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Responses of riverine dissolved organic matter to damming in two distinct hydrological regimes in northern Spain

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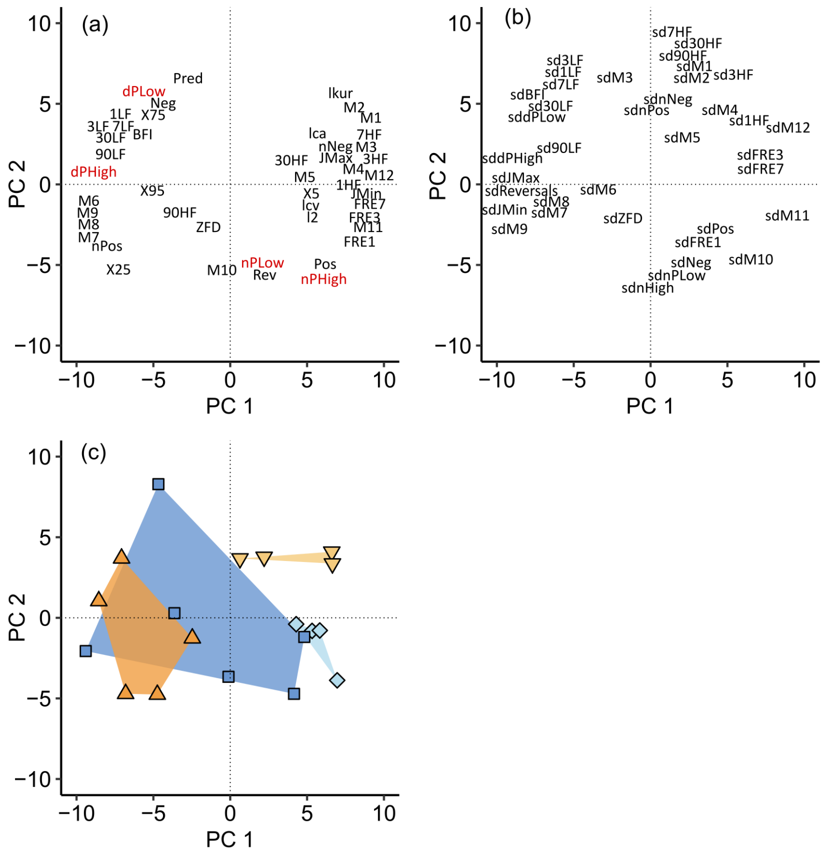

Figure S 1. A PCA based on flow indices to show the differences among the flow regimes. To improve visibility, variable scores (factor loadings) were plotted as points rather than the traditional arrows, and the indices (A) and their standard deviations (B) are separated. The scores of each river and the respective polygon indicating each flow regime (C) are given following the same color scheme; natural Atlantic (nA) in light blue, altered Atlantic (aA) in dark blue, natural Mediterranean (nM) in light orange, and altered Mediterranean (aM) in dark orange. The indices for the duration and number of low and high flow periods used to characterize flow regimes in Fig. 3 are indicated in red.

