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Multiple drying aspects shape dissolved organic matter composition in intermittent streams

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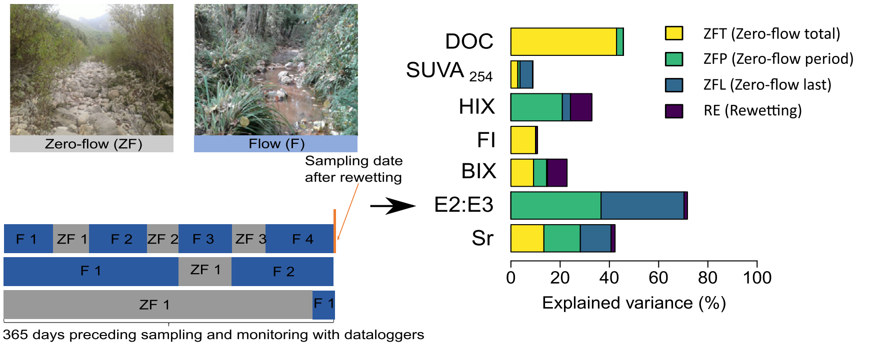
HIGHLIGHTS

- Drying duration and frequency increase DOC concentration and modify DOM composition.
- Multiple drying aspects are needed to explain DOM composition.
- Drying duration and frequency reduce autochthonous and aromatic compounds.
- Drying frequency and last dry event duration increase humic-like substances.

GRAPHICAL ABSTRACT



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ABSTRACT

Water availability is a fundamental driver of biogeochemical processing in highly dynamic ecosystems such as intermittent rivers and ephemeral streams (IRES), which are recognized as the most common fluvial ecosystem globally. Because of their global extent, IRES have a remarkable contribution to organic matter processing, which is expected to intensify as climate change and water extraction expand IRES extension. Nevertheless, the effect of the complexity of the drying process on river biogeochemistry remains unclear. This study investigated how drying aspects affect the dissolved organic carbon (DOC) concentration and composition in 35 streams along a wide flow-intermittence gradient in the NE Iberian Peninsula. To do that, four drying aspects: annual drying duration, annual frequency, duration of the last drying event, and time since the last drying event were characterized. Results showed that DOC concentration and the contribution of humic-like compounds were positively associated with intensifying drying conditions. In addition, protein-like compounds decreased over the drying gradient. More specifically, changes in DOC concentration were driven mainly by annual drying duration, whereas annual drying frequency and the duration of the last drying event jointly explained dissolved organic matter composition. These results suggest that the quantity and composition of dissolved organic matter in streams respond differently to the temporal aspects of the drying process. Our study can help to better anticipate changes in organic matter in the context of climate change.

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1. Introduction

Fluvial ecosystems are hotspots of organic matter processing (Battin et al., 2008; McClain et al., 2003) because they receive large amounts of organic matter from terrestrial ecosystems. It is well established that hydrology has a key role in controlling biogeochemistry in flowing waters (Baek et al., 2019; Fasching et al., 2016; Guarch-Ribot and Butturini, 2016). In particular, recent evidence highlights the impact of flow intermittence on the global carbon cycle (Dewey et al., 2020). Thus intermittent rivers and ephemeral streams are receiving more attention due to their global distribution and expected expansion as a consequence of climate change (Datry et al., 2014, 2018; Granados and Butturini, 2019; Shumilova et al., 2019). However, the complexity of the drying process can give rise to different annual (drying duration and frequency) and previous drying aspects (duration of the last drying event and rewetting) (Arias-Real et al., 2021; Butturini, 2021; Ejarque et al., 2017; Granados and Butturini, 2019). Thus, understanding how these drying aspects influence organic matter dynamics is a fundamental step to better predict how global carbon cycles will respond to global change.

Previous studies have found that water availability strongly influence the concentration of dissolved organic carbon (DOC) and the composition of dissolved organic matter (DOM). For instance, drying reflects a reduction of hydrological connectivity with terrestrial ecosystems, which increases the concentrations of autochthonous DOM sources (e.g., protein-like constituents) (Fellman et al., 2011; Siebers et al., 2016; Vázquez et al., 2015; von Schiller et al., 2015). Persistent drying conditions are also associated with a marked increase of DOC concentrations and the prevalence of humic-like compounds (Granados et al., 2020; Harjung et al., 2018, 2019). However, DOM shows a more aromatic and humic-like character during rewetting, although protein-like and microbial-derived sources are also discernible (Inamdar et al., 2011; Shumilova et al., 2019). Although there is evidence showing that both drying and rewetting periods are “hot moments” for DOM production, transformation and transport (Casas-Ruiz et al., 2016; Harjung et al., 2018; Vazquez et al., 2011; von Schiller et al., 2015), it is still unclear how the duration and frequency of these hydrological phases influence DOC concentration and DOM composition.

