Scientific Research Publishing

Journal of Geoscience and Environment Protection, 2021, 9, 84-99
https://www.scirp.org/journal/gep
ISSN Online: 2327-4344
ISSN Print: 2327-4336

Carbon Burial in Young Tropical Reservoirs Is Higher at Lower Latitudes*

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How to cite this paper: Sikar, E., dos Santos, M. A., Moterani, A. C., Matvienko, I., Veras, A. C. M., Dias, J. P. P., da Silva Jr., O. M., Pavani, C., Amorim, M., Nzualo, T. D. N. M., Bentes Jr., A. M. P., & Duarte, R. (2021). Carbon Burial in Young Tropical Reservoirs Is Higher at Lower Latitudes. *Journal of Geoscience and Environment Protection, 9,* 84-99.
https://doi.org/10.4236/gep.2021.912006

Received: November 19, 2021
Accepted: December 25, 2021
Published: December 28, 2021

Abstract

Man-made environments such as tropical hydroelectric reservoirs alter the preexisting carbon (C) cycle and remove C from circulation through burial in sediments. Carbon burial (CB) was measured using the silica-tracer method during four field surveys in the less than six-year-old Belo Monte tropical reservoir. Fresh C sedimentation was also measured. Belo Monte's CB median rate 276 (n = 84; min 0; max 352,625 mg $C \cdot m^{-2} \cdot d^{-1}$) is within the range (230 to 436 mg $C \cdot m^{-2} \cdot d^{-1}$) of CB rates measured further downstream at the Xingu Ria and higher than the averaged over 50 years oceanic rate 244 mg $C \cdot m^{-2} \cdot d^{-1}$ estimated for an increasingly deoxygenated ocean. Carbon burial median rates of tropical reservoirs with similar age and trophic state correlate inversely with latitude at a rate of 17.5 mg $C \cdot m^{-2} \cdot d^{-1}$ per degree. Carbon burial efficiency of these reservoirs correlates positively with latitude at a ratio of 0.22% per degree.

Keywords

Carbon, Burial, Sediments, Hydroelectric Reservoirs

1. Introduction

Humanity has been changing Earth's landscapes and atmosphere with deforesta-

*Carbon burial rates in young tropical hydroelectric reservoirs in Brazil.
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tion, agriculture, resource extraction, overpopulation and flooding. Science and technology contribute with assessments and attempts to prevent and alleviate the state of affairs, such as Awuh (2021)'s identification of adaptation measures employed to combat urban-heat-island effects, Salameh (2021)'s investigation on how a whole groundwater stock can be exhausted by exploitation of deep groundwater resources and Liu et al. (2021)'s proposal for long-term implementation of the sustainable supply chain method to ameliorate the impacts of water diversion projects.

Landscape change comes with altered carbon (C) circulation, such as the originated by hydroelectric reservoir creation (Kopittke et al., 2021; Reynolds, 2021). In these reservoirs autochthonous organic matter is produced (Kunz et al., 2011), carbon burial (CB) can sustain methane emission (Sobek et al., 2012) and unfavorable decomposition conditions promote CB (Isidorova et al., 2019).

Sedimentation rates are controlled by precipitation, water inflow, water residence time and surrounding reservoir land use (Leite, 1998). Quantification of the sediment magnitude and its increase (Lewis et al., 2013; Miranda & Mauad, 2014; Hilgert & Fuchs, 2015) and its C concentration can and have been used to determine sedimentary C stock increase (Bernardo et al., 2017). Tropical reservoirs emit more methane (Sikar et al., 2005; Bertassoli et al., 2021) and bury 3 times more carbon (Sikar et al., 2009) compared to the pre-flooded area.

Despite the ongoing debate about incorporation, or not, of C that is buried by hydroelectric reservoirs, into greenhouse gas inventories (IPCC, 2019) there is increasing action to acknowledge (Mendonça et al., 2012) and quantify C burial rates by these reservoirs (Teodoru et al., 2012; Wang et al., 2019; Phyoe et al., 2020).

