The Assessment of Content and Dynamics of Nutrients in Water and Sediments from the Plumbuita Lake, Bucharest

II. Study on nitrogen content and distribution

ECATERINA MARCU[1]*, GYORGY DEAK[1], IRINA ELENA CIOBOTARU[1], ALEXANDRU ANTON IVANOV[1], PETRA IONESCU[1], CARMEN TOCIU[1], ELENA DIACU[2]

[1]National Institute for Research and Development in Environmental Protection, 294 Splaiul Independentei, 060031, Bucharest, Romania

[2]University Politehnica of Bucharest, Faculty of Applied Chemistry and Materials Science, 1-7 Polizu Str., 011061, Bucharest, Romania

Water pollution with nutrient-based contaminants represents a special concern at national level as it may lead to the occurrence of water eutrophication affecting the properties of the water bodies. This paper presents the characterisation of nitrogen distribution in water and sediments from the Plumbuita Lake (Bucharest, Romania) and the speciation of this element in the form of ammonium, nitrite, nitrate and organic nitrogen. The results of this study prove the importance of an integrated approach regarding the quantification of nutrient content with the nutrient dynamics in the evaluation of the eutrophication phenomenon.

Keywords: nitrogen dynamics, nitrogen species, sediment characterisation

The permanent and systematic improvement of the quality of water sources is a desiderate of the modern society as they are scarce and often contaminated with compounds resulting from diverse anthropic activities [1]. The presence of excessive amounts of some pollutants may determine the occurrence of unwanted phenomena. For example, the high contents of nutrient may determine the emergence of water eutrophication which has received a great interest as it affects water visual and physico-chemical properties (algae development, organic matter content, oxygen regime) [2,3]. A considerable number of papers reported in the literature [3 -14] depict the causes of the eutrophication process as well as the role of sediments in eutrophication.

The limiting factors of the eutrophication phenomenon are the nutrient content (phosphorus, nitrogen) as well as their distribution in the sediments which affects the redox and the dissolution processes that take place at the sediment-water interface. Therefore, for a comprehensive assessment of the eutrophication phenomenon, investigations on the main elements that contribute to the trophic status of the lake are required [9, 11-28].

Efforts have been made for nutrient removal from water and wastewater, however continuous and thorough efforts towards the improvement of sewer and rising of awareness regarding water quality protection are required [4-9, 11-36].

The Plumbuita Lake is part of the assembly of lakes disposed on the Colentina River which crosses the northern part of the Bucharest city (Romania), in the park with the same name. The lake has a large area and multiple uses, such as recreational, fishing purposes, irrigations. Due to its location in a highly populated area and the demand of environmental protection within this area, the monitoring of water and sediments quality is required and useful for the protection of biodiversity and of the appearance of the lake.

This study reflects the current concerns about the impact of nutrients on the quality of water and sediments and is a sequel of our research regarding the characterisation and the dynamics of several quality indicators for the evaluation of eutrophication of Plumbuita Lake.

This paper shows the contribution of nitrogen to the eutrophication phenomenon with special focus on its distribution in water and sediments as limiting factor of the ecological status of the lake.

Experimental part

Plumbuita Lake is formed by the stream of the Colentina River and has a total area of 44 ha. Taking into account the shape of the lake, an insulated area is formed at the end of the water body, where hypoxic conditions may emerge. For the characterisation of the nitrogen speciation and the dynamics of nitrogen in the Plumbuita Lake, sampling campaigns were conducted during the year 2015. Water and sediment samples were taken from three points located on both side (P1, P3) and, respectively at the end of the lake (P2), as depicted in figure 1.

Fig. 1. Aerial view of the sampling points location on the Plumbuita Lake [37]

* email: ecaterina.marcu@incdpm.ro; Phone: (+40)213052681

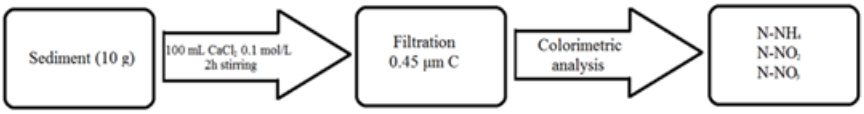

Fig. 2. The extraction procedure used for the analysis of nitrogen species from the sediment

