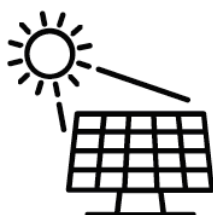




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III Congresso
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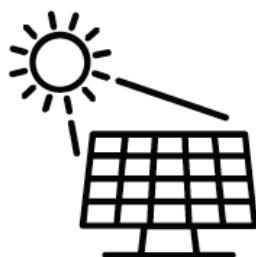
12 a 14 de julho de 2017





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Ibero-Americano de Empreendedorismo,
Energia, Ambiente e Tecnologia:
Livro de atas**

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Editores: Américo Vicente Leite
Ana Isabel Pereira
Ângela Paula Ferreira
Artur Jorge Gonçalves
João Paulo Almeida
José Luis Calvo Rolle
Manuel Joaquim Feliciano
Orlando Manuel Soares
Ronney Arismel Boloy

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Email: cieemat2017@ipb.pt

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Américo Vicente Leite

Presidente da Comissão Organizadora

Caros Autores e Participantes

Bem-vindos ao III Congresso Ibero-Americano de Empreendedorismo, Energia, Ambiente e Tecnologia (CIEEMAT).

Este Congresso, na sua terceira edição, dá continuidade ao trabalho desenvolvido no Brasil pelo Centro Federal de Educação Tecnológica Celso Suckow da Fonseca – Rio de Janeiro, atravessando o oceano Atlântico para a sua primeira edição no contexto da Península Ibérica.

Concebido para englobar um conjunto abrangente de áreas temáticas, este evento serve de ponto de encontro entre profissionais, investigadores, professores e estudantes dos países Ibero-Americanos, num fórum que reforça o perfil internacional do Instituto Politécnico de Bragança, assim como das demais Instituições Organizadoras e Parceiras, designadamente, no âmbito de Programas de Dupla Diplomação.

Nos três dias do evento, esperamos que encontrem oportunidades para a partilha de ideias e resultados de investigação, reforçando ou estabelecendo novos contactos e parcerias no espaço Latino-Americano.

Por fim, espero que a Vossa estadia em Bragança seja agradável e que levem de volta gratas recordações do CIEEMAT 2017.

Saudações Cordiais.

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III Congresso Ibero-Americano de Empreendedorismo, Energia, Ambiente e Tecnologia
CIEEMAT 2017 - PROGRAMA

| | 12/07/2017 Quarta-feira | 13/07/2017 Quinta-feira | 14/07/2017 Sexta-feira |
|---------------|----------------------------|----------------------------|--|
| 08:30 - 09:00 | | | |
| 09:00 - 09:30 | Registo CIEEMAT | Registo CIEEMAT | Registo CIEEMAT |
| 09:30 - 10:00 | Sessão de Abertura | Sessão Plenária 2 | Sessão Plenária 3 |
| 10:00 - 10:30 | Sessão Plenária 1 | | |
| 10:30 - 11:00 | | Coffee break | Coffee break |
| 11:00 - 11:30 | Coffee break | | |
| 11:30 - 12:00 | Comunicações Orais 1 | Comunicações Orais 3 | Comunicações Orais 6 |
| 12:00 - 12:30 | | | |
| 12:30 - 13:00 | Almoço | Almoço | Almoço |
| 13:00 - 13:30 | (Cantina alternativa) | (Cantina alternativa) | (Cantina alternativa) |
| 13:30 - 14:00 | | | |
| 14:00 - 14:30 | | | |
| 14:30 - 15:00 | Mesa redonda: | Comunicação Convidada 1 | Comunicação Convidada 2 |
| 15:00 - 15:30 | Programas de Dupla | | |
| 15:30 - 16:00 | Diplomação | Comunicações Orais 4 | Comunicações Orais 7 |
| 16:00 - 16:30 | Comunicações em Póster 1 | Comunicações em Póster 2 | Comunicações em Póster 3 |
| 16:30 - 17:00 | | | |
| 17:00 - 17:30 | Coffee break | Coffee break | Coffee break |
| 17:30 - 18:00 | Comunicações Orais 2 | Comunicações Orais 5 | Workshop : Encontro de Interesses de |
| 18:00 - 18:30 | | | Pesquisa para Projetos de Dupla Diplomação |
| 18:30 - 19:00 | | | |
| 19:00 - 19:30 | | | |
| 19:30 - 20:00 | Porto de honra | | |
| 20:00 - 20:30 | (Castelo de Bragança) | | |
| 20:30 - 21:00 | | Jantar CIEEMAT2017 | |
| 21:00 - 21:30 | | (Cantina alternativa) | |
| 21:30 - 22:00 | | | |