Carbon burial rates in man-made tropical reservoirs are significantly higher than those in natural waterbodies. At latitude 19°N organic carbon burial average post-1950-to-2013 rates measured in natural oligotrophic high mountain lakes El Sol (60 - 301 mg $C·m^{-2}·d^{-1}$), La Luna (99 - 263 mg $C·m^{-2}·d^{-1}$) (Alcocer et al., 2020) and average early 1980s-2005 rates measured in natural oligotrophic maar Lake Alchichica (41 - 71 mg $C·m^{-2}·d^{-1}$) (Alcocer et al., 2014) are about up to an order of magnitude smaller than those measured in constructed reservoir Vale de Bravo (eutrophic since 1993) averaged between 1992-2006 (474 - 1041 mg $C·m^{-2}·d^{-1}$) (Carnero-Bravo et al., 2015).

With increasing attention to quantification of anthropogenic C emissions, it becomes also more imperative to assess the expanding realm of man-caused C retention rates. In this respect, Hamido et al. (2016) measured significant C storage (252 - 638 mg $C·m^{-2}·d^{-1}$) in domestic turfgrass lawns in Alabama USA and Dilla et al. (2019) conclude that by increasing the density of *f. albida* trees from 5.80 to 100 ha^{-1} in a tropical parkland (8.5˚N) soil C sequestration could be estimated as 132 mg $C·m^{-2}·d^{-1}$ for 42 years.

The C sink status of the sediments in man-made reservoirs has long been foreseen by Mulholland & Elwood (1982) and references therein. Ignoring this C sequestration path in global C inventories is akin to exempting reservoirs from methane emissions.

This present work reports latitude dependences found using carbon burial rates measured in three young tropical Brazilian reservoirs of similar trophic states.

2. Study Site

Inaugurated in 2016 the Belo Monte (BM) hydroelectric reservoir is located on the eastern side of the Amazon forest in the Brazilian state of Pará. Its total area is 478 km^2 and comprises a main and a secondary reservoir. Built by flooding land along the Xingu River the main reservoir's area is 359 km^2. The secondary reservoir was created by flooding 119 km^2 of forested terrain with water diverted from the Xingu River through a constructed canal 20 km long. The dams of both reservoirs shortcut 120 km of winding river length. The achieved purpose was to flood less land while maximizing the altimetric gradient necessary to generate hydropower. Turbines are at the secondary reservoir dam which is located at 3.1˚S 51.7˚W about 200 km south from where the Xingu River flows into the Amazon River. The main reservoir's dam controls the water flow of the Xingu River's bypassed stretch. A study conducted prior to flooding classified BM's forming waters as meso-oligotrophic (Camargo & Ghilardi Jr., 2009). We measured carbon burial rates during four field surveys: from 1) 20 to 24 Aug 2019; 2) 23 to 27 Nov 2020; 3) 22 to 26 May 2021 and 4) 22 to 26 Jun 2021. Measured sites were: three on the Xingu River upstream from the main reservoir, thirteen sites on the main (also known as Xingu) reservoir and eight sites on the secondary (aka intermediary) reservoir (**Figure 1**).

3. Materials and Methods

Three definitions relevant to this work are:

1) OC sedimentation rate is the daily quantity of total (aka "fresh") OC that lands on the sediment. Some of the fresh OC will undergo decomposition and return to circulation while another portion will escape decomposition and remain permanently sedimented.

2) OC burial rate (CB) is the daily amount of OC that escaped decomposition and therefore is out of the carbon circulation process and is permanently sedimented.

3) Carbon burial efficiency (CBE) is the ratio "organic carbon burial rate/ organic carbon sedimentation rate".

Organic carbon burial rates were measured between Aug 2019 and June 2021 during four field surveys at same 24 investigated sites ($24 \times 4 = 96$ C burial rate measurements). Site depth was measured upon arrival. Field campaigns were carried out on Aug 2019 (20 - 24), Nov 2020 (23 - 27), May 2021 (22 - 26) and Jun 2021 (22 - 26).