Despite the progress in the field, previous studies have typically explored drying effects on stream ecosystems by focusing on qualitative hydrological descriptors (perennial vs. intermittent), short-term assessments spanning weeks (pre- and post-drying) or using a single drying descriptor (e.g., drying duration; Arias-Real et al., 2020; Belmar et al., 2019; Reynolds et al., 2015). However, integrating different drying aspects, such as frequency or characteristics of recent drying events, has the potential to better predict organic matter dynamics in intermittent streams.

This study investigated the effects and importance of annual and recent drying aspects on DOM quantity (DOC concentration) and composition (DOM optical qualitative parameters). To do that, 35 Mediterranean streams were selected across a wide flow-intermittence gradient and four drying aspects were characterized: annual drying duration (total number of zero-flow days; ZFT), annual frequency (total number of zero-flow periods; ZFP), the duration of the last drying event (number of zero-flow of the last zero-flow period; ZFL) and the flowing time since the last rewetting event (RE). Next, the effect and importance of these drying aspects on DOC level and DOM composition were investigated, while controlling for other key non-hydrological abiotic factors (water temperature and altitude). According to previous studies (Casas-Ruiz et al., 2016; Granados et al., 2020; Harjung et al., 2018; von Schiller et al., 2015), it is expected that the duration of the last drying event and the time since the last rewetting event will be more important than the annual drying aspects for DOC level and DOM composition.

2. Materials and methods

2.1. Study site

This study was conducted at 35 independent streams located in nine river basins across Catalonia (NE Spain) over a wide flow intermittence gradient (from permanent to ephemeral streams). Stream catchments include natural, semi-natural or extensive agriculture land cover (cereals, olive trees, vineyards; see Appendix A, Table A1 for more details), which resulted in low to moderate nutrient concentrations (median dissolved inorganic nitrogen = 1.44 mg/L, median soluble reactive phosphorous = 0.02 mg/L). The stream order ranges from two to five. Climate is typically Mediterranean, characterized by warm and dry summers and precipitation occurring mainly in autumn and spring. Summer storms can occasionally occur during summer.

2.2. Characterization of drying aspects

To characterize drying aspects, one year before our sampling campaign (on February 2016), temperature and water level data loggers were placed on each streambed, which enabled the inference of water presence and absence (Arias-Real et al., 2021; Gionchetta et al., 2020). The data loggers were recording data at hourly intervals during one year (from February 2016 until February 2017; see Methodological details in Appendix B). Once temperature and water level data were retrieved (that is, on February 2017) four drying aspects were calculated (Fig. 1). First, the annual drying duration was calculated as the total number of dry days (zero-flow total days, ZFT). Second, the drying frequency was calculated as the annual number of dry periods (annual frequency ZFP). Then, the duration of the last dry period was calculated (zero-flow last, ZFL). Finally, the duration of the last rewetting event was calculated (RE, rewetting). Drying aspects exhibited a wide range of variation, ranging from permanent-flow streams with 0 annual dry days to ephemeral streams with >324 annual dry days. Moreover, annual drying frequency ranged from 0 to 8. The duration of the last dry period oscillated from 0 to 294 days, whereas the rewetting duration since the last drying event ranged from 6 to 274 days (Appendix C Table C1).

2.3. Dissolved organic carbon and optical measurements

Water samples for DOC and DOM analysis were collected just after the rainy season (on February 2017) to ensure that all streams were in flowing phase. Water samples were filtered using precombusted (450 °C) glass fiber filters (Whatman GF/F, 0.7 μm pore size) followed by nylon filters with a 0.22-μm pore. The filtered samples were placed in precombusted amber glass bottles previously washed with diluted acid. Samples were kept cooled in dark conditions, being immediately transported to the laboratory, where they were stored at 4 °C until analysis.

