PHYSICAL-CHEMICAL CHARACTERIZATION OF INFLUENT AND EFFLUENT WATERS FROM THE TREATMENT PLANT PITESTI AND THEIR INFLUENCE ON THE CHEMISTRY OF LAKE GOLEŞTI

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Abstract. The treatment plant of Piteşti is situated on the right bank of the Argeş river and it discharges the treated effluent into lake Goleşti (reservoir built to produce hydropower, to alleviate flooding, for irrigation and water supply). This lake belongs to the chain of reservoirs built along the Argeş river – which, together with its tributaries, form a rich hydrographic network with a total length of about 200 km. Knowing the effects that the treated water has on the ecosystem of lake Goleşti represents a necessity for health assessment, trophic level and for setting decisions and management plans for its conservation and exploitation.

Keywords: the Argeş River, physical and chemical indicators, economic importance.

Rezumat. Caracterizarea fizico-chimică a apelor influente şi efluente provenite de la staţia de epurare Piteşti şi influenţa acestora asupra chimismului lacului Goleşti. Staţia de epurare a oraşului Piteşti este situată pe malul drept al Argeşului şi evacuează efluentul epurat în lacul Goleşti (lac de baraj construit în scopul producerii de hidroenergie, pentru atenuarea inundaţiilor, irigare si alimentare cu apă). Acest lac face parte din salba de lacuri de acumulare amenajate de-a lungul râului Argeş - care împreună cu afluenţii săi formează o reţea hidrografică bogată cu o lungime totală, de aproximativ 200 km. Cunoaşterea efectelor pe care apele epurate le exercită asupra ecosistemului lacului Goleşti, reprezintă o necesitate pentru evaluarea stării sale de sănătate, a gradului de trofie şi pentru stabilirea deciziilor şi planurilor de management pentru conservarea şi exploatarea acestuia.

Cuvinte cheie: râul Argeş, indicatori fizico-chimici, importanţă economică.

INTRODUCTION

One of the requirements imposed to Romania after joining the European Union is ensuring a good water condition. Knowing the status of aquatic ecosystems is a complex action which takes into account tracking and determining the qualitative and quantitative aspects of water resources.

The main factors that determine water quality in reservoirs are water composition (physical-chemical characteristics), the hydrological regime, the structure and the functions of the integrated biocoenosis and the catchment morphology. These factors depend largely on the characteristics of the water of the tributaries in the catchment area of the river in question. If there are significant sources of water pollution on the tributaries of the river, in many cases its self-purification capacity will be exceeded and the accumulation that feeds it will become water with an impaired quality (BREZEANU et al., 2011; VLĂDUŢU, 2005).

MATERIALS AND METHODS

The selection of the physical-chemical parameters to be analyzed took into account the list of the main pollutants described in annex VIII of “Water Framework Directive”, being considered important to determine the concentrations of suspended solids in the water mass, of nutrients that contribute to eutrophication (nitrogen and phosphorus), the concentration of dissolved oxygen in water and its pH.

Thus, for a proper monitoring, research stations were provided on the surface of lake Goleşti (Fig. 1): at the upstream end (at the treatment plant Piteşti) of the lake (A), at the outlet of the treatment plant Piteşti (I, E), at the actual entrance portion in the lake basin Goleşti (G) and in the terminal portion of the lake, in the proximity of the dam Goleşti, about 7.5 km far from the treatment plant discharge (G0, G3, G10); on depth profiles of water main, here, samples were taken from the surface of the water (0m deep), but also from the depth of 3m and 10m.

During the four year study (2006-2009), the necessary samples for physical-chemical determinations were taken as it follows: monthly, for the upstream and downstream sections of the treatment plant Piteşti, and daily, for the influent and effluent waters of the wastewater treatment plant Piteşti.

The values of the physical-chemical parameters analysed in lake Goleşti between 2006 and 2009 were expressed as average monthly values per sampling station (MĂLĂCEA, 1969; ROJANSCHI, 1995; 1997; HAIDUC & BODOŞ, 2005; VOLLENWIDER, 1969).