Using zooplankton community as indicator of seasonal changes in some water quality parameters in a meso-eutrophic reservoir

Ana Maria Geraldes

CIMO, Escola Superior Agrária do Instituto Politécnico de Bragança Campus de Santa Apolónia
5300-253 Bragança, Portugal
geraldes@ipb.pt

Pedro Silva-Santos

NOCTULA - Consultores em Ambiente, Quinta da Alagoa
Lote 222 1º Frente,
3500-606 Viseu, Portugal
pedross@noctula.pt

Maria Cristina Crispim

Universidade Federal da Paraíba
João Pessoa, Brasil
ccrispim@hotmail.com

Abstract—This research was aimed to monitor and characterize the zooplankton community of Agueira reservoir (40.33 N; 8.19 W). Agueira trophic state, nutrient concentration (the highest amounts were observed in summer) and water quality, can be correlated to the internal disturbances induced by the intense water level fluctuations. These criteria indeed lead to an increase in the suspended particulate material in the water column. In addition, the input of allochthonous nutrients originated from human activities in the catchment area will increase the phytoplankton biomass (mainly Cyanobacteria) during summer. The phytoplankton community was dominated by the Cyanobacteria, whereas the zooplankton community by the rotifer, *Keratella cochlearis* and by the caldoceran, *Chydorus sphaericus*. In the absence of Cyanobacteria, the subsistence of *Copidodiptomus numidicus*, *Daphnia longispina* and *Bosmina coregoni* was highly evident. Zooplankton community showed similar spatial and inter-annual patterns. However, n-MDS ordination was able to differentiate between the two identified groups: samples obtained from December-March and from May-September. Canonical correspondence analysis (CCA) identified two main environmental gradients that shape zooplankton community. One being temporal, mainly related to temperature. The other is a trophic gradient which is associated to chlorophyll a concentration, water transparency, nitrates and nitrites. Variance partitioning using CCA revealed that the largest portion (45%) of the total variation observed (70%), was attributed to the interaction between lake and environmental variables.

Keywords— zooplankton community; water quality parameters reservoir.

I. INTRODUCTION

Freshwater resources are scarce in Portugal. Therefore, reservoirs can provide large amount of water for agriculture and urban supply, energy generation, fishing and recreational purposes. Hence these freshwater systems are mainly influenced by watershed geology, climate, soil, land slope and

intrinsic factors such as age of the reservoirs, water level fluctuations, morphometry and water residence times [1,2]. Anthropogenic activities in the catchment area and in the reservoir vicinity cause intensification of surface runoff with an increase in eutrophication, thus threatening water quality. Runoff rates depend mainly on land use, vegetation cover and landscape mosaic [3, 4, 5, 6, 7, 8]. Zooplankton constitutes a crucial link in the energy transfer to higher trophic levels being a keystone on ecosystem functioning. Moreover, its size structure, reproduction and survival, among other characteristics, are affected by both top-down (fish or invertebrates) and bottom-up (nutrient level and phytoplankton) controls. Thus, the observed community structure reflects the fluctuation of environmental factors, disturbance events and ecosystem resilience. Besides, zooplankton shows quick responses to environmental changes [9, 10, 11, 12, 13, 14]. Agueira Reservoir (Latitude: 40°19'53, 83"N; Longitude: 8° 11'47, 76"W) is located in the Iberian Peninsula, in Portugal on the Mondego River catchment. The reservoir is used to generate hydroelectrical power and to provide urban water supply. Due to this, accentuated water level fluctuations occur. The catchment is occupied with intensive forestry, agriculture and livestock production and with several medium sized towns. Therefore, the aim of the present research was: (1) to characterise zooplankton community and (2) to assess how zooplankton community respond to the variations of several environmental parameters.