DOC concentration was analyzed by oxidative combustion infrared analysis on a Shimadzu TOC-VS (Shimadzu Corporation, Kyoto, Japan) on preacidified samples (HCl, final sample pH = 2–3). DOM composition was characterized using spectroscopic methods. Absorbance spectra for the DOM were obtained using a UV1700 PharmaSpec spectrophotometer (Shimadzu) and a 1-cm quartz cell. Absorbance data were obtained in the double-beam mode, with the wavelength scanned from 200 to 800 nm, using deionized water as the blank. Excitation-Emission matrices (EEM) were generated with an RF-5301 PC spectrofluorometer (Shimadzu). Spectra were obtained over (excitation-emission) wavelengths of 240–420 nm and 280–690 nm. EEMs were standardized with the method by Goletz et al. (2011), using the Mathematica software (Wolfram Research). The same method was used to correct the inner filter effects on the absorbance data (Lakowicz, 2006). To correct the wavelength-dependent inefficiencies of the detection system, the method of Gardecki and Maroncelli (1998) for emission measurements and the method of Lakowicz (2006) for excitation correction were applied. Daily measurements of the area under the Raman peak of Milli-Q water blanks were used to normalize the data from each day of analysis with the spectrofluorometer (Lawaetz and Stedmon, 2009).

DOM optical indices included three chromophoric indices and three fluorophoric indices. The chromophoric indices were: (a) the specific ultra-violet absorbance at 254 nm (SUVA254), (b) the ratio of absorbance at 250 nm to that at 365 nm (E2:E3) and (c) the spectral slope ratio (Sr). The three fluorophoric indices considered were: (a) the humification

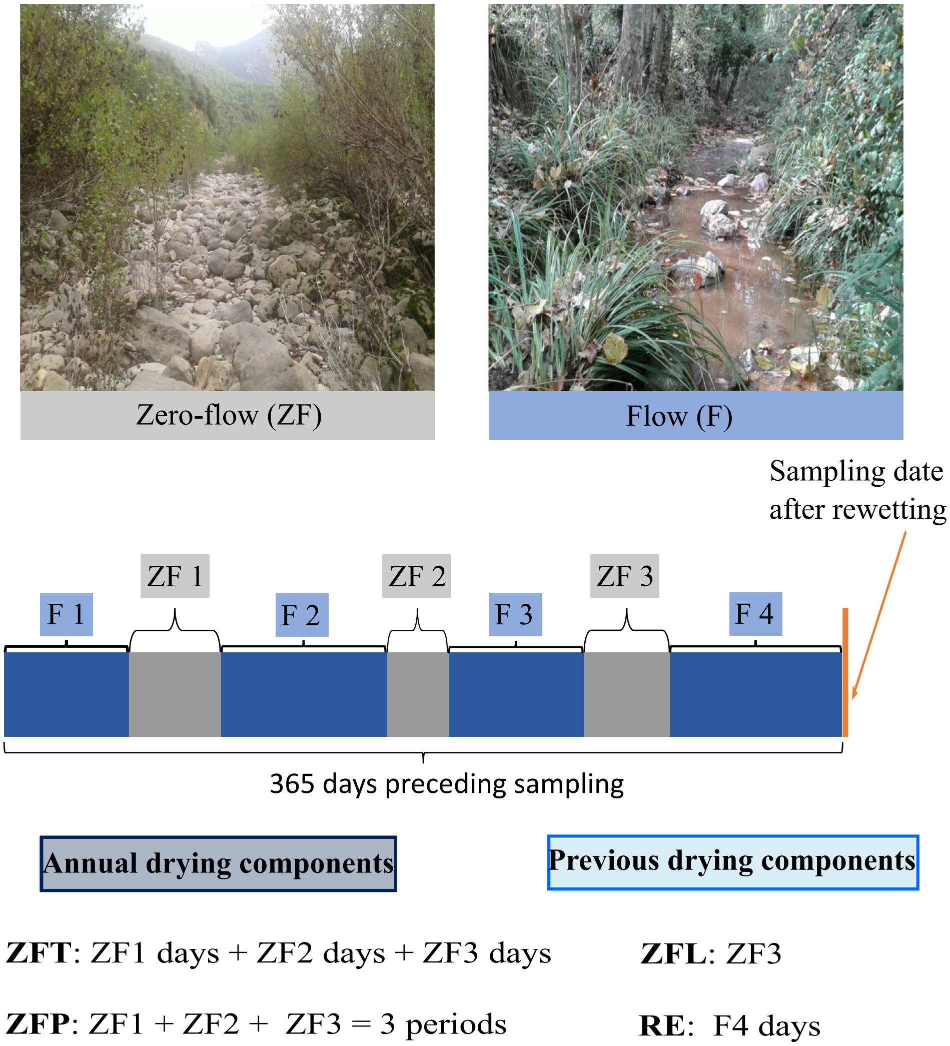

Fig. 1. Characterization of drying aspects. F corresponds to flowing conditions, ZF to zero-flow conditions. ZFT is the annual number of days with zero flow, ZFP is the annual number of zero-flow periods, ZFL is the number of zero-flow days during the last drying event, and RE is the number of days since the last drying event.