Indicator	Unit	Minimum value - maximum value (mean value)
Temperature	°C	8.8-31 (20.8)
pH	pH units	7.5-9.43 (8.32)
Dissolved oxygen (DO)	mg O_2/L	7.58-13.07 (10.64)
Biochemical oxygen demand (BOD_5)	mg O_2/L	3.39-8.73 (6.84)
Chemical oxygen demand (COD-Mn)	mg O_2/L	4.56-13.94 (9.23)
Chemical oxygen demand (COD-Cr)	mg O_2/L	14.38-97.91 (40.67)
Ammonium (NH_4^+)	mg/L	0.02-0.34 (0.17)
Nitrites (NO_2^-)	mg/L	0.01-0.05 (0.03)
Nitrates (NO_3^-)	mg/L	0.05-2.43 (0.62)
Total nitrogen (TN)	mg/L	1.52-3.79 (2.29)

Table1
WATER QUALITY PARAMETERS FOR PLUMBUITA LAKE

The sediment samples consisted of two distinctive layers and subjected to were drying at room temperature, milling and sieving through a 90µm-sieve. Nitrogen species (ammonium, nitrite and nitrate) were analysed according to a standard method used for soil samples (fig. 2) [38]. For the analysis of nitrogen species, the sediment sample was extracted with a 0.01 mole/L $CaCl_2$ solution by stirring the mixture for two hours at 1000 rpm, followed by filtration through a cellulosic filter rinsed with boiled doubly distilled water. The nitrogen species were analysed from the resulting filtrate, by direct colorimetric analysis, using specific agents and wavelengths.

Results and discussions

The nitrogen content was determined together with the oxygen regime, expressed as biochemical and chemical oxygen demand. As one may see from table 1, the values of the indicators follow the limits provided by the Romanian Ministry Order no. 161/2006 [39] for the first and second quality class, excepting the biochemical and chemical oxygen demand during July and September fall in the fourth and third quality class, respectively; nitrites values for March fall in the third quality class.

Figures 3-5 depict the distribution of nitrogen species in sediments. The analysis of nitrogen species showed high contents of organic compounds, the organic form representing up to 99% of the total nitrogen content, regardless of the core depth, due to the high solubility of ionic nitrogen fractions compared to the organically bound fractions contained in the slowly decomposing detritus. As to inorganic forms (figs. 3-5), the results showed that 62-95% of the ionic nitrogen species is represented by

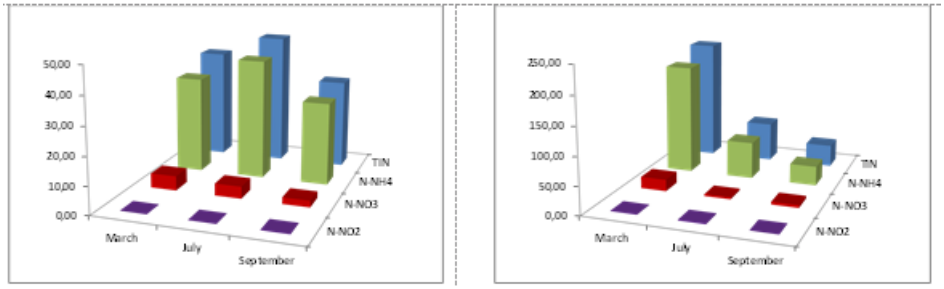

Fig. 3. Total ionic nitrogen and nitrogen species in: (a) the upper layer and (b) the lower layer of sediment samples from the P1 sampling point: TIN - total ionic nitrogen; $N\text{-}NH_4$ -ammonium; $N\text{-}NO_3$ - nitrates; $N\text{-}NO_2$ - nitrites

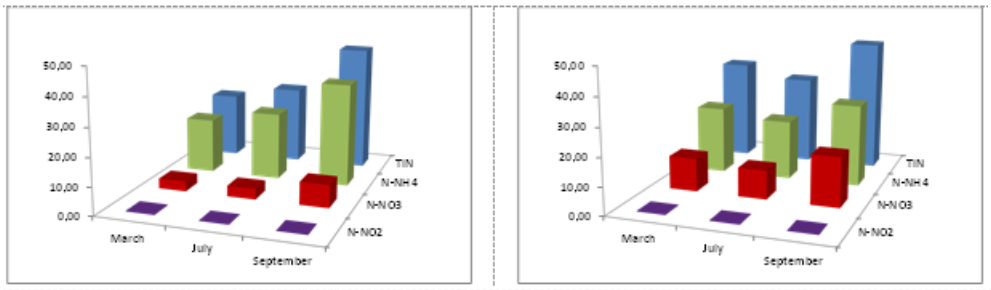

Fig. 4. Total ionic nitrogen and nitrogen species in: (a) the upper layer and (b) the lower layer of sediment samples from the P2 sampling point: TIN - total ionic nitrogen; $N\text{-}NH_4$ – ammonium; $N\text{-}NO_3$ - nitrates; $N\text{-}NO_2$ - nitrites