II. MATERIAL AND METHODS

A. Field sampling and laboratory analysis)

Samples were collected seasonally from March 2010 to December 2011 at three sampling points: P1, P2 and P3. Euphotic zone data was obtained. The depth of this zone was considered to be 2.5 times the Secchi disk depth. Integrated water samples were obtained at 2 m intervals along the euphotic zone with a Van Dorn bottle. Samples were pooled

together and the total sample was used for chlorophyll *a*, (CHL *a*) nitrites, nitrates, ammonia and phosphorus determination. These variables were estimated according to [15]. Water temperature, pH, conductivity and dissolved oxygen (DO) were determined “in situ” using a multiparameter probe (YSI 6820). Zooplankton were collected on each sampling date by taking two vertical hauls using a 64 µm mesh size Wisconsin type net equipped with a flowmeter. Animals were anaesthetised with carbonated water and preserved in sugar-saturated formaldehyde (4% final concentration). Depending on density, zooplankton in 5, 10, 20 ml sub-samples or in total sample were counted and identified to the species level. Carlson’s Trophic State Index (TSI) [16] was computed from Secchi disk transparency (TSI (SD)), and CHL *a* concentrations (TSI (CHL)).

B. Data analysis

Non-metric Multidimensional Scaling (n-MDS) was used to determine if environmental variables and zooplankton community had changed with sampling sites over seasons and years. Bray-Curtis distance was used to measure the dissimilarity between samples. In this method samples were arranged in a continuum that those close together are similar and those which are far apart are dissimilar. Statistical differences between clusters identified in n-MDS plot were investigated by a randomization method, ANOSIM [17]. This method employs R statistics to examine the existence of differences between the established groups for each considered factor (groups and differences between sampling sites, seasons and years). To determine the influence of the studied environmental variables on the zooplankton species composition, a Canonical Correspondence Analysis (CCA) was performed. In both analyses, taxa were included only if they reached a relative abundance larger than 1%. Absolute zooplankton counts were transformed to log (x+1) and rare species were down weighted. In CCA the automatic forward selection procedure by Monte Carlo permutation tests (9999 permutations) was used to remove the redundant environmental variables, allowing the selection of those contributing to the explanation of the whole data set [18].

III. RESULTS

A. Environmental variables

Environmental variables showed similar values during both years in each sampling site (Table 1). Spatial and inter-annual variations in these parameters were not relevant. However, seasonal variations were observed. n-MDS ordination (Figure 1) was able to differentiate between the two identified groups: samples obtained in December, January and March from those obtained in May and September (2D stress: 0.02). ANOSIM test confirmed significant differences between the two groups (R= 0.829; p<0.001). The environmental variables that showed clear seasonal variations and contributed for these differentiations were temperature, Secchi disk depth, CHL *a* concentrations and pH. The highest values for temperature, pH, CHL *a* concentrations were observed in the samples obtained in May and September. Conversely, the lowest values of Secchi disk depth were

observed in January and March. According to Carlson’s Trophic State Index (the two components together- TSI (SD) and TSI (CHL *a*)), this reservoir was classified as mesotrophic in winter (the values ranged between 24 and 42). In summer it was eutrophic (values of both components of the index reached 57).

TABLE I. MINIMUM-MAXIMUM RANGE OF ENVIRONMENTAL VARIABLES OBTAINED FOR 2010 AND 2011 IN THE DIFFERENT SAMPLING SITES.

| Parameter | 2010 | | | 2011 | | |
|---|----------|----------|----------|---------|-------|-------|
| | P1 | P2 | P3 | P1 | P2 | P3 |
| | 11.9- | 12.2- | 12.8- | 14.7- | | |
| Temperature (° C) | 23.0 | 23.2 | 22.8 | 25,0 | 14.2 | 13.4 |
| pH | 7,3-9,9 | 7,2-10,1 | 7,3-10,0 | 7,1-9,8 | 7.21 | 7.3 |
| Conductivity (µS cm ⁻¹) | 70,4- | 76,2- | 68,8- | 64,8- | 63,4- | |
| Secchi disk(m) | 1,5-3,0 | 1,5-3,0 | 1,5-3,0 | 1,2-4,0 | 2.5 | 2.5 |
| | <0,01- | <0,01- | <0,01- | <0,01- | | |
| NO ₂ (mg L ⁻¹) | 0,08 | 0,11 | 0,06 | 0,03 | 0,04 | 0,03 |
| NO ₃ (mg L ⁻¹) | <4,4-5,4 | <4,4-5,5 | <4,4-5,5 | <4,4 | 5,5 | 4,9 |
| NH ₄ (mg L ⁻¹) | <0,05 | <0,05 | <0,05 | <0,05 | <0,05 | <0,05 |
| P ₂ O ₅ (mg L ⁻¹) | <0,23 | <0,23 | <0,23 | <0,23 | <0,23 | <0,23 |
| Chlorophyll <i>a</i> (µg L ⁻¹) | 0,36- | 0,36- | 1,40- | 0,52- | 0,89- | 0,53- |
| | 16,21 | 14,20 | 15,68 | 14,43 | 10,69 | 5,88 |

