Low-head dam reservoirs: sinks for N and sources of CH_4?

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Introduction

Low-head dams (< 5 m in height) comprise the majority of dams in the US. Like larger dams, low-head dams create reservoirs that decrease localized water velocity, alter biotic assemblages, and change sediment transport regimes. Few studies, however, have investigated the impacts of small dams on functional processes like nitrogen (N) and methane (CH_4) cycling. In reservoirs of larger-sized dams, research shows that reservoirs can be efficient removers of N and producers of CH_4 (Wall et al. 2005; David et al. 2006; St. Louis et al. 2000). However, will similar trends be found in low-head dam reservoirs? Based on preliminary data, we hypothesized that similar trends would be observed or that ***low-head dam reservoirs would be sinks for N and sources of CH_4***. We tested this hypothesis indirectly using a comparative study. Results therefore assess the relative sink/source strength of reservoirs as compared with reference conditions (free-flowing riverine systems).

Methods

Field and Laboratory

- 3 samples of sediment and water were randomly collected from 10 stations (Figure 1) in spring, summer, and autumn of 2007; sediment grab samples were collected with an Ekman dredge, water grab samples with a van Dorn water sampler.
- Potential nitrification (NIT; Hart et al. 1994), denitrification (DEA; acetylene inhibition), and methane oxidation (PMO; Bodelier et al. 2000) assays were completed with substrate additions; CH_4 porewater concentrations were determined using methods of Roy and Knowles (1994).
- Slurry aliquots from NIT assays and water grab samples were filtered and acidified; filtrates were analyzed for NO_3/NH_4 on a Lachat QuikChem 8500; N_2O and CH_4 gas samples from DEA and PMO assays were analyzed on a Shimadzu GC 14A equipped with ECD and FID detectors.

Statistical

- Block design two-factor ANOVAs (treatment: reservoir vs riverine; season) were completed on natural log transformed DEA and CH_4 porewater values and arcsine transformed NIT, PMO, and water column NH_4 values; $\alpha = 0.10$.

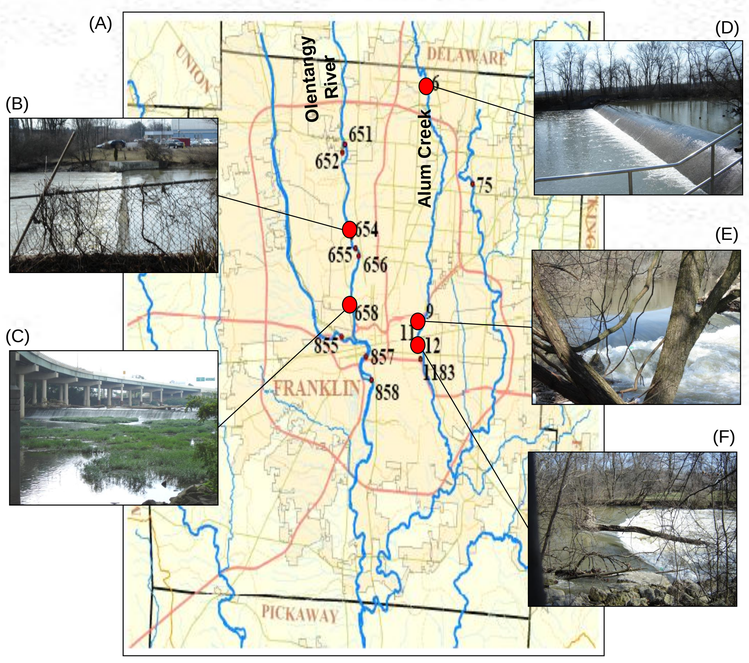

Figure 1. *Five coupled reservoir-riverine sites (i.e., 10 stations) were selected in the Columbus, Franklin County, OH. (A) inventory map of all dams in Franklin County; research sites are indicated with larger red circles. (B) dam 654: Clinton-Como Park. (C) dam 658: 5th Ave. (D) dam 6: Cherrington Park. (E) dam 9: Nelson Park. (F) dam 12: Wolfe Park.*

Results

Table 1. *Treatment effects (reservoir vs riverine) on sediment and water column N and CH_4 parameters. Mean value of parameters ± 1 standard deviation. Significant differences are bolded. DEA: denitrification (µgN gDM^{-1} h^{-1}); NIT: nitrification (µgN gDM^{-1} h^{-1}); PMO: methane oxidation (µgCH_4 gDM^{-1} h^{-1}). (1) units in µgCH_4 L^{-1} water or sediment; (2) units in µgN L^{-1} water; (3) analyses performed on spring and summer data; (4) analyses performed on summer and autumn data.*

	SEDIMENT				WATER COLUMN		
	DEA	*NIT*	*PMO*	*CH_4 porewater(1,4)*	*NO3(2,3)*	*NH_4(2,3)*	*CH_4(1,4)*
reservoir	1.238 0.896	0.136 0.056	1.276 0.592	2283 1270	1.345 0.719	0.010 0.104	151.08 11.99
riverine	0.438 0.504	0.233 0.268	0.936 0.382	984 383	1.521 0.696	0.183 0.310	147.75 11.68
P-value	**0.044**	0.421	**0.075**	**0.005**	0.423	0.931	0.403

Table 2. *Seasonal effects within sediments and water. Mean values ± 1 standard deviation. Significant differences are bolded. DEA: denitrification (µgN $gDM^{-1}h^{-1}$); NIT: nitrification (µgN $gDM^{-1}h^{-1}$); PMO: methane oxidation (µgCH4 $gDM^{-1}h^{-1}$). (1) units in µgCH_4 L^{-1} water or sediment; (2) units in µgN L^{-1} water; * data not available.*

	SEDIMENT				WATER COLUMN		
	DEA	*NIT*	*PMO*	*CH_4 porewater(1)*	*NO3(2)*	*NH_4(2)*	*CH_4(1)*
spring	0.327 0.267	0.168 0.056	0.992 0.367	*	1.668 0.822	0.264 0.307	*
summer	1.005 0.995	0.198 0.261	1.113 0.360	1548 1144	1.245 .540	.043 0.032	142.34 10.42
autumn	1.181 0.814	*	1.215 0.759	1719 1171	*	*	156.49 8.17
P-value	**0.084**	0.114	0.655	0.265	0.404	**0.005**	**0.003**

Discussion

- Higher rates of DEA and porewater CH_4 in low-head dam reservoir sediments support our hypothesis; however, water column data (NO_3, NH_4, CH_4) are non-supportive.
- Higher rates of PMO in reservoir sediments may counter higher concentrations of pore-water CH_4 in reservoirs and explain similar water column CH_4 levels in the two systems.
- Although concentrations of water NO_3 tended to be lower in reservoirs, the statistical test did not support our hypothesis (reservoirs being greater sinks for N). Post hoc analysis showed the test had a low power value (0.150), indicating that there may be a significant difference in water NO_3 levels that the test is not detecting.

Conclusion

The low-head dam reservoirs in this comparative study are not significant sources of CH_4. These systems could be sinks for N as indicated by: (1) higher rates of potential denitrification and (2) a general trend of lower water concentrations of NO_3 in reservoirs. But, a low power value for the water NO_3 test did not allow us to come to a solid conclusion. Additional data is needed to further test the N portion of our hypothesis.

References

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