index (HIX), (b) the fluorescence index (FI) and (c) the biological index (BIX). These optical indices are able to capture different components of the DOM composition (Hansen et al., 2016), including aromaticity ($SUVA_{254}$), humic-like substances (HIX), autochthonous DOM sources and protein-like substances (FI, BIX) and molecular weight (E2:E3 and Sr) (see Table 1 for more details).

Table 1
Description of the DOM optical qualitative indices.

Index	Calculation	Interpretation	Reference
$SUVA_{254}$ Specific ultra-violet absorbance at 254 nm	The absorption coefficient at 254 nm is normalized by the DOC concentration.	Higher values of $SUVA_{254}$ are typically related to greater aromaticity.	(Weishaar et al., 2003)
HIX Humification index	The area under the emission spectra at 435–480 nm divided by the peak area at 310–345 nm from the spectra at an excitation wavelength of 254 nm.	HIX indicates the extent of humification by quantifying the shift in the emission spectra towards longer wavelengths due to lower H: C ratios. HIX values range from 0 to 1. Higher values indicate a greater degree of DOM humification.	(Ohno, 2002)
FI Fluorescence index	The ratio of emission intensity at 470 nm to that at 520 nm emitted at an excitation wavelength of 370 nm.	The FI is a proxy of the DOM origin. High values suggest the prevalence of labile, algal-, or microbial-like sources (i.e., stream-produced DOM).	(Cory and McKnight, 2005)
BIX Biological index	The BIX is calculated at an excitation wavelength of 310 nm as the fluorescence intensity ratio emitted at 380 nm to that emitted at 430 nm.	High BIX values (>1) suggest the presence of autochthonous and fresh DOM. Values of 0.6–0.7 indicate low or zero autochthonous DOM production.	(Huguet et al., 2009)
E_2:E_3	The ratio of absorbance at 250 nm to that at 365 nm.	E_2:E_3 provides information about the DOM molecular size. This index is inversely related with molecular weight.	(De Haan and De Boer, 1987)
Sr Slope ratio	Dimensionless parameter. The ratio of the logarithmically transformed absorbance spectra slope at 275–295 nm ($S_{275–295}$) to that estimated at 350–400 nm ($S_{350–400}$).	The Sr integrates shifts in the molecular size of DOM. High values of this index indicate an increase in the proportion of the small DOM molecular fraction.	(Helms et al., 2008)

2.4. Data analysis

First, Pearson correlations were used to understand the covariation between DOC and DOM optical indices over the drying gradients. Next, the effect and importance of the drying aspects (ZFT, ZFP, ZFL and RE) on DOC concentration and DOM optical indices were estimated using linear regression models and a multi-model inference approach (Burnham and Anderson, 2002; Grueber et al., 2011). Altitude and water temperature were also included as predictors to account for the non-hydrological variation in our models. See Appendix D, Table D1 for more details on model construction.

To do so, the explanatory capacity of 12 multiple-regression models were evaluated, considering all possible combinations of predictors, excluding those with high collinearity (i.e., $r \leq |0.70|$ or the variance inflation factor ≤ 2). Models that simultaneously included ZFT and ZFL were discarded because they showed high collinearity ($r = 0.78$; see Appendix E, Table E1 and E2 for more details). Afterwards, for each response variable, all 12 models were ranked using the values of the Akaike information criterion for small sample sizes (AICc), retaining those showing a ΔAICc < 2 with respect to the model ranked first (Zuur et al., 2009). The explained variance (R^2) and Akaike weights were also calculated to determine the explanatory power and relative likelihood of each model being the best model. MuMIM R package was used to obtain AICc, Akaike weights and explained variance (Bartoń, 2016).

A variance partitioning analysis was used to evaluate the effects of drying aspects and non-hydrological abiotic factors on DOC concentration and DOM optical indices (Hoffman and Schadt, 2016). For all models, residual plots were visually checked to verify model assumptions. Before analysis, to reduce distribution skewness, a log-transformation for DOC, HIX, SUVA254 and Sr a square-root transformation for E2:E3, ZFL, ZFP and ZFT, and a fourth-root transformation for RE were performed. Finally, to produce standardized and comparable model coefficients, predictors were standardized to a comparable scale (mean = 0, SD = 1). All statistical analyses were performed in R 3.5.1 (R Development Core Team, 2011).

