PRIMARY PRODUCTION AS THE MAIN DRIVER OF PYRENEAN HIGH MOUNTAIN LAKES TRANSPARENCY

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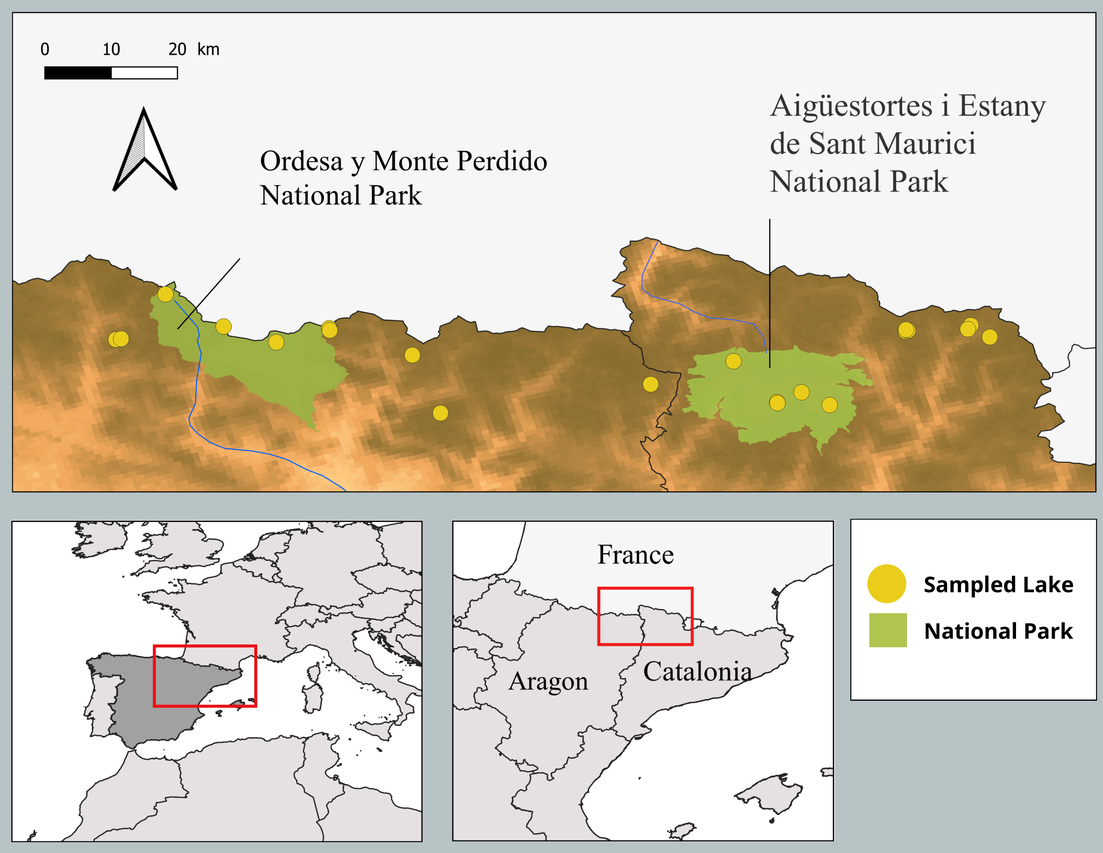
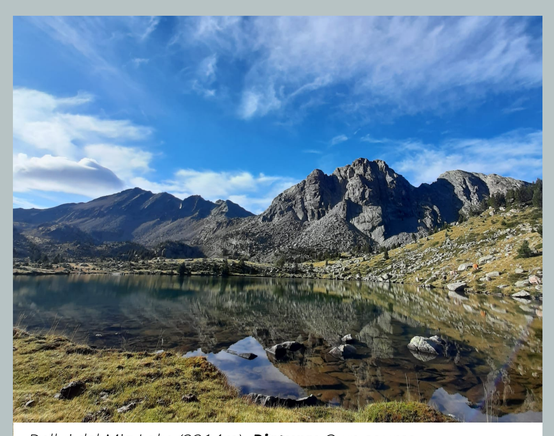
INTRODUCTION