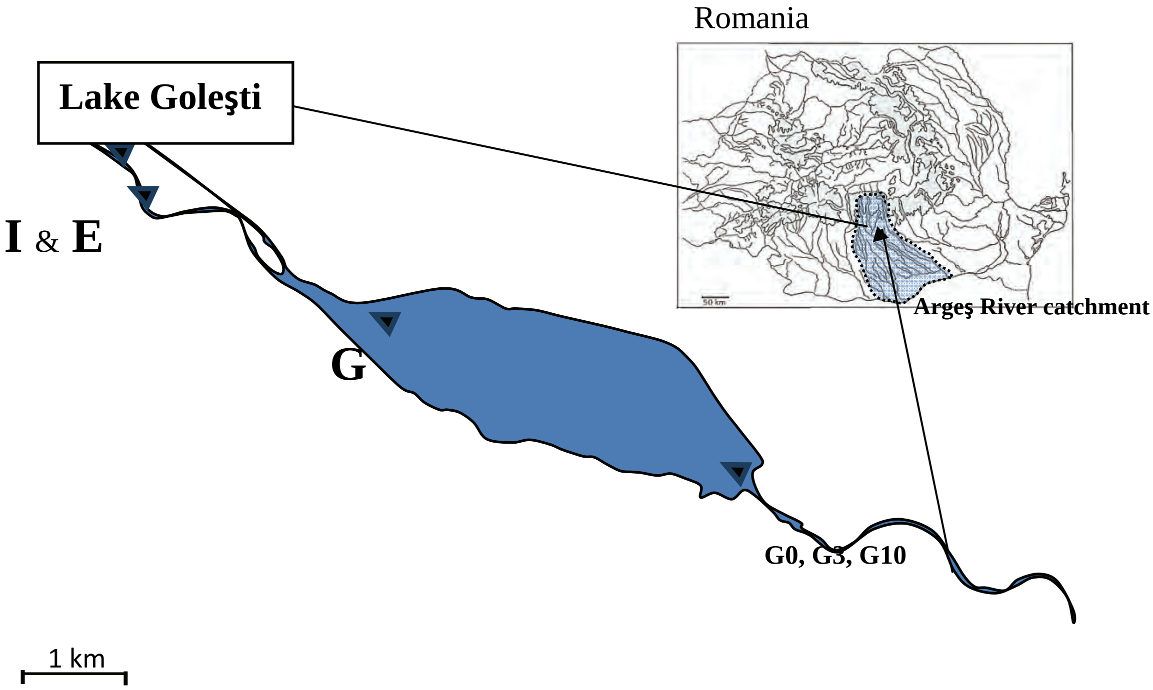

Figure 1. Location of the research stations A-upstream the treatment plant-Piteşti I, E, - the treatment plant Piteşti (influent –I-and effluent –E-waters were studied) – G-entrance in lake Goleşti and G0, G3, G10-station in close proximity to the dam Golesti, where measurements and samplings were accomplished on the depth of the water main (at the surface-0 m, respectively at 3 m and 10 m deep) (original).

RESULTS AND DISCUSSION

Water pH. The pH dynamics has not recorded a clear upward or downward trend in lake Goleşti, during the studied range; in all permanent stations for monitoring the water quality in the area, pH values kept the effectual NTPA 001, complying with the imposed limits. The values of this parameter fluctuated between 6.5 and 8.5 upH (basic character), being higher in the station upstream the discharge of the treatment plant (A), but close to those recorded in the effluent of the treatment plant (E). Vertically, in sections G0, G3, G10, the pH values had a neutral character (Fig. 2).

BOTNARIUC & VĂDINEANU (1982) mention that in general, water basins, marine and continental are characterized by values of the pH in the range of fluctuation 6 and 8.5.

The analysis of the oxygen, as expected, showed differences between the values recorded in the monitoring stations A, G0, G3, G10 and section E. Thus, for sections A and G0, G3 and G10 (during the period 2006-2009) O_2 concentration was within the normal values specified by the professional literature as normal for aquatic ecosystems (8-15mg O_2/L). Horizontally, from the upstream section (A) to the end of the dam lake (G0), the concentration of dissolved oxygen in water increased, which correlated with the decrease of the content of organic substances and nutrients. Maximum values are also found in spring, followed by decreasing concentrations in the summer and a second increase in the amount of oxygen from September. The concentration of oxygen varies vertically, too, being higher in the superficial layers of the water and lower in deep waters (Fig. 3).