3. Results

3.1. Variation of dissolved organic matter quantity and composition over the drying gradient

DOC concentration and DOM optical indices (see Table 1) showed high variability across the studied streams. DOC concentrations ranged from 0.7 to 14.6 mg C·L^{-1}, the SUVA$_{254}$ varied from 1.83 to 8.59 L mg C^{-1} m^{-1}, the HIX values fluctuated from 0.49 to 0.94, the FI ranged from 1.47 to 1.92, the BIX varied from 0.48 to 0.81, the E_2:E_3 ranged from 1.47 to 9.21 and the Sr varied from 0.73 to 3.91 (see Table 1 for a full description of DOM optical indices). DOC was positively correlated with the HIX ($r_P = 0.62$) and E2:E3 ($r_P = 0.48$) and negatively associated with the SUVA254 ($r_P = -0.22$), FI ($r_P = -0.41$), BIX ($r_P = -0.67$) and Sr ($r_P = -0.44$).

3.2. Effects of drying aspects on dissolved organic matter quantity and composition

Two contrasting patterns in response to annual and recent drying aspects were identified. The first group of variables, including DOC concentration, and the HIX and E_2:E_3, tended to increase with the annual drying duration and frequency. DOC concentration increased with both annual drying duration and frequency (Fig. 2), whereas the HIX and E_2:E_3 showed a positive response to annual drying frequency and the duration of the last drying event (Fig. 3). However, rewetting duration showed a positive effect on the E_2:E_3, negative effect on the HIX and no effect on the DOC concentration. On the contrary, the second group of variables, including the SUVA$_{254}$, FI, BIX and Sr indices decreased with drying conditions to different degrees. The SUVA$_{254}$ and Sr also decreased with the annual drying frequency and the duration of the last drying event. The BIX and FI responded positively to rewetting duration, whereas the Sr showed a negative response (Fig. 3). Water temperature and altitude had an overall positive effect on DOC, and the SUVA$_{254}$ and FI and an overall negative effect on the HIX and E2:E3 (Appendix F, Table 1). Altitude had an overall positive effect on the Sr.

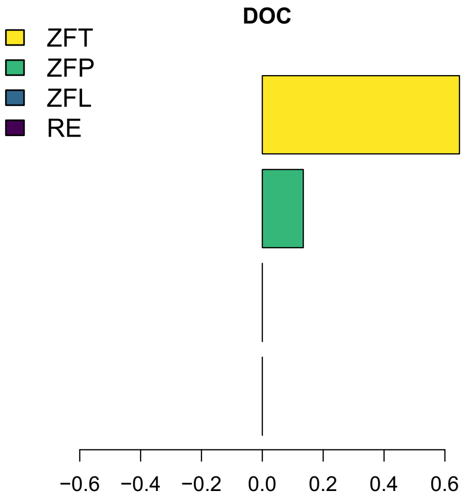

Fig. 2. Mean standardized effects of drying aspects on DOC concentration. ZFT: annual drying duration; ZFP: annual drying frequency; ZFL: duration of the last drying event; RE: the number of rewetting days since the last drying event.

3.3. Importance of drying aspects on dissolved organic matter quantity and composition

Annual drying duration was the best predictor of DOC concentration (mean explained variance: 42.9 %), whereas DOM composition was explained by a combination of multiple drying aspects (Fig. 4). Annual drying duration showed a limited capacity to predict variations in DOM composition (mean explained variance: 5.9 %) compared to annual drying frequency (mean explained variance: 13.1 %) and the duration of the last drying event (mean explained variance: 9.2 %). Annual drying frequency was the best predictor of the E_2:E_3 (mean explained variance: 36.5 %), HIX (mean explained variance: 20.9 %) and Sr (mean explained variance: 14.8 %). The duration of the last drying event also explained the E_2:E_3 (mean explained variance: 33.7 %) and Sr (mean explained variance: 12.5 %). Rewetting duration showed a certain explanatory capacity for the BIX (mean explained variance: 8.7 %) and HIX (mean explained variance: 7.9 %). Water temperature was generally relevant for DOC and DOM indices (mean explained variance: 7.2 %, range: 1.3–17.9 %), but altitude had a weak predictive capacity (mean explained variance: 1.1 %, range: 0.0–3.2 %). Water temperature was particularly important for the SUVA$_{254}$ (mean explained variance: 17.9 %) and FI (mean explained variance: 14.9 %).