Sediments were sampled using a stainless-steel dredge (**Figure 2**), and after drying weighed with a Gehaka AG200 analytical balance.

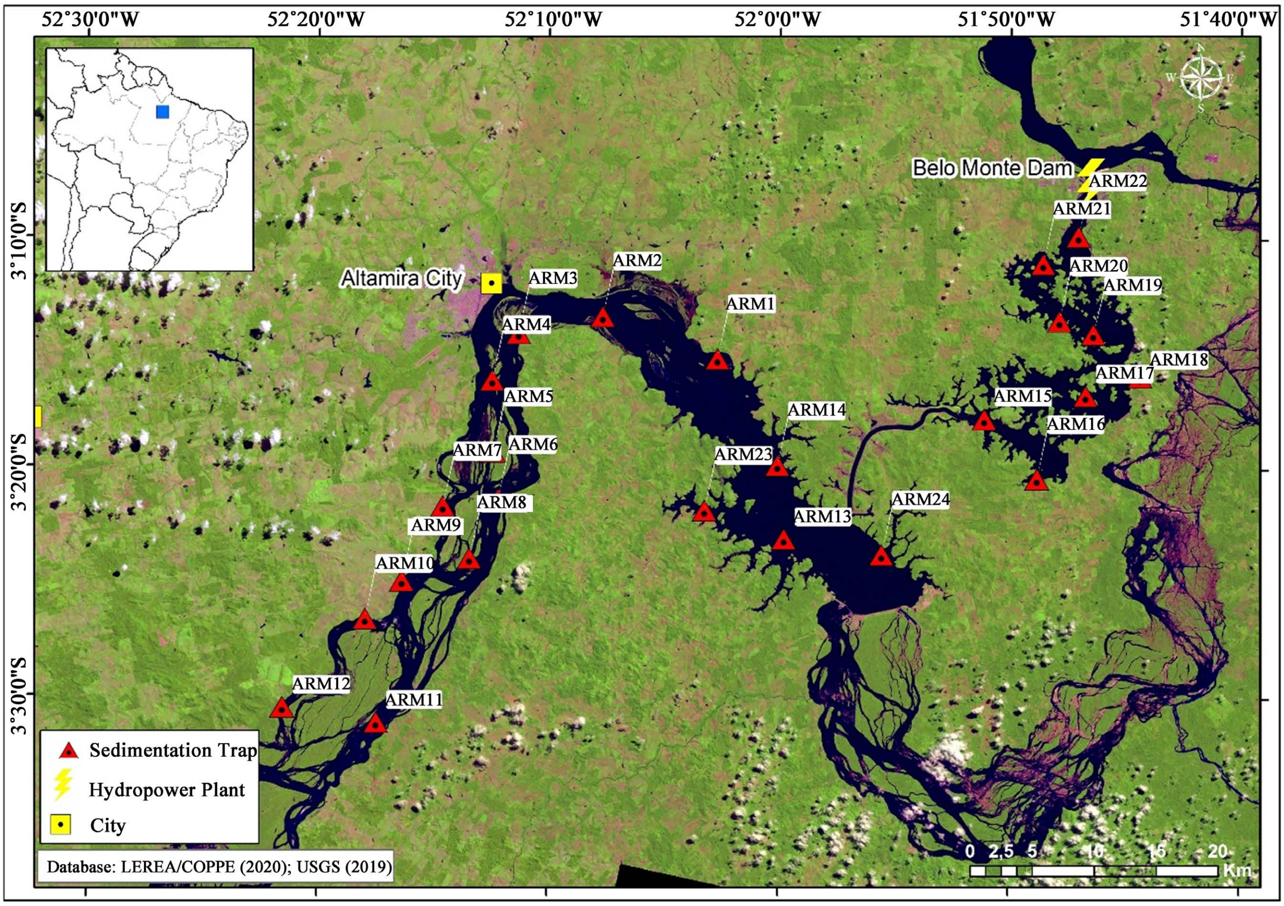

Figure 1. Location of Belo Monte Hydroelectric Reservoir and the 24 sampled sites (ARMadilha de sedimentação = sedimentation trap).