Pyrenean high mountain lakes are ultra **oligotrophic lotic ecosystems.** Thus, these water bodies are **highly transparent** in an original, natural state (Catalan et al., 2017).
Transparency is commonly affected by perturbances and hence, is very often **used as an indicator** of **ecological health** when monitoring high mountain lakes (Kosten et al., 2009; Li et al., 2019) since it is related to biodiversity, ecosystemic stability and overall lake health state (Nürnberg, 1996; Rose et al., 2014).
Secchi Disk is likely to be the most widespread method to **assess water clarity** and calculate **Kd** (diffuse attenuation coefficient) in water bodies. This paper is set to determine the **main factors** involved in Pyrenean high mountain lakes **transparency**. Secchi disk measurements will be compared with underwater PAR sensor LI-192, and Poole & Atkins (1929) constant will be revised.



Map 1: *Study site map including sampled lakes in the Aragonese and Catalan Pyrenees. Green polygons show National Park Areas. Yellow dots correspond to sampled lakes*

Ibón Helado de Monte Perdido (2978m). ***Picture:*** *Own source*



Dellui del Mig Lake (2314m). ***Picture:*** *Own source*

Variables	AIC	R2	P-value
Chl-a***, DOC	-25.6	0.577	<0.05
Equation			
0.684+(0.227)·Chl-a+(0.144)·DOC			

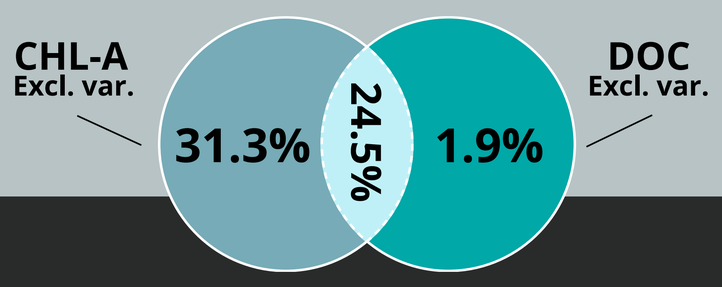


Table 1. *Multiple regression equation, Y=Kd*
Signif. codes: *(***) 0.001*

MATERIALS & METHODS

A total of **21 lakes** were sampled in the **Spanish Pyrenees** in **2021** (see *Map 1*). Ten lakes located in the **Aragon** region and eleven in the **Catalonia** region. All ten Aragon lakes were surveyed once during July. Nine out of eleven Catalan lakes were sampled twice in July and September.
Underwater light was estimated through Secchi disk depth measurements (*ZSD; m*) and attenuation coefficient (*Kd; m-1*) using the equation by Poole & Atkins (1929). Complementary, Kd was calculated from PAR measurements obtained with the sensor LI-192 by LI-COR. Water column physicochemistry, morphological parameters and land coverage were surveyed too.

RESULTS

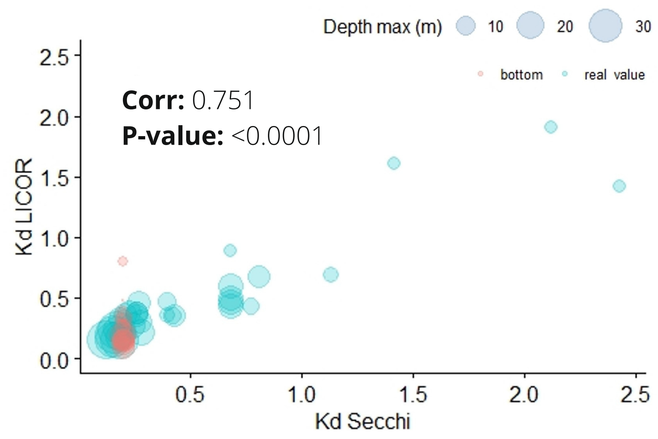


Figure 1. *Correlation between Kd estimated through Secchi disk and Kd estimated by LI-192 sensor. Red dots show 0.2 generalized Kd values.*