4. Discussion

This study demonstrated that preceding drying increased DOC concentration and modified DOM composition during the flowing phase. In addition, DOC concentration was mainly explained by annual drying duration, whereas DOM composition was better predicted by multiple drying aspects than by a single drying descriptor. Specifically, annual drying frequency, the duration of the last drying event and the time since the last drying event jointly explained changes in DOM composition. These findings suggest that the quantity and composition of DOM in streams respond differently to the temporal components of the drying process.

4.1. Effects of drying aspects on dissolved organic matter quantity and composition

The results of this study align with previous evidence showing that drying events tend to increase DOC concentration (Granados et al., 2020; Harjung et al., 2018; Vazquez et al., 2011; von Schiller et al., 2015). This pattern

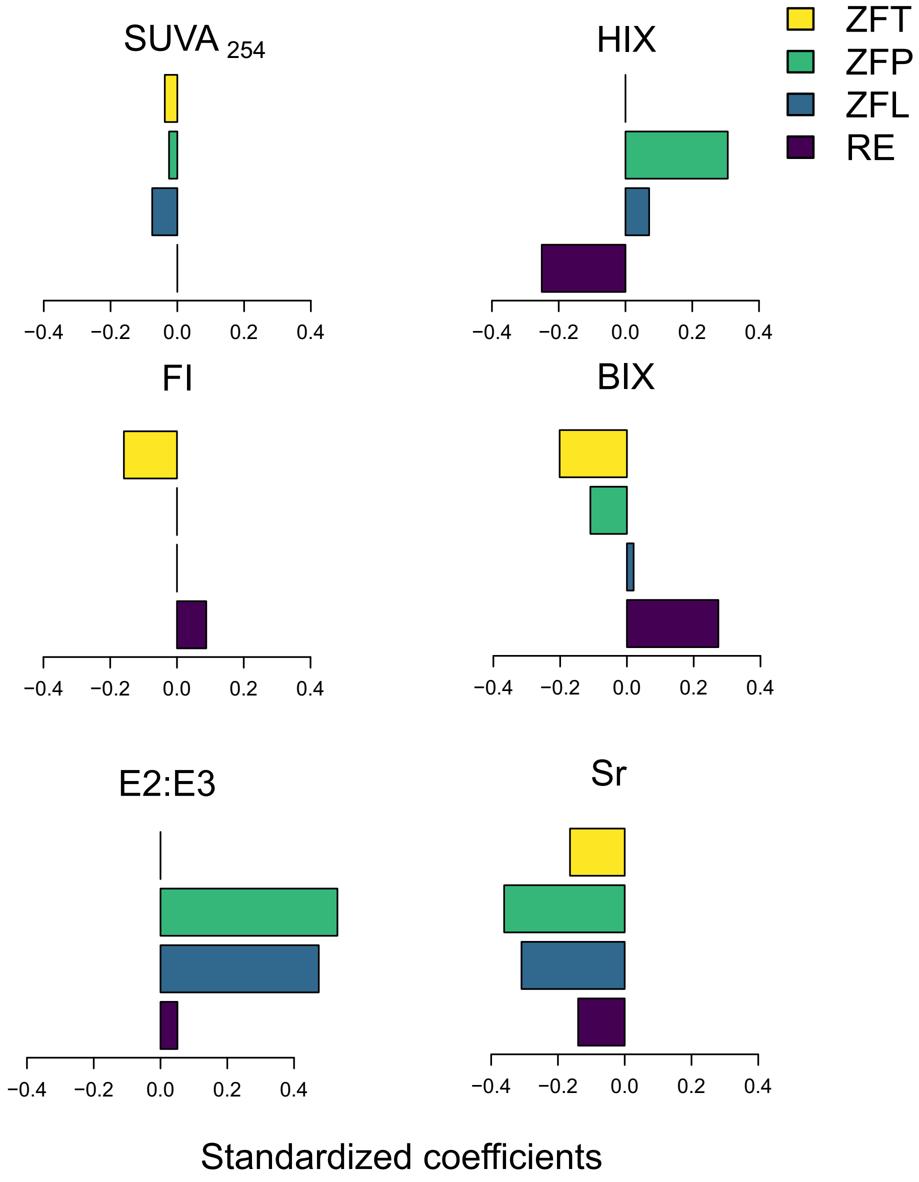

Fig. 3. Mean standardized effects of drying aspects on DOM optical indices. ZFT: annual drying duration; ZFP: annual drying frequency; ZFL: duration of the last drying event; RE: the number of rewetting days since the last drying event.