The dissolved oxygen is the most important element in the process of self-purifying in aquatic environments. The intensity of biochemical decomposition processes of organic matter, the processes of oxidation of certain minerals and the populating with microorganisms of aquatic systems depend on its concentration (ROJANSCHI & OGNEAN, 1997).

The organic content of the water volume was determined using indirect methods based on biochemical and chemical consumption of oxygen. The Water Framework Directive, in annex VIII, paragraph 12 specifies the parameters “Biochemical oxygen consumption determined after 5 days (BOC_5)” and “Chemical oxygen consumption” (COC) that can be used to identify the presence of the negative impact on the balance of oxygen in water.

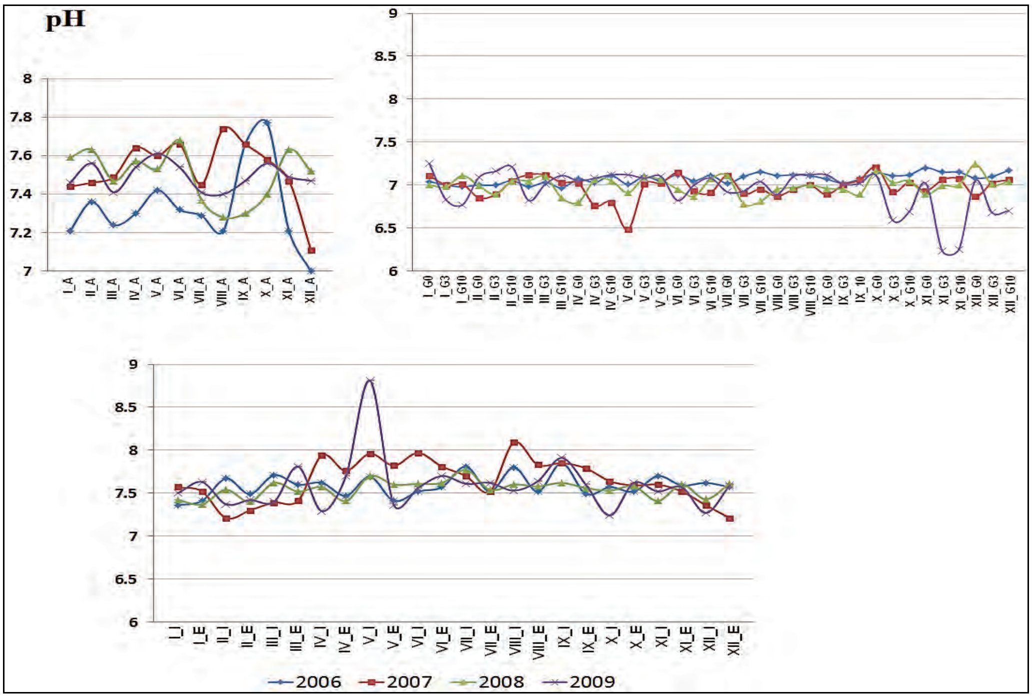

Figure 2. pH variation at the treatment plant in Piteşti (I and E) and lake Goleşti (in section A-upstream the treatment plant Piteşti and vertically in close proximity of the dam Goleşti-G0, G3 and G10) in the period 2006-2009 (monthly: January-December) (original).