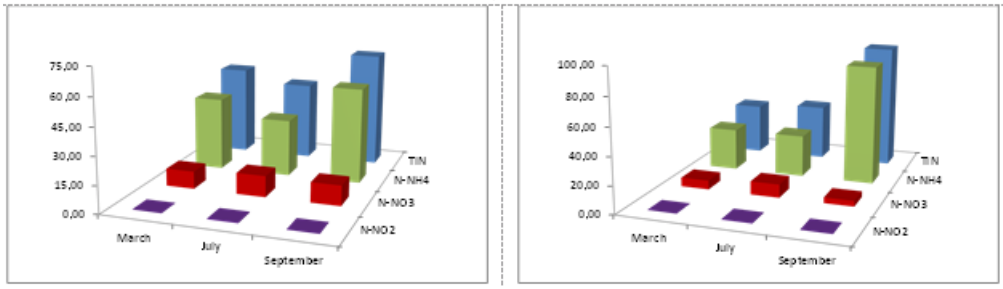

Fig. 5. Total ionic nitrogen and nitrogen species in: (a) the upper layer and (b) the lower layer of sediment samples from the P3 sampling point: TIN – total ionic nitrogen; $N\text{-}NH_4$ - ammonium; $N\text{-}NO_3$ - nitrates; $N\text{-}NO_2$ - nitrites

ammonium, which gives information on the intensity of the biogeochemical processes that may take place at the sediment-water interface [40] and affects the eutrophication process [41], followed by nitrates (5-38%) and nitrites (up to 1.6%).

The results showed similar variation for ammonium and nitrites, with highest values during July. Nitrates and total nitrogen showed similar variation for P2 and P3 sampling points, with lowest values during July, when the lake is prone to hypoxic conditions and the lake surface is covered with vegetation, and a distinct variation for P1 sampling point, with lowest values in September, consistent with the low content of dissolved oxygen.

Conclusions

The present study focuses on the assessment of content and dynamics of nitrogen from water and sediments from the Plumbuita Lake, located in an overcrowded district of Bucharest city (Romania). The concentrations of nitrogen species in water showed higher values during summer and at the beginning of autumn, when hypoxic conditions emerge. The distribution of nitrogen species from the sediments from Plumbuita Lake (Bucharest, Romania) indicate a significant variability, with the lowest concentrations during summer due to abundant vegetation and to a decrease of dissolved oxygen content. The results showed that up to 99% of the nitrogen is represented by the organic nitrogen. Of the ionic nitrogen species, ammonium represents 62-95%, followed by nitrates (5-38%) and nitrites (up to 1.6%).

Together with phosphorus and carbon, nitrogen represents a factor of the eutrophication phenomenon and determines the excessive growth of algal species. Overall, the conducted studies proved that the nutrient content and distribution in water and sediments are inter-connected and the efforts concerning the remediation of the lake should take this issue into consideration. Therefore, the results may constitute a useful tool for the environmental engineers in their efforts to control water eutrophication phenomenon.

Study on phosphorus content and distribution was presented in [42].