Figure 2. Ekman type dredge used for sediment sampling.

Silica was used as an OC burial tracer (Sikar et al., 2012). Concomitantly and for the sake of comparison with OC burial rates, fresh OC sedimentation rates were also measured (Sikar et al., 2012).

Sediment dredging and sediment trap deployment procedures were performed at each of the 24 sampled sites (**Figure 3**).

4. Results and Discussion

Water median depths were smaller during the second survey and higher during the third, for all three sampled environments (**Table S1**).

Within Aug 2019-Jun 2021 time span, organic carbon burial rates (**Figure 4** and **Table S2**) were smallest upstream at the Xingu River sites (median 81 mg $C \cdot m^{-2} \cdot d^{-1}$; n = 12; min = 9 mg $C \cdot m^{-2} \cdot d^{-1}$; max = 2978 mg $C \cdot m^{-2} \cdot d^{-1}$), highest at the secondary reservoir sites (767; 32; 23; 48,236) and highly variable at the main reservoir sites (201; 52; 0; 352,625). Median of BM (main and secondary environments) collective carbon burial rates was 276 (n = 84; min = 0; max = 352,625).

Possibly due to reservoir youngness, a somewhat generalized paucity of dredgable sediment and even more so of sediment with "expected" appearance (muddy, clayey, layered) was noted. We assumed that with flooding and subsequent sediment layer formation in this young aquatic low latitude environment (the occasionally dredged) vegetation residue was prone to sepultation and thus a valid sediment sample. For example, the last (BM4) survey's highest CB rate was 15,341 mg $C \cdot m^{-2} \cdot d^{-1}$ mainly due to high (50%) C concentration in what appeared to be leaf remains (second row fourth sample from left to right, **Figure 5**). Corroborating our assumption, Sobek et al. (2009) noted the higher likelihood of allochthonous

Figure 3. Dredge ready to be lowered from the boat (a) and the sediment-trap-pair deployment (b). The yield of one sediment trap quantifies silica sedimentation rate and fresh OC sedimentation rate the other.

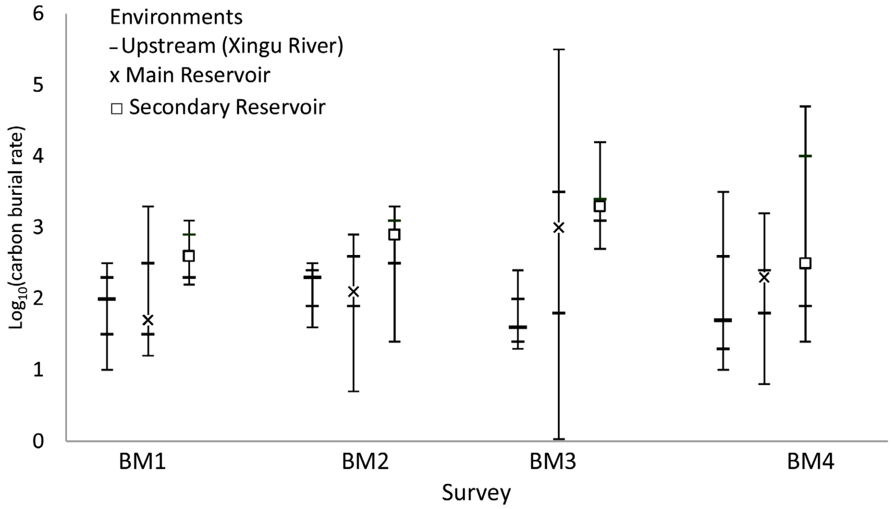

Figure 4. Logarithms of organic carbon burial rates (mg $C \cdot m^{-2} \cdot d^{-1}$) measured during four field campaigns between Aug 2019 and June 2021 at Belo Monte (main and secondary) reservoir and upstream. Highest rate was 352,625 mg $C \cdot m^{-2} \cdot d^{-1}$ measured at site ARM7 in the main reservoir during the third campaign. Log of minimum, first quartile, median, third quartile and maximum values are shown on each line plot.