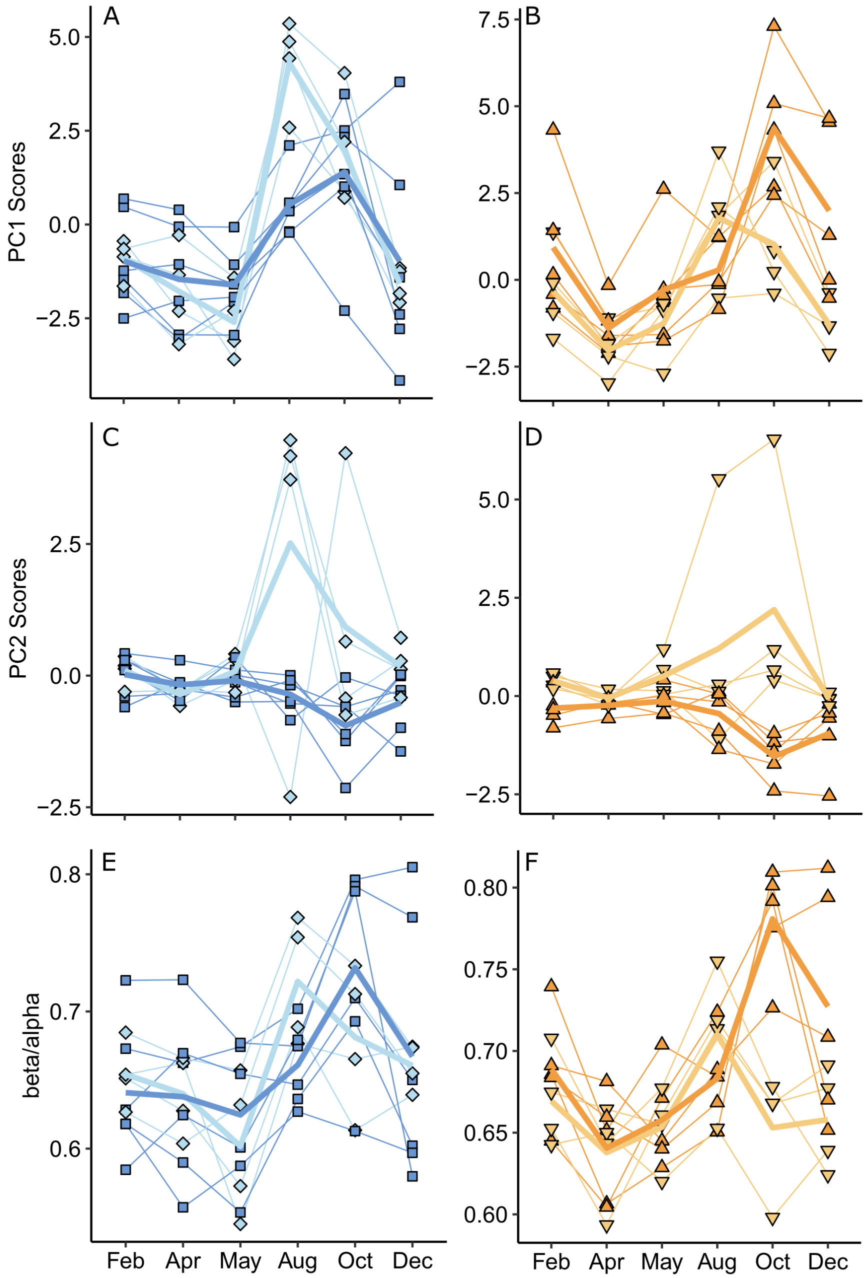

Figure S 2. Timelines of selected DOM indicators; (A-B) PC1 scores, (C-D) PC2 scores, (E-F) β/α where Mediterranean and Atlantic plots are separated. The values of each river are given following the same color scheme; natural Atlantic (nA) in light blue, altered Atlantic (aA) in dark blue, natural Mediterranean (nM) in light orange, and altered Mediterranean (aM) in dark orange. The thick lines are the monthly averages for the respective flow regimes.

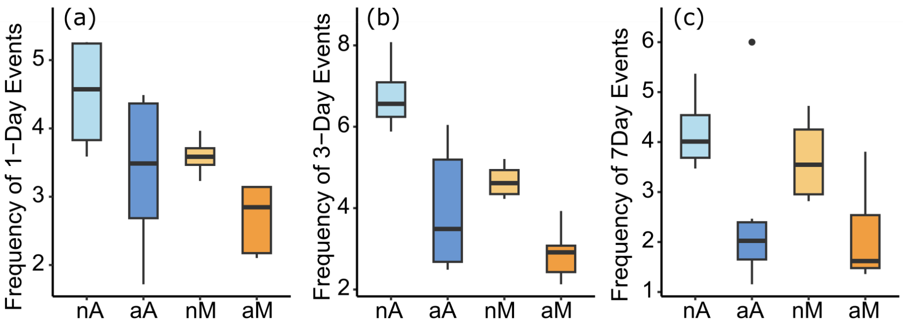

Figure S 3. The frequency of 1-day, 3-day and 7-day high flow events for natural Atlantic (nA) in light blue, altered Atlantic (aA) in dark blue, natural Mediterranean (nM) in light orange, and altered Mediterranean (aM) in dark orange

Table S 1. Discharge from the upstream gauges (m^3/s) on each sampling occasion.

