class (fig. 7) [27].

Conclusions

Poiana Uzului Reservoir uses the water of the Uz catchment basin for drinking water and industrial water supply and for electric power production. The volume of accumulated water is insufficient, but it is substituted by the high quality of mountainous waters. The modest development of anthropic activities and the high resistance of the geological substrate lead to highly qualitative waters (first and second quality class). It is necessary to maintain the current natural and anthropic parameters in the area of the Poiana Uzului catchment basin. Only total suspended materials determine the decrease in water quality from the first quality class to the second quality class, which corresponds to the *Very Good* category. Electric power production does not influence the quality or the amount of water distributed in the supplying network for human settlements.

References

1. BANADUC, D., REY, S., TRICHKOVA, T., LENHARDT, M., CURTEAN-BANADUC, A., Science of the Total Environment, 545-546, 2016, p. 137-151.
2. MERECKI, N., AGIC, R., SUNIC, L., MILENKOVIC, L., ILIÆ, Z.S., Fresenius Environmental Bulletin, 24, no. 11c, 2015, p. 4212-4219.
3. BEJENARU, L., DANU, M., STANC, S., International Journal of Conservation Science, 7, no. 1, 2016, p. 93-100.
4. VAN LEEUWEN, B., PRAVETZ, T., LIPTAY, Z.A., TOBAK, Z., Carpathian Journal of Earth and Environmental Sciences, 11, no. 2, 2016, p. 497-510.
5. KOMINKOVA, D., NABEIKOVA, J., VITVAR, T., Journal of Soils and Sediments, 16, no. 5, 2016, p. 1569-1583.
6. ROBA, C., ROSU, C., PISTEA, I., PISLARU, G., Air and Water Components of the Environment, 2016, p. 386-391.
7. ASHAARY, N.A., WAN ISHAK, W.H., KU-MAHAMUD, K.R., The 2nd International onference on Mathematical Sciences and Computer Engineering (ICMSCE 2015), 2015, p. 103-107.
8. PARASCA, A.G., BUTNARU, G.I., Procedia Economics and Finance, 15, 2014, p. 679-686.
9. CATIANIS, I., RADAN, S., GROSU, D., International Journal of Innovation and Applied Studies, 9, no. 1, 2014, p. 260-278.
10. NANDI, D., MISHRA S.R., International Journal of Conservation Science, 5, no. 1, 2014, p. 79-84.
11. PURI, P.J., YENKIE, M.K.N., BATTALWAR, D.G., GANDHARE, N.V., DHANORKAR, D.B. Rasayan J. Chem., 3, no. 4, 2010, p. 800-810.
12. POLICHT-LATAWIEC, A., BOGDAL, A., KAMOWNIK, W., KOWALIK, T., OSTROWSKI , K., Journal of Ecological Engineering, 16, no. 1, 2015, p. 100-109.
13. SOJA, R., WIEJACZKA, L, Water and Environment Journal, 28, no. 4, 2013, p. 473-482.
14. MAKINDE, O.O., EDUN, O.M., AKINROTIMI, O.A., Journal of Environment Protection and Sustainable Development, 1, no. 3, 2015, p. 126-133.
15. YADAV, P., YADAV, V.K., YADAV, A.K., KHAR,E P.K., Octa Journal of Biosciences, 1, no. 2, 2013, p. 177-184.
16. BARBULESCU, A., Studies on Time Series Applications in Environmental Sciences, 103, 2016, p. 145-151.
17. ROMANESCU, G., STOLERIU, C., Natural Hazards, 69, 2013, p. 1351-1367.
18. COJOC, G., ROMANESCU, G., TIRNOVAN, A., Natural Hazards, 77, no. 3, 2015, p. 1421-1451.
19. ROMANESCU, G., CURCA, R.G., SANDU, I.G., International Journal of Conservation Science, 6, no. 3, 2015, p. 261-269.
20. WRZESIÑSKI, D., CHOIÑSKI, A., PTAK, M., SKOWRON, R., Acta Geophysica, 63, no. 6, 2015, p. 1664-1684.
21.Administratia Bazinala de Apa Siret, Bacau, Raport, 2015.
22.MIFTODE, I.D., ROMANESCU, G., PROFIR, O., Lucrarile Seminarului Geografic Dimitrie Cantemir, 41, 2016, p. 37-46.
23. MIFTODE, I.D., ROMANESCU, G., Lucrarile Seminarului Geografic Dimitrie Cantemir, 41, 2016, p. 27-36.
24. MIFTODE, I.D., ROMANESCU, G., Aerul si apa componente ale mediului, Cluj Napoca, 2016, p. 125 - 133.
25. ROMANESCU, G., TIRNOVAN, A., SANDU, I., COJOC, G.M., BREABAN, I.G., MIHU-PINTILIE, A., Rev. Chim. (Bucharest), **66**, no. 10, 2015, p. 1700.
26. MIHU-PINTILIE, A., ROMANESCU, G., STOLERIU, C.C., Carpathian Journal of Earth and Environmental Sciences, 9, no. 2, 2014, p. 113.
27. MIHU PINTILIE, A., PAIU, M., BREABAN, I.G., ROMANESCU, G., 14th SGEM GeoConference on Water Resources. Forest, Marine and Ocean Ecosystems, SGEM2014 Conference Proceedings, 1, 2014, p. 639.
28. BREABAN, I.G., PAIU, M., MIHU PINTILIE, A., CRETESCU, I., 14th SGEM GeoConference on Water Resources. Forest, Marine and Ocean Ecosystems, SGEM2014 Conference Proceedings, 1, 2014, p. 815.
29. COZMA, D.G., CRUCEANU, A., COJOC, G.M., MUNTELE, I., MIHU-PINTILIE, A., 15th SGEM GeoConference on Water Resources. Forest, Marine and Ocean Ecosystems, SGEM2015 Conference Proceedings, 1, 2015, p. 625.
30. CRUCEANU, A., COJOC, G.M., COZMA, D.G., MUNTELE, I., MIHU-PINTILIE, A., 15th SGEM GeoConference on Water Resources. Forest, Marine and Ocean Ecosystems, SGEM2015 Conference Proceedings, 1, 2015, p. 159.
31. STOLERIU, C.C., STOLERIU, O.M., MIHU-PINTILIE, A., 14th SGEM GeoConference on Ecology, Economics, Education and Legislation, SGEM2014 Conference Proceedings, 2, 2014, p. 625.
32. MIHU PINTILIE, A., ROMANESCU, G., STOLERIU, C.C., STOLERIU, O.M., International Journal of Conservation Science, 5, no. 2, 2014, p. 243.
33. PATROESCU, V., JINESCU, C., COSMA, C., CRISTEA, I., BADESCU, V., STEFAN, C.S., Rev. Chim. (Bucharest), **66**, no. 4, 2015, p. 537
34. BURADA, A., ODOR, D.S., TEODOROF, L., NASTASE, C., NASTASE, A., NAVODARU, I., GEORGESCU, L.P., Journal of Environmental Protection and Ecology, 15, no. 3, 2014, p. 842-850.
35. IORDACHE, M., POPESCU, L.R., PASCU, L.F., LEHR, C.,UNGUREANU, E.M., IORDACHE, I., Romania. Rev. Chim. (Bucharest), **66**, no. 7, 2015, p. 1009
36. CIRTINA, D., CAPATINA, C., SIMIONESCU, C.M., Rev. Chim. (Bucharest), **66**, no. 8, 2015, p.1184