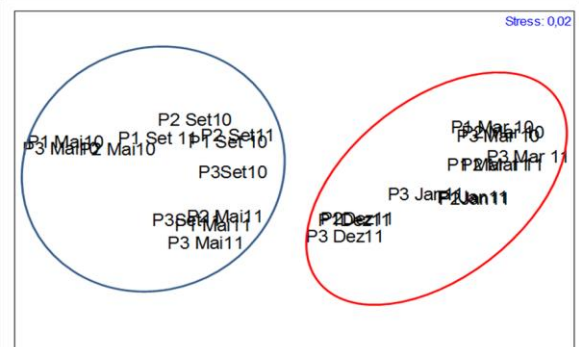


Fig.1. Results of n-MDS ordination considering environmental variables.

Sampling sites: P1, P2, P3.

Jan, Dez, Mar, Mai, Set: Samples obtained in January, December, March, May and September, respectively

B. Zooplankton community

During the sampling period 12 taxa of Rotifera, 7 of Cladocera and 3 of Copepoda were recorded. Zooplankton community

showed similar spatial and inter-annual patterns. From all the zooplanktonic species found in Aguieira the most abundant in both the years were the rotifers, *Keratella cochlearis* (both in May 2010/2011) and *Polyarthra sp.* (mainly in 2010); the Cladocera, *Bosmina coregoni* and *Chydorus sphaericus* (in September) and the Copepoda, *T. prasinus* and *Copidodiaptomus numidicus* (mainly in December and January). *Daphnia* and other coarse mesh filter-feeder zooplankters always showed low abundance.

n-MDS ordination (Figure 2) was able to differentiate between the identified samples obtained in December-March and those obtained in May- September (2D stress: 0.12). ANOSIM test confirmed the significant differences between the two groups (R= 0.803; p<0.001). These differences can be explained by the increase of *Daphnia longispina*, *C. numidicus* and *Bosmina coregoni* during December- March period. These species prefer lowest temperatures and lowest densities of

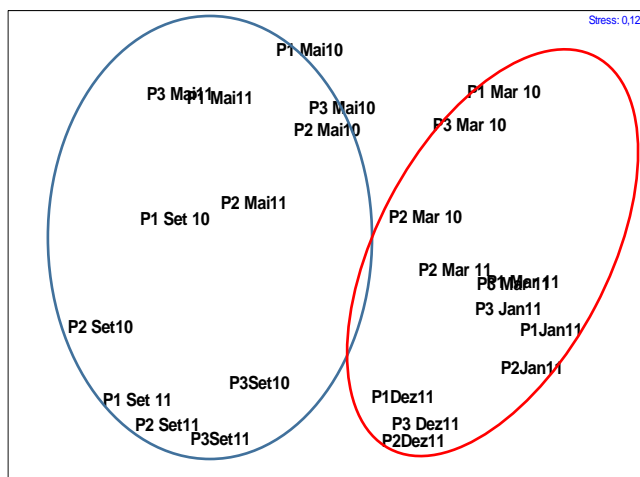
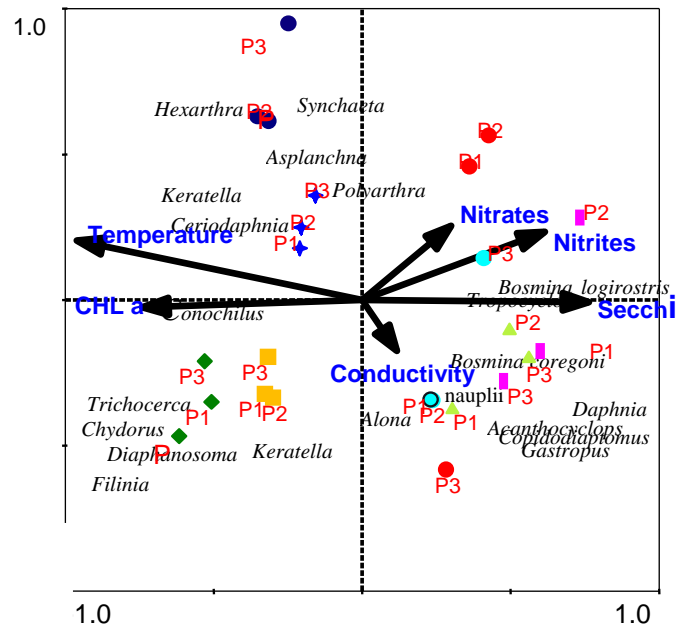


Fig. 2. Results of n-MDS ordination considering zooplankton. P1, P2, P3 - sampling sites. Jan, Dez; Mar, Mai Set-Samples obtained in January, December, March, May and September, respectively.