Figure 5. BM4 survey sediment samples from the 24 sites.

(terrestrial particulate organic carbon) rather than autochthonous organic matter burial in sediments of inland waters and also, vegetal remains have been observed in the 111 - 88 and 48 - 11.5 cm deep sediment layers of an Amazonia floodplain lake by Moreira-Turcq et al. (2004). However, anthropogenic allochthonous carbon in more severely impacted waterbodies, such as the semi-treated sewage flowed into subtropical eutrophic Lake Donghu located in Wuhan City/China, might not be as recalcitrant as allochthonous carbon of natural origin (Yang et al., 2008).

Measured CB rates of all four surveys varied between 0 and 352,625 mg $C·m^{-2}·d^{-1}$ (**Figure 4** and **Table S1**). The lower (null) rate is due to the amount of carbon in sediment sample being below the detection limit of the analytical balance. The higher rate is because of the high (54%) C content in what appeared to be a preserved seed in the sediment sample and the high (10,918 mg $m^{-2}·d^{-1}$) sedimentation rate of silica.

BM Reservoir's CB median rate 276 mg $C·m^{-2}·d^{-1}$ is higher than those found in tropical reservoirs Serra da Mesa (14˚S; median 87 mg $C·m^{-2}·d^{-1}$; n = 14; min 19; max 516) and Manso (15˚S; 62; 9; 18; 212) measured when they were between 3.7 and 6.7 years old (Sikar et al., 2012).

This reveals a robust (R^2 = 0.99) inverse correlation ratio of 17.5 mg $C·m^{-2}·d^{-1}$ per degree South, for young tropical hydroelectric meso-oligotrophic reservoirs located between 3˚S and 15˚S in Brazil (**Figure 6**). If the burial efficiency increase rate of 0.22% yr^{-1} measured in tropical reservoirs almost two decades ago (Sikar et al., 2012) holds it can be used with the inverse correlation ratio 17.5 mg $C·m^{-2}·d^{-1}$ per degree South here obtained to predict burial rates in tropical reservoirs of similar characteristics e.g. flooded land type and trophic state. Curuá-Una is a hydroelectric oligotrophic reservoir inaugurated in 1977 (44 years old) located 266 km NW of BM and only 0.5˚ north. Assuming it buried a "corrected for latitude" 276 mg $C·m^{-2}·d^{-1}$ when it was 5 years old (as BM) an estimate

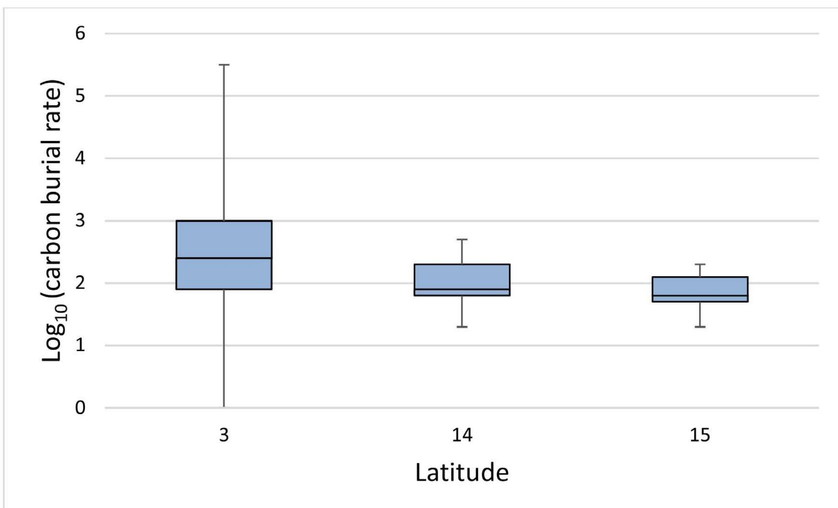

Figure 6. Logarithms of carbon burial rates (mg $C·m^{-2}·d^{-1}$) measured in three young tropical (˚S) meso-oligotrophic reservoirs in Brazil.