37. FELFOLDI, T., RAMGANESH S., SOMOGYI B., KRETT G., JURECSKA L., SZABÓ A., VOROS L., MARIALIGETI K., MATHE I., Geomicrobiology Journal, 1-36, 2015.
38. SEVIANU, E., STERMIN, A.N., MALOS, C., RETI, K., MUNTEANU, D., DAVID, A., Carpathian Journal of Earth and Environmental Sciences, 10, no. 4, 2015, p. 173-180.
39. BARBULESCU, A., MAFTEI, C., Rom. Journ. Phys., 60, no. 7–8, 2015, p. 1163–1170.
40. PINTILIE, O., ANDRIES, C., COSMA, A., ZAHARIA, M., DROCHIOIU, G., VASILACHE, V., SANDU, I., Rev. Chim. (Bucharest), **66**, no. 9, 2015, p. 1321
41. VASILACHE, V., CRETU, M.A., PASCU, L.F., RISCA, M., CIORNEA, E., MAXIM, C., SANDU, I.G., CIOBANU, C.I., International Journal of Conservation Science, 6, no. 1, 2015, p. 93-98.
42. POPESCU, L.R., IORDACHE, M., BUICA, G.O., UNGUREANU, E.M., PASCU, L.F., LEHR, C., Rev.chim.(Bucharest), **66**, no. **12**, 2015, p. 2060
43. PATROESCU, V., IONESCU, I., TIRON, O., BUMBAC, C., MARES, M.A., JINESCU, G., Rev. Chim. (Bucharest), **67**, no. 5, 2016, p. 958-961.
44. DIRTU, D., PANCU, M., MINEA, M.L., CHIRAZI, M., SANDU, I., DIRTU, A.C., Rev. Chim(Bucharest), **67**, no. 6, 2016, p. 1167
45. KOUAME, I.K., KOUASSI, L.K., DIBI, B., ADOU, K.M., RASCANU, I.D., ROMANESCU, G., SAVANE, I., SANDU, I., Journal of Environmental Protection, 4, 2013, p. 1441-1448.
46. ROMANESCU, G., STOLERIU, C., ZAHARIA, C., Journal of Environmental Science and Engineering, 5, no. 11, 2011, p. 1435-1444.

Manuscript received: 12.04.2016