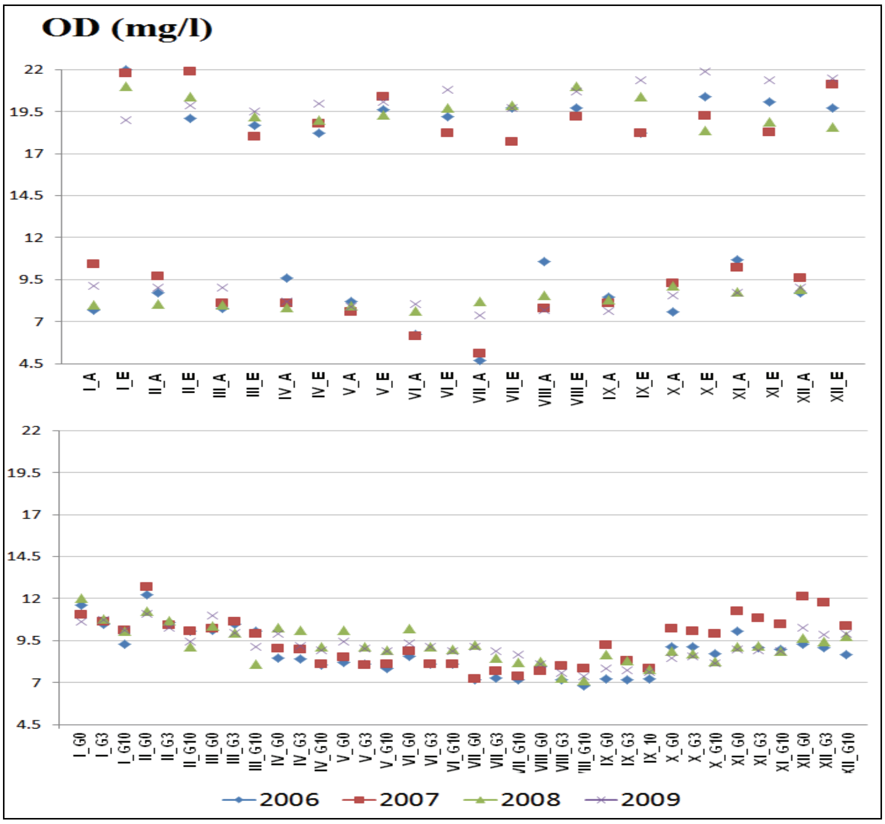

Figure 3. The variation of the concentration of DO (dissolved oxygen in the water, mg/L) in effluent waters of the treatment plant Piteşti (E) and in lake Goleşti (in section A - upstream the treatment plant and vertically in close proximity of the dam Goleşti - G0, G3 and G10), during the period 2006-2009 (monthly January-December) (original).

In our case study, upstream the treatment plant Pitesti the values BOC_5 fluctuated between 9.9 mg O2/L (July 2006) and 54.4 mg O_2/L (July 2008). The highest values of this parameter were recorded in summer, during the period 2007-2009.

In influent waters, BOD5 ranged from 80.7 mg O_2/L (in December 2008), to 147.1 mg O_2/L (in July 2008); regarding the effluent of the treatment plant, the highest value, 54.4 mg O_2/L (in July 2008) was recorded in July 2008, and the lowest value, 15.3, in April 2008. The trend of the higher values manifested in both the influent waters and in the influent ones, between April and August/September. At the exit of the lake near the dam Goleşti, it was found that on the levels of depth-from 0 m to 10 m - the decrease in the consumption of oxygen occurs; this fact is justified by the decrease of organic matter in the water volume, along with the depth increase.

At this station, too, the lows BOD5 were determined in the colder months of the year (at 0 m: 1.38 mg O_2/L, in February 2006, at 3 m: 0.98 mg O_2/L in February 2006, in September 2007, at 3 m: 79 mg O_2/L in September 2008 and at 10 m: 7.12 mg O_2/L in September 2008).

Also, BOD5 and COD-Cr is an indicator that directly expresses the organic content of waste water, but by the equivalent concentration of oxygen, that is necessary for the chemical oxidation of organic substances in the water (VARDUCA, 1997). 60-70% of the quantity of organic substances in the water volume, also composed of non-biodegradable compounds is generally determined by this indicator. For the studied period, in lake Goleşti, upstream the treatment plant Piteşti, the values of the chemical consumption of oxygen ranged between 11 (December 2009) and 66 mg O_2/L (October 2007). In the influent waters in the treatment plant Piteşti CCO-Cr ranged between 187 (in February and September 2006) and 350 mg O_2/L (June 2007). In the discharged waters from the treatment plant there were determined oxygen concentrations between 34.1 mg O/L (January 2007) and 11 mg O/L (July 2007).

In the control section of the dam 0 m, the consumed chemical oxygen ranged between 8.09 m O_2/L (in May and June 2007) and over 20 mg O_2/L (in December 2006; at the depth of 3 m, the values CCO-Cr were between 8.3 mg O_2/L (May 2006) and 19.27 mg O_2/L(December 2006), and at 10 m the values varied between 7.47 (June 2006) and 19.46 mg O_2/L (December 2006) (GHIMICESCU, 1974; VARDUCA, 1997; 2000).