for this year (2021) is:

$$\left[276\text{ mg C}\cdot\text{m}^{-2}\cdot\text{d}^{-1}+\left(17.5\text{ mg C}\cdot\text{m}^{-2}\cdot\text{d}^{-1\circ}S^{-1}\times(0.5)^{\circ}S\right)\right]\times\left[1.0022^{44-5}\right] = 310\text{ mg C}\cdot\text{m}^{-2}\cdot\text{d}^{-1} \quad (1)$$

In comparison, lifetime average carbon burial rates measured in Curuá-Una 4 years ago using a linear model of sediment accumulation rate and organic carbon accumulation rate yielded a 20% smaller rate (249 mg C·m^{-2}·d^{-1} (Quadra et al., 2020) than what we estimated for this present year 2021 (Equation (1)).

The CB/latitude ratio here noted will not hold as trophic states increase. In extreme cases sediment dredging is necessary in order to restore volume capacity. This was observed in the subtropical urban stretches (23.5˚S - 23.6˚S) of Brazilian rivers Tietê and Pinheiros both located in the megacity of São Paulo and both with high emissions of methane and carbon dioxide, >5% nitrogen concentration in bubbles (Sikar et al., 2019) and high concentrations of ammonium (>15 mg N-NH_4^+ L^{-1}; (Cetesb, 2012)). Although located within the same basin these two riverine urban stretches are heavily impacted by different sources such as domestic effluents and industrial waste disposal in Tietê and insecticides in Pinheiros (Cunha et al., 2011). Extremely high burial rates of 879,153 mg C·m^{-2}·d^{-1} in Tietê and 271,437 mg C·m^{-2}·d^{-1} in Pinheiros were measured in year 2012 (unpublished results).

Arctic lakes bury average rates of 10 mg C·m^{-2}·d^{-1} (Anderson et al., 2019) and 8.4 to 37 mg C·m^{-2}·d^{-1} (Sobek et al., 2014), natural and constructed wetlands in northern regions of the northern hemisphere accumulate carbon in their sediments at rates varying between 8.2 and 6027 mg C·m^{-2}·d^{-1} (Table 2 in (Kayranli et al., 2010)) and high mountain tropical lakes bury average rates of 60 to 301 mg C·m^{-2}·d^{-1} (Alcocer et al., 2020). This roughly points to a background tendency of increasing carbon burial with decreasing latitude, in – albeit experiencing human activity intervention—primarily natural sediments.

Estimated C burial rates ranged between 408 and 995 mg C·m^{-2}·d^{-1} in the USA man-made reservoirs located between latitudes 25˚N and 50˚N and longitudes 67˚W and 125˚W (Figure 3D in (Clow et al., 2015)). There, only a tenuous (if any) latitude dependence but a much stronger longitude—carbon burial rates increasing from east to west – dependence can be noted. Ranking high in CB is Acton Lake, a hypereutrophic hard-water 2.5 km^2 lake constructed in 1957 at latitude 39˚N in southwestern Ohio USA, with 932 mg C·m^{-2}·d^{-1} (Knoll et al., 2013). This potentially shows how the CB latitude dependence can be unobservable when comparing constructed reservoirs of different trophic states and characteristics.