CCA revealed two gradients that influenced zooplankton community (see Figure 3). First is the temporal gradient related to temperature (P=0.0000) and the other is the trophic gradient associated to algal biomass CHL *a* (P=0.004), Secchi disk depth (P= 0.04), conductivity (P=0.009), nitrates (P= 0.014) and nitrites (P=0.029). The ordination space defined by the first two CCA axes accounted for 70% of species-environment relation and represented 45% of the variation in species data.



ts of CCA. h samples: March 2010 – red circles; May 2010 – blue stars; 2010 – yellow squares; January 2011 – pink rectangles; – green triangles; May 2011 – dark blue circles; September 2011- nds and December 2011- light blue circles.

IV. DISCUSSION

est values for pH, CHL *a* concentrations were both in May and September and were related to the of blooms of Cyanobacteria. The blooms were composed of *Raphidopsis mediterranea*, *Anabaena* and *Gophosphaeria lacustris*, which were recorded for the first time in this reservoir by [19]. The increase in pH during this period is a consequence of high consumption of CO₂ by these microorganisms leading to the alkalization of the euphotic zone. The conditions created by late spring- summer temperatures and irradiance combined with high levels of nutrients provided the ecological optimum for cyanobacteria dominance [20, 21]. The trophic state of this reservoir, varying between meso-eutrophic and eutrophic state, might be a consequence of the disturbance caused by extreme and aperiodic water level fluctuations (because of hydroelectricity production). The exposure of littoral sediments to cycles of drying and wetting might have implications on nutrient cycling. This assumption is supported by the results obtained from [22] and [23] in reservoirs where water level fluctuations were accentuated and refilled over a short period of time. According to these authors, littoral sediments that were periodically exposed, experiencing cycles of drying and wetting, have less capacity to adsorb nutrients than those that remain inundated.

Zooplankton composition and abundance was similar in all sampling sites. Slight differences such as the higher abundance of the copepod, *T. prasinus* in P1 in March 2010,

can be explained by spatial variations on fish predation pressure [24]. The obtained results evidenced that zooplankton communities can be regarded as “reservoir mirrors”. In fact, when cyanobacteria blooms occurred, Rotifera (*Keratella* sp. and *Polyarthra* sp.) were dominant. In this period, Caldocera (*Chydorus sphaericus* and *Ceriodaphnia*) and Copepoda were also present, but in much smaller densities. Therefore, specialists on small particle feeding, for those the food preferences are mostly detritus-bacteria, are favoured in these environmental conditions. Whereas cyanobacteria are known to negatively affect mesh filter-feeders (large herbivores) such as *Daphnia*, either by being of low nutritional value, by clogging the feeding apparatus or by producing toxins [25, 9, 26, 27]. Besides, large herbivores have larger generations, lower tolerance to turbidity and higher temperatures [28, 29, 30]. Therefore, *Daphnia longispina*, *C. numidicus* and *Bosmina coregoni* were abundant in December, January and March.

V. CONCLUSION

The results of the present study conclude that the water temperature, pH, CHL *a*, and Secchi disk depth explained to an extent of the variability, abundance and composition of zooplankton community. But the other factors such as the anthropogenic disturbance degree reflected in the water level fluctuations, climate change, biotic interactions also seemed to play an important role in structuring the zooplankton community. It is important that the further limnological studies may actually contribute to fully assess the relative importance of all these different variables. The obtained data constitute a preliminary study and might be a basis to develop management plans to mitigate some negative impacts resulting from anthropogenic activities in this reservoir. Furthermore, data obtained in this study will allow monitoring the efficiency of those plans by detecting changes in this community, which can be related to changes in water quality and in the overall ecosystem health.

Acknowledgment

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III Congresso Ibero-Americano de Empreendedorismo, Energia, Ambiente e Tecnologia

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