Total nitrogen (NT, mg/l). In the present work, the study of the concentration of nitrogen ions (NH4+), of nitrates (NO3+) and nitrites (NO2+) was considered to be relevant. The expression of these compounds in total mineral nitrogen concentration in the water volume has allowed the elucidation of an important parameter to explain the dynamics of the analysed phytoplankton communities.

The nitrogen concentrations were significantly lower in the upstream control section (A), compared to those determined in sections I and E, but higher than those in sections G0, G3, G10-near the exit of the lake (Fig. 4). The influent waters that reach the treatment plant have higher nitrogen concentrations, because they are mostly domestic waste waters; the concentration N decreases downstream due to dilution and self-purification of the effluent waters in lake (G0:0.08 mg/l in January 2007 and 3.56 mg/l in September 2006). Vertically, the nitrogen concentration decreased with the increase of the depth (Fig. 5).

The content of phosphorus in the wastewater that entered the treatment plant Piteşti varied between 1.97 and 5.3 mg/L. In the upstream control section, the concentrations of this nutrient were (like nitrogen) higher than those in the terminal section of the lake.

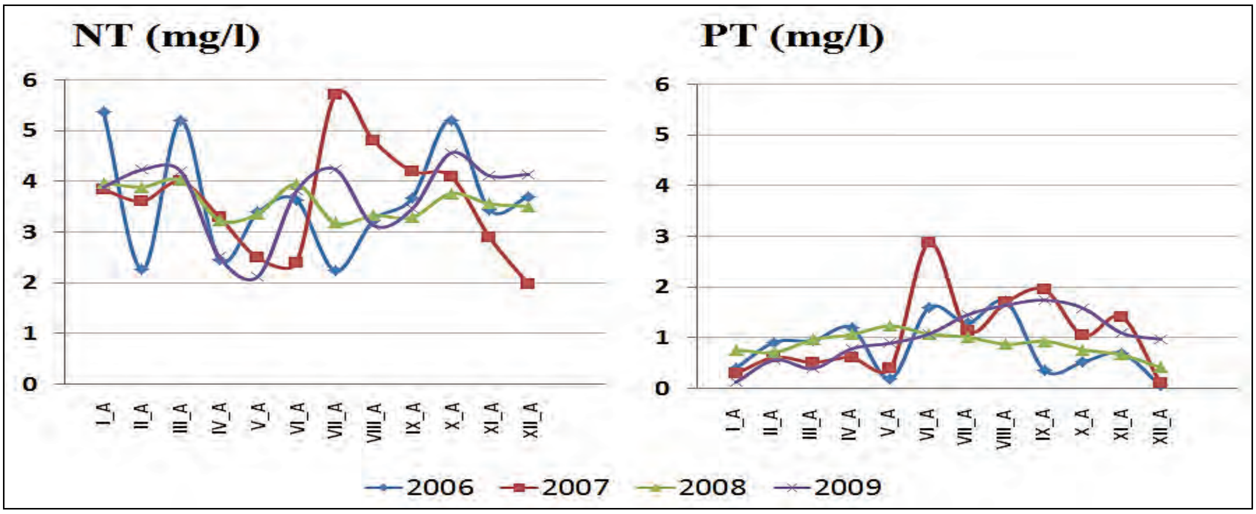

Figure 4. The variation of NT and PT concentrations (total nitrogen and total phosphorus, mg/L)
in the waters section (A) upstream of the treatment plant Piteşti, in period 2006-2009 (monthly: January-December).