	Regime	Str Order	Oct - 17	Dec - 17	Feb - 18	April - 18	June - 18	August - 18
Aguilar	aM	3^{rd}	3.74	2.70	2.83	2.96	4.69	20.76
Pisuerga	aM	3^{rd}	0.61	1.19	6.39	25.18	10.67	2.98
Carrion	aM	3^{rd}	1.25	1.22	1.44	1.05	0.99	0.93
Duero	aM	3^{rd}	2.33	0.88	0.70	17.43	4.56	9.43
Ebro	aM	4^{th}	4.91	1.10	1.22	1.18	1.09	5.31
Luna	aM	3^{rd}	2.93	2.32	1.77	2.42	1.93	1.55
Arlanzon	aA	2^{nd}	0.91	0.75	0.83	8.48	1.13	3.78
Esla	aA	2^{nd}	4.79	2.31	2.52	11.21	15.94	35.85
Nalon	aA	3^{rd}	1.80	40.26	41.28	34.04	28.81	3.20
Nansa	aA	4^{th}	1.04	5.69	6.45	7.56	5.07	0.15
Narcea	aA	4^{th}	4.10	100.60	136.80	78.80	54.70	14.82
Porma	aA	3^{rd}	2.52	1.56	1.19	8.58	9.20	20.69
Cea	nM	3^{rd}	0.16	2.94	2.84	12.56	7.19	0.54
Ega	nM	3^{rd}	1.14	9.10	45.78	206.31	7.97	1.34
Omana	nM	4^{th}	0.44	3.62	12.59	26.47	15.03	1.18
Tiron	nM	3^{rd}	0.10	3.43	4.90	9.31	2.65	0.11
Bernesga	nA	2^{nd}	0.30	7.37	6.01	13.99	12.52	0.93
Curueno	nA	2^{nd}	0.33	2.42	3.82	4.82	3.69	0.58
Deva	nA	4^{th}	1.18	18.23	23.75	21.16	16.71	4.97
Sella	nA	4^{th}	3.34	44.42	55.01	43.27	33.99	4.13

Table S 2: Results of multivariate tests of differences in DOM regimes: Differences of mean DOM composition (river centroids) among flow regimes were assessed with permutational MANOVA, differences of temporal DOM turnover (dispersion, i.e. average distance to river centroid) were assessed with ANOVA followed by planned t-tests, differences of among-river variation of mean DOM composition (dispersion of river centroids) was assessed by PERMDISP, differences of among-river variation of temporal DOM turnover (variance of dispersion to river centroids) was assessed by Bartlett-test followed by planned F-tests. We ran the same set of tests for the first and second axes of the PCA separately. Pairwise tests between two flow regimes were done only when a priori tests with all 4 flow regimes were significant. Df was 3 for nM and nA, 5 for aA and 4 for aM.

	Flow Regime	Natural nM vs nA	Atlantic aA vs nA	Mediterranean aM vs nM
Global Tests				
Mean DOM composition (river centroids)	$F_{3,15}$ = 2.20, p <0.05	$F_{3,6}$ = 1.74, p = 0.36	$F_{3,8}$ = 1.44, p = 0.73	$F_{3,7}$ = 2.94, p = 0.21
Temporal DOM turnover (dispersion, i.e., average distance to river centroid)	$F_{3,20}$ = 4.22, p <0.05	t = - 1.89, p = 0.33	t = - 4.26, p <0.05	t = - 0.42, p = 1
Among-river variation of mean DOM composition (dispersion of river centroids)	$F_{3,15}$= 0.33, p = 0.80	-	-	-
Among-river variation of temporal DOM turnover (variance of dispersion to river centroids)	$K^2{}_3$ = 1.80, p = 0.61	-	-	-
Tests on PC1				
Mean DOM composition along PC 1	$F_{3,8}$ = 1.03, p = 0.43	-	-	-
Temporal DOM turnover	$F_{3,20}$ = 4.66, p <0.05	t =-2.45, p = 0.15	t = -3.05, p <0.05	t = 1.57, p = 0.48
Among-river variation of mean DOM composition	$K^2{}_3$ = 3.15, p = 0.37	-	-	-
Among-river variation of temporal DOM turnover	$K^2{}_3$ = 3.10, p = 0.38	-	-	-
Tests on PC2				