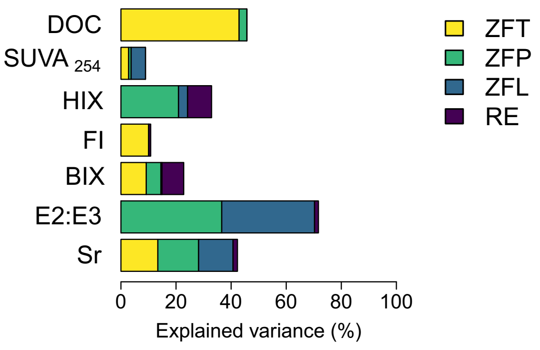

Fig. 4. Mean importance of the drying aspects on DOC and DOM patterns. ZFT: annual drying duration; ZFP: annual drying frequency; ZFL: duration of the last drying event; RE: the number of rewetting days since the last drying event.

can be explained by the reduced capacity of intermittent and ephemeral streams to degrade organic matter (Abril et al., 2016; Arias-Real et al., 2020). Channel desiccation slows down microbial activity (Gionchetta et al., 2020) and reduces microbial diversity (Febria et al., 2012), which jointly can limit the degradation of certain organic compounds (e.g., drying events inhibit lignocellulolytic enzyme activities; Arias-Real et al., 2018; Bärlocher, 2016; Mas-Martí et al., 2015). For example, the contrasting correlation of labile (the BIX and FI) and humic-like substances (the HIX) with DOC seems to support these processes, where the more reactive substances are replaced by refractory organic compounds as drying intensifies (Granados et al., 2020). In addition to desiccation, hydrological contraction and fragmentation leading to isolated pools, can also reduce DOM degradation (Catalán et al., 2017; Gómez-Gener et al., 2016). Collectively, the annual and recent aspects of the hydrological fragmentation and drying phases appear as critical factors determining dissolved organic matter concentration and composition.

The main novelty of the present study was in finding that DOM composition during the flowing phase was better explained by a wider range of drying aspects than previously thought. Thus, in addition to annual drying duration, annual drying frequency, the duration of the last dry period and the time since the last dry period explained changes in DOM composition. Furthermore, DOM constituents changed over this drying gradient towards a progressive reduction in the amount of protein-like, autochthonous and aromatic compounds, and an increase in humic-like substances.

Reductions in protein-like and autochthonous organic compounds can be linked to two different processes. First, drying can limit algal and heterotrophic microbial production during the dry phases. This can occur as a result of desiccation processes that slow down the metabolic activity of aquatic organisms (Gionchetta et al., 2020; Graça et al., 2022) or due to cascading effects disrupting species interactions and synergisms (Arias-Real et al., 2022). Second, after rewetting, the organic carbon pool of IRES might loss the most-reactive components due to the intense carbon degradation during this hydrological phase (Inamdar et al., 2011; Shumilova et al., 2019; von Schiller et al., 2019). Flash storms can lead to an episodic but rapid recovery of microbial activity, even during the dry phase, which might further accelerate the consumption of the most labile DOM (Amalfitano et al., 2008; Inamdar et al., 2011; Marxen et al., 2010). However, these patterns contrast with the early steps of stagnation, where hydrological contraction and fragmentation increase protein-like and autochthonous DOM (Casas-Ruiz et al., 2016; Vazquez et al., 2011; von Schiller et al., 2015). These contrasting patterns between hydrological phases suggest that intermittent streams experience abrupt changes in organic matter quantity and composition over the hydrological cycle, potentially influencing microbial biodiversity and associated functions.

Reduced aromaticity in response to the duration of the last drying event might be linked to the reduced surface runoff and thus terrestrial organic matter inputs during drying events. Yet episodic storms can increase DOM aromaticity through an increase in terrestrial carbon inputs (Inamdar et al., 2011). However, models showed a limited capacity to explain changes in the $SUVA_{254}$, calling for caution to verify these expectations.