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References

1. DEAK, Gy, DAESCU, V, HOLBAN, E, MARINESCU, P, TANASE, G, CSERGO, R, DAESCU, AI, GAMAN, S, J Environ Prot Ecol., **16**, 2015, p. 304.
2. YANG X, WU X, HAO H-I, HE Z-L, J Zhejiang Univ-Sc B, **9**, 2008, p.197.
3. QIN BQ, GAO G, ZHU GW, ZHANG YL, SONG YZ, TANG XM, XU H, DENG JM, Chinese Sci Bull, **58**, 2013, p. 961.
4. NÜRNBERG GK, Limnetica, **10**, 1994, p. 1.
5. CARPENTER SR, P Natl Acad Sci USA, **102**, 2005, p. 10002.
6. KHAN FA, ANSARI AA, Bot Rev, **71**, 2005, p.449-482.
7. LUKKARI K, HARTIKAINEN H, LEIVUORI M, Limnol Oceanogr-Meth, **5**, 2007, p.433.
8. SEN S, HAGGARD BE, CHAUBEY I, BRYE LR, COSTELLO TA, MATLOCK MD, Water Air Soil Poll., **179**, 2007, p.67.
9. CHAO W, JIN Q, ZHI-YONG G, LI Z, XIAO-CHEN L, Pol J Environ Stud, **17**, 2008, p.155.
10. WANG H, WANG H., Prog Nat Sci., **19**, 2009., p.1445.
11. WANG Q, LI Y., J Soil Sediment, **10**, 2010, p. 1159.
12. GAO L, Procedia Environ Sci, **13**, 2012, p.2077.
13. ZHANG K, CHENG P-D, ZHONG B-C, WANG D-Z, J Hydrodyn, **24**, 2012, p. 589.
14. ZHU Y, ZHANG R, WU F, QU X, XIE F, FU Z, Environmental Earth Sciences, **68**, 2012, p. 1041.
15. OLILA OG, REDDY KR, HARRIS WG, Hydrobiologia, **302**, 1995, p. 147.
16. HOUSE WA, WARWICK MS, Hydrol Process, **13**, 1999, p. 1103.
17. RYDIN E, Water Resour, **34**, 2000, p. 2037.
18. GOLTERMAN HL, Limnetica, **20**, 2001, p. 15.
19. HU WF, LO W, CHUA H, SIN SN, YU PHF, Environ Int, **26**, 2001, p. 369.
20. FYTIANOS K, KOTZAKIOTI A, Environ Monit Assess, **100**, 2005, p.191.
21. HAGGARD BE, SOERENS TE, Ecol Eng, **28**, 2006, p. 280.
22. MOOSMANN L, GACHTER R, MÜLLER B, WUEST A, 2006, Limnol Oceanogr, **51**, p. 763.
23. DA SILVA I S, TERRAE, **6**, 2009, p. 52.
24. MIDDELBURG JJ, LEVIN LA, Biogeosciences, **6**, 2009, p. 1273.
25. SAHIN Y, DEMIRAK A, KESKIN F, Lakes, reservoirs and ponds, **6**, 2012, p. 139.
26. WANG X, Procedia Environ Sci, **12**, 2012, p.379.
27. KANGUR M, PUUSEPP L, BUHVESTOVA O, HALDNA M, KANGUR K, Est J Earth Sci, **62**, 2013, p. 171.
28. TOPCU A, PULATSU S, J Agr Sci, **20**, 2014, p. 63.
29. KEMP ALW, MUDRUCHOVA A, Limnol Oceanogr, **17**, 1972, p. 855.
30. AUER MT, TOMASOSKI KA, BABIERA MJ, NEEDHAM ML, EFFLER SW, OWENS EM, HANSEN JM, Lake Reserv Manage, **14**, 1998, p. 278.
31. KAPANEN G, Est J Ecol, **57**, 2008, p. 244.
32. IONESCU, P., RADU, V.M., DIACU, E., Rev. Chim. (Bucharest), **66**, no. 11, 2015, p. 1725.
33. JINGFU W, JINGAN C, DALLIMORE C, HAIQUAN Y, ZHIHUI D, Lake Reserv Manage, **31**, 2015, p. 214.
34. RADU, V-M, DIACU, E, IONESCU, P, DEAK, G., Rev Chim. (Bucharest), **66**, no.5, 2015, p.601.
35. TOCIU C, DIACU E, U Politeh B Ser B, **77**, 2015, p.29.
36. IONESCU P, DIACU E, RADU V-M, U Politeh B Ser B, **76**, 2014, p. 23.
37. *** SR ISO 14255:2000 Soil quality. Determination of nitrite nitrogen, ammonium nitrogen and total soluble nitrogen in air-dry soils using calcium chloride solution as extractant. Romanian.
38. *** Google Earth, https://earth.google.com.
39. *** Order 161/16.02.2006 on the approval of the Normative regarding the classification of the quality of surface water in order to establish the ecological status of water bodies.
40. BOLALEK J, GRACA B, Estuar Coast Shelf S, **43**, 1996, p. 767.
41. MAKSYMOWSKA-BROSSARD D, PIEKAREK-JANKOWSKA H, Oceanologia, **43**, 2001, p. 113.
42. MARCU, E., DEAK, G., CIOBOTARIU, I.E., IVANOV, A.A., IONESCU, P., TOCIU, C., DIACU, E., Rev. Chim. (Bucharest), **68**, no. 11, 2017, p. 2492

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