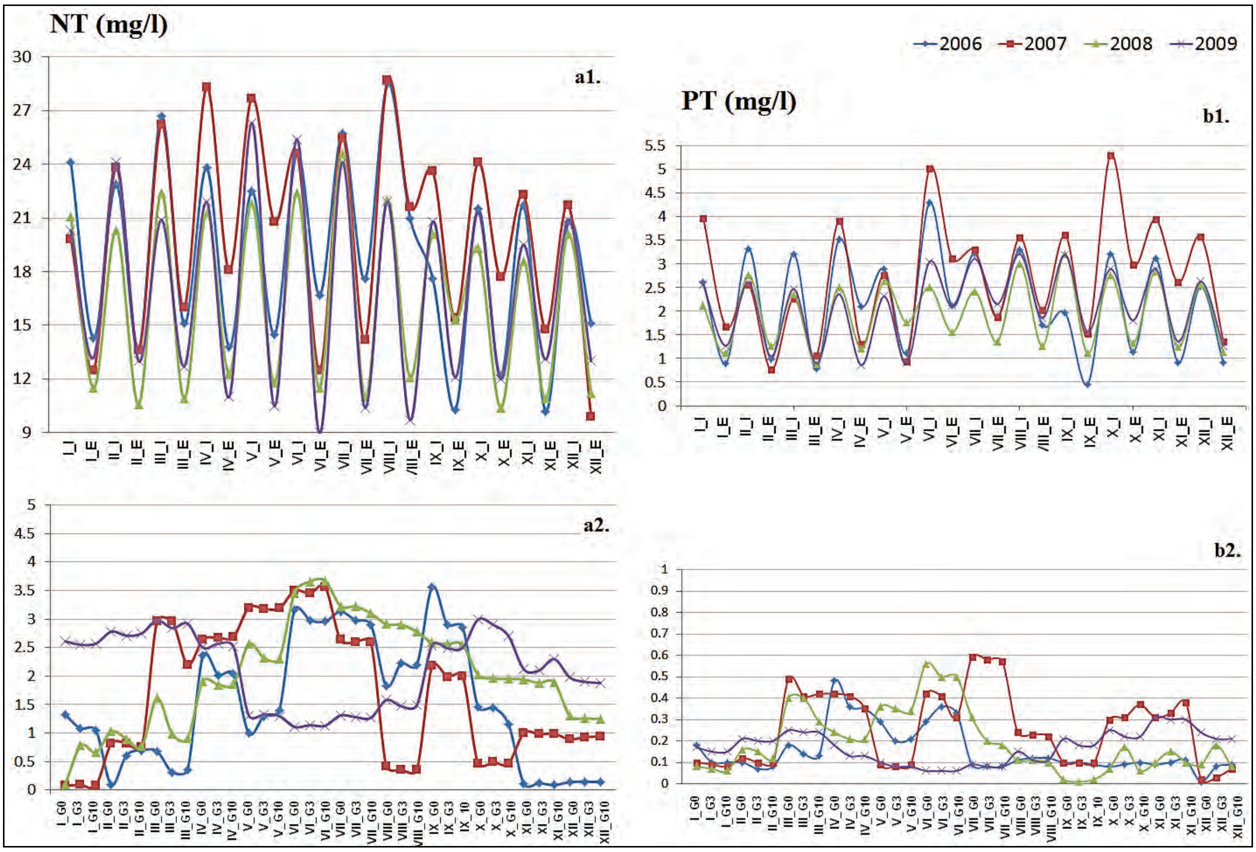

Figure 5. The variation of NT and PT (total nitrogen and total phosphorus, mg/L) in influent (I) and effluent (E) waters of the treatment plant Piteşti and vertically in the close proximity of the dam Goleşti (G0, G3 and G10) during the period 2006-2009 (monthly: January-December). Total material in suspension MTS, mg/L.

Regarding the characterization of the total suspended matter content in the study area (during the period 2006-2009), and upstream the treatment plant, the MTS values varied between 12 mg/l (in June 2006 and July 2007) and 39 mg/L (February 2006). In the influent water, the MTS values were within the range: 76 mg/L (March, July 2007 and August 2006) and 220 mg/L (September 2006). The MTS concentrations in the effluent waters from the treatment plant Piteşti fluctuated between 18 (April 2008) and 64 mg/L (September 2006) except October 2007 (104 mg/L).

At dam Goleşti, at the water surface, the quantity of MTS varied between 2 (December 2008) and 29 mg/L (June 2009) at a depth of 3 m between 3 (October 2008) and 19 mg/L (June 2009) and at a depth of 10 m, the MTS concentration varied between 2 mg/L in December 2008 and 16.4 mg/L in December 2009.

MTS mild elevations were found in spring and autumn months due to rain and snow (which cause the run off of significant amounts of organic matter and sediments). That the MTS values, recorded upstream the treatment plant Piteşti, were relatively higher than those downstream the proximity of the dam Goleşti.