The observed increase in humic-like substances over the drying gradient can be related to the accumulation of refractory DOM constituents as water renewal decreases (Casas-Ruiz et al., 2017; Catalán et al., 2016). During the first moments of the hydrological contraction and fragmentation, humic-like compounds increase abruptly (Granados et al., 2020). In addition, after flow resumption, humic-like substances tend to persist over the river continuum because of their refractory composition (Catalán et al., 2017). In this study, the large inputs of terrestrial organic matter during autumn and winter preceding data collection, could have further favored the persistence of humic-like substances in the streams with lower water renewal (i.e., the most intermittent and ephemeral streams).

4.2. Importance of drying aspects on dissolved organic matter quantity and composition

The results of this study underscore the importance of considering additional drying aspects beyond annual drying duration to better understand the biogeochemistry of IRES. Annual drying frequency and the duration of the last drying events emerge as complementary drivers of DOC and DOM composition, potentially reflecting a wider array of hydrological, geochemical and biological processes (Gómez-Gener et al., 2021). Unexpectedly, the time since the beginning of the last rewetting had a low explanatory capacity of DOC and DOM composition. Previous studies have highlighted the importance of this hydrological phase in organic matter processing (Shumilova et al., 2019; von Schiller et al., 2019). For example, in small intermittent streams, rewetting causes a large input of allochthonous compounds followed by a delayed microbial carbon processing of 2–3 days (Guarch-Ribot and Butturini, 2016; Vazquez et al., 2011; von Schiller et al., 2015). However, because of the timing of our study (February 2017), this study was unable to capture this short-term, episodic processes, suggesting that this drying aspect needs to be refined to be useful. Future studies should determine a more suitable timing to capture how the duration and frequencies of short-term rewetting processes influence the spatial distribution of DOC and DOM. In addition to drying aspects, water temperature contributed to explain variations in DOM composition, whereas altitude had a limited capacity to explain organic carbon concentration and composition. In this study, warmer waters were linked to more labile and aromatic organic compounds and less humified DOM constituents. A potential explanation is that warmer waters are related to reduced riparian cover and increased instream autotrophic and microbial productivity, which results in a higher production of protein-like compounds (Adams et al., 2010; Morin et al., 1999). These findings match previous results showing that climatic variables, such as temperature and precipitation, control organic matter processing at large scales (Catalán et al., 2018; Picazo et al., 2020; von Schiller et al., 2019).

4.3. Implications for global biogeochemical cycles

The results of this study suggest that watercourses are expected to show increased DOC concentration and altered DOM composition in response to climatically-driven increases of drying duration and frequency (Döll and Schmied, 2012; Koutroulis et al., 2019; Messager et al., 2021). Accordingly, this can lead to an increased flux of DOC to oceans due to the reduced processing over drainage networks only if the discharge does not decrease as well, with implications for coastal ecosystems and the global carbon cycle (Aufdenkampe et al., 2011; Battin et al., 2009). In this sense, increasing drying conditions might turn intermittent rivers and ephemeral streams into more passive carbon conduits than perennial watercourses (Casas-Ruiz et al., 2020; Cole et al., 2007). Thus, this study can be helpful to better understand how future spatial changes in drying conditions can influence global carbon dynamics and budgets.

5. Conclusions

The comprehensive characterization of the drying process in Mediterranean streams allowed to evaluate the effect and importance of multiple drying aspects on DOM quantity and composition. This study showed that single indicator of drying (annual drying duration) captured variations in DOC but did not fully capture changes in DOM composition. This highlights the need to integrate additional drying aspects, such as drying annual frequency and the duration of the last drying event, in biogeochemical studies. This study also indicated that increasing drying severity and frequency resulting from climate change can further increase DOC concentration and alter DOM composition. Collectively, these findings can help to better understand the role of drying events in organic matter processing and to anticipate the consequences of climate change.

CRediT authorship contribution statement

Verónica Granados: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Validation, Visualization, Writing – original draft, Writing – review & editing. **Rebeca Arias-Real:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Validation, Visualization, Writing – original draft, Writing – review & editing. **Cayetano Gutiérrez-Cánovas:** Data curation, Formal analysis, Investigation, Methodology, Validation, Visualization, Writing – review & editing. **Biel Obrador:** Conceptualization, Data curation, Investigation, Methodology, Validation, Visualization, Writing – review & editing. **Andrea Butturini:** Conceptualization, Data curation, Investigation, Methodology, Validation, Visualization, Writing – review & editing.

Data availability

Data will be made available on request.

Declaration of competing interest

The authors declare no conflict of interest.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.scitotenv.2022.158376.

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