Mean DOM composition	$F_{3,7}$ = 12.3, p <0.05	t = 0.24, p = 1	t = -5.66, p <0.05	t = -2.63, p = 0.10
Temporal DOM turnover	$F_{3,7}$ = 24.0, p <0.05	t = -1.88, p = 0.45	t = -7.17, p <0.05	t = -0.40, p = 1
Among-river variation of mean DOM composition	$K^2{}_3$ = 8.96, p <0.05	$F_{3,32}$= 16.62, p <0.05	$F_{3,52}$ = 1.05, p = 0.96	$F_{3,42}$ = 0.18, p = 0.14
Among-river variation of temporal DOM turnover	$K^2{}_3$ = 9.87, p <0.05	$F_{3,32}$= 75.41, p <0.05	$F_{3,52}$ 14.91, p <0.05	$F_{3,42}$ = 0.15, p = 0.10

Table S 3: The list of indices and their abbreviation used in Peñas and Barquín (2019) are given in the table. The indices are grouped according to their flow describing properties and the total number of indices included in the model describing each flow regime component is given in parenthesis. The indices with VIP values >1 in the PLSR model are indicated with a *.

Group	Indice	SD	Description
Magnitude of annual and monthly flows (28)	l2	-	Linear moment of the calculated flow duration curve variance
	lcv	-	Linear moment that represents the CV of the calculated flow duration curve
	lca	-	Linear moment of skewness of the flow duration curve
	lkur*	-	Linear moment of kurtosis of the flow duration curve
	M1*	sdM1	Mean magnitude of flow of month X and their SD
	M2	sdM2	
	M3*	sdM3	
	M4*	sdM4	
	M5*	sdM5	
	M6*	sdM6*	
	M7*	sdM7*	
	M8*	sdM8*	
	M9*	sdM9*	
	M10*	sdM10*	
	M11*	sdM11*	
	M12*	sdM12*	
Magnitude and duration of annual extremes (28)	1HF*	sd1HF*	Magnitude of maximum annual flow of X-day duration and their SD
	3HF*	sd3HF	
	7HF*	sd4HF	
	30HF	sd30HF	
	90HF*	sd90HF	
	X25*	-	Magnitude of flows exceeded 25% of the time (high flow pulses)
	X5	-	Magnitude of flows exceeded 5% of the time (high flow pulses)
	1LF	sd1LF*	Magnitude of minimum annual flow of X-day duration and their SD
	3LF	sd3LF*	
	7LF	sd7LF*	
	30LF*	sd30LF*	
	90LF*	sd90LF*	

	X75	-	Magnitude of flows exceeded 75% of the time (high flow pulses)
	X95	-	Magnitude of flows exceeded 95% of the time (high flow pulses)
	ZFD	sdZFD	Number of zero flow days and its SD
	BFI*	sdBFI*	Seven-day minimum flow/mean annual daily flows and its SD
Timing of extreme flow events (5)	JMin*	sdJmin*	Date of the annual minimum flow
	JMax	sdJmax	Date of the annual maximum flow
	Pred	-	Predictability
Frequency and duration of high and low flow pulses (14)	FRE1*	sdFRE1*	Number of high flow events per year (upper threshold of X-time median flow over all years) and their SD
	FRE3*	sdFRE3	
	FRE7*	sdFRE7	
	nPHigh*	sdnPHigh*	Number of high pulses per year and its SD
	dPHigh*	sddPHigh*	Duration of high pulses per year and its SD
	nPLow	sdnPLow*	Number of low pulses per year and its SD
	dPLow	sddPLow*	Duration of low pulses per year and its SD
Rate and frequency of flow changes (10)	nPos*	sdnPos*	Number of days with increasing flow and its SD
	nNeg*	sdnNeg*	Number of days with decreasing flow and its SD
	Pos*	sdPos	Rise Rate and its SD
	Neg*	sdNeg	Fall Rate and its SD
	Rev*	sdRev*	Number of hydrological reversals and its SD

References

Peñas, F. J. and Barquín, J.: Assessment of large-scale patterns of hydrological alteration caused by dams, Journal of Hydrology, 572, 706–718, https://doi.org/10.1016/j.jhydrol.2019.03.056, 2019.