CONCLUSIONS

In order to clearly define the physical-chemical characteristics of the water upstream the treatment plant Piteşti, of the purified water – discharged by the treatment plant, and of the water in lake Goleşti - the receiver of the treatment plant, we also considered appropriate the achievement of an overall analysis of the fluctuation area of the values of all physical and chemical parameters that had been previously analysed and discussed. The chosen analysis is represented by a multivariate statistical ordinate technique, of testing the relative existing similarity in the data set that described the abiotic characteristics of the water in the study areas-NMDS (Non-metric Multi-Dimensional Scaling) (Fig. 6).

Thus, in our data set, the visual distances between the points represented in the flowchart allowed us to detect the following aspects (Fig. 6):

- the existence of a better similarity between the physical-chemical characteristics of the water taken upstream the treatment plant (A) and those of the effluent water (E), but also the existence of a similarity between the physical-chemical quality of the water in the upstream section and of the one in close proximity of the dam (G0,G3 and G10). One possible explanation of the fact that the waters upstream of the treatment plant show physical-chemical characteristics similar to those of the effluent of the treatment plant, is the fact that they are influenced by the water quality of lake Piteşti, which is situated upstream lake Goleşti (on the Argeş river; it is known that the hydro-chemical regime of reservoirs is a result of the chemistry of the tributaries (MIRON et al., 1983; RADU, 2011; SAVIN, 2005; VĂDINEANU, 2004);

- the graphic highlighting of the tendency of gradual gathering of the samples taken near the dam, on the depth profile: G0,G3 and G10;
- and a clear dissimilarity between the physical-chemical quality of the water which is discharged into the lake with the water that is discharged by the effluent wastewater of the treatment plant (E) and by the water in the terminal section of lake Goleşti (G0, G3 and G10), near the Argeş river bed (due to poising action and improving of the treated water quality, discharged from the treatment plant Pitesti by the self-purification processes developing in the lake).

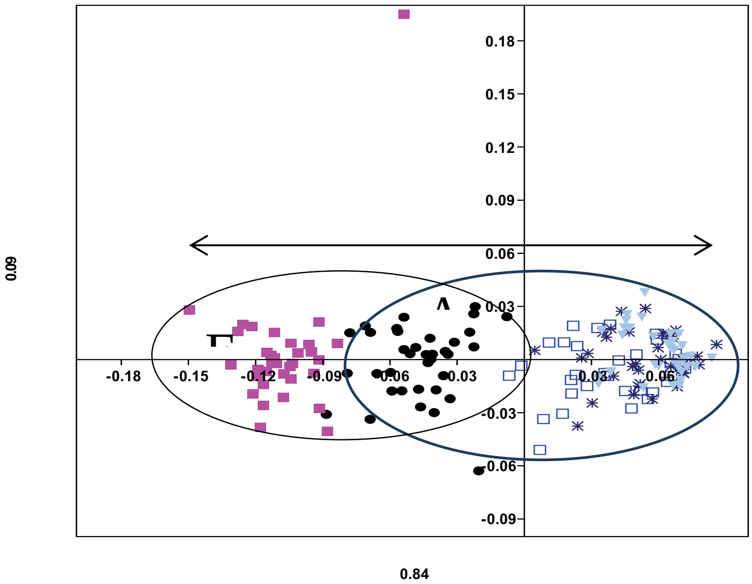

Figure 6. The comparative analysis of the characteristics of the physical-chemical parameters that were determined at the following stations: upstream, effluent treatment plant and dam Goleşti (0 m,3 m,10 m), during the period January - December 2006-2009; NMDS (stress 0,1052, Bray-Curtis). Caption of the used symbols: The upstream station A=black dots, the effluent station-E=pink squares and the dam Goleşti station-Go= empty blue squares, G.

We should mention that, since 2010, upgrading works at the treatment plant Pitesti have begun, which consisted mainly in:

- adding a nitrification- de-nitrification step for a more efficient removal of nitrogen compounds (the processes of nitrification are aerobic processes wherewith the bacterial populations oxidizes the ammonia in the water to nitrate, along with the intermediate formation of nitrite; the de-nitrification processes also involve the bacterial reduction of nitrate to nitrite and ultimately to nitrogen gas without significant effect on the environment).
- the building of the station for phosphorus removal, with performance based on the addition of ferric chloride.

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