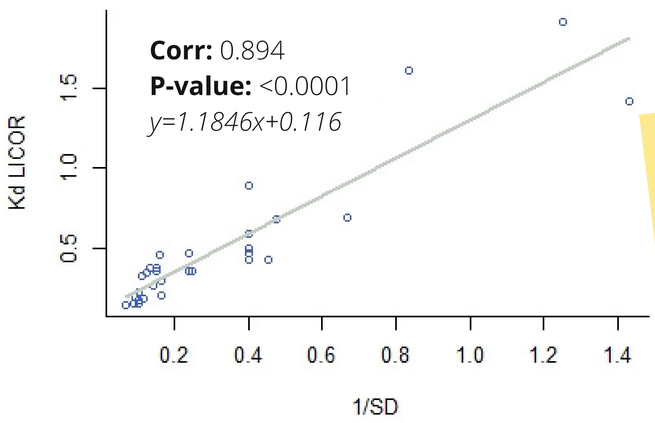


Figure 2. *Correlation between Kd estimated by LI-192 sensor and 1/SD (Secchi disc).*

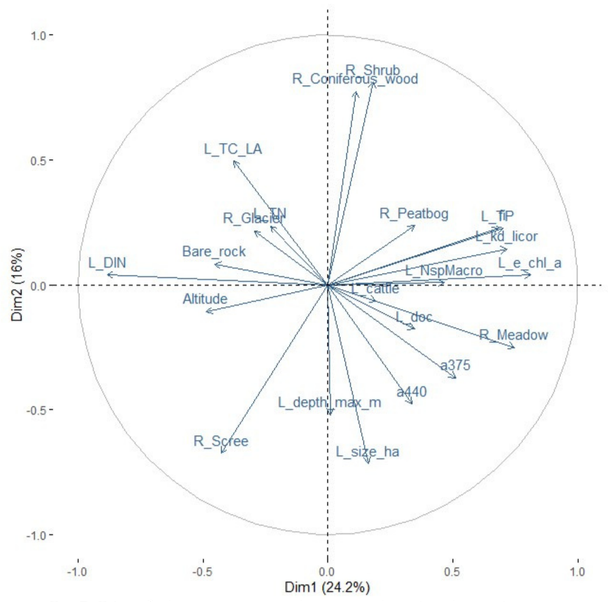


Figure 3. *PCA of the water column physiochemistry, morphological parameters of the lakes and basin land coverage.*

DISCUSSION

Several authors highlight the use of **Secchi disk** as a good method to assess trophic state and as a measurement of transparency (Heiskary & Wilson, 2008; Nürnberg, 1996). Even so, as seen in *Figure 1*, in comparison to LI-192 PAR sensor, some **Kd values** calculated through **Secchi disk** reported **not to be precise** and show some variance when generalised to **0.2** (when *SD* reaches lake's bottom still being visible, shown as red dots).
SD equation **constant** C (Poole & Atkins, 1929) was **recalculated** for the Pyrenean lake set used and the new value proposed (**C = 1.18**) upgrades Kd estimation preciseness in the study frame when *SD* is used compared to the 1.7 original value suggested by Poole & Atkins (1929).

Figure 1 shows some lakes where transparency can be explained because of **lake depth**. However, the **multiple regressions** carried out between transparency (Kd) and other variables show that the best model selects **Chlorophyll-a** as the **main driver** of transparency in the Pyrenean lake set used (*Table 1*). **DOC** (from **authochtonous** origin in the vast majority of lakes), although included in the model, **is not** considered a **main driver** of the lake set.

CLIMATE CHANGE

Vegetal formations such as **forests** are likely to go through an **altitudinal migration**, which would increase vegetal coverage in nowadays low vegetated lake basins (Peñuelas & Filella, 2001). **DOC** concentrations will possibly **increase** and become an important factor driving **transparency** in the **future** (Moser et al., 2019).

BIBLIOGRAPHY

Check the complete bibliography and the full paper scanning the following QRs.

Complete bibliography

Full paper