Carbon burial efficiency is defined and approached in more than one way. For instance, non-mineralized organic carbon burial efficiencies are better constrained through refinement of the power law that describes organic carbon oxidation by incorporating the exposure time of sediments to oxygen (Katsev & Crowe, 2015). More, due to lack of available data on organic matter settling rates, Alin & Johnson (2007) defined CBE as the fraction of primary production that is buried in the sediments of the large lacustrine waterbodies investigated in their study.

Using the CBE here defined (Materials and Methods) the upstream, a more river-like environment, had the smallest CBE median (1.3%) and the secondary reservoir had the highest (16.3%; **Table S3**). The median carbon burial efficiency of young tropical meso-oligotrophic reservoirs has a positive correlation ratio with latitude of 0.22 % per degree south. The data used for this estimate is from Manso Reservoir (15˚S; 6.3%) in Table 1 of Sikar et al. (2012) and the here reported 3.7% (**Table S3**).

The silica-tracer method was devised to obtain higher temporally resolved estimations of CB to compare with daily emissions of greenhouse gases.

In spite of this method being used to measure present day CB rates the 276 mg $C\cdot m^{-2}\cdot d^{-1}$ median here reported is also within the 230 to 436 mg $C\cdot m^{-2}\cdot d^{-1}$ range found in the Xingu Ria (Bertassoli et al., 2017) downstream from BM measured with dating methods that yield retroactive burial rates.

Interestingly and for contextualization sake, median 276 mg $C\cdot m^{-2}\cdot d^{-1}$ is 13% higher than the oceanic carbon burial 50-year-average rate upscaled for the entire oceanic area 359 × 10^6 km^2 (about 244 mg $C\cdot m^{-2}\cdot d^{-1}$) that we estimated based on the ocean's expanding zones of minimum oxygen's impact on oceanic C burial calculated by Baroni et al. (2020).

5. Conclusion

A robust (R^2 = 0.99) inverse correlation of 17.5 mg $C\cdot m^{-2}\cdot d^{-1}$ per ˚S between carbon burial rate and tropical latitude was found in young tropical man-fabricated meso-oligotrophic reservoirs situated between latitudes 3˚S and 15˚S. While carbon burial rate decreases with increasing latitudes, carbon burial efficiency (here defined as ratio total-organic-carbon-buried-in-sediment/total-organic-carbon-landed-on-sediment) increases with increasing latitude at 0.22% per ˚S.

Younger than six-year-old BM Reservoir presently buries carbon at median rate 276 (n = 84; min 0; max 352,625) mg $C\cdot m^{-2}\cdot d^{-1}$ and lands carbon on its sediment layer at median rate 5818 (81; 604; 79,932) mg $C\cdot m^{-2}\cdot d^{-1}$.

Belo Monte Reservoir's carbon burial median rate here obtained is within the lower range of buried carbon rates measured in the Xingu Ria further downstream.

For the purpose of carbon inventories if burial rates of carbon downstream of the dam have increased (or decreased) since the reservoir creation then C burial attributable to the reservoir could be higher (or lower) than the measured rate here reported.

Finally, quantifying not only the carbon sink rates but also the circulating carbon will better constrain the carbon budget of man-made environments.

Acknowledgements

This investigation of carbon fluxes in Belo Monte Hydroelectric Reservoir is funded by the R&D Project "Development of a Methodology for the Calculation of Greenhouse Gas Emissions in the Reservoir of the Belo Monte HPP, Norte Energia, ANEEL code PD-07427-0119/2019". And GEP's review comments, to which we are grateful, improved this manuscript.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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Carbon Burial in Young Tropical Reservoirs is Higher at Lower Latitudes—Supplementary Information

Table S1. Measured depths during each of the four surveys.

Location	Site	Depth (m)			
		1	2	3	4
Up stream	ARM12	5.1	3.7	10.6	8.1
	ARM11	2.0	2.2	6.5	7.1
	ARM10	5.2	5.6	10.4	7.1
Upstream median		5.1	3.7	10.4	7.1
Xingu Reservoir (Main Reservoir)	ARM9	3.5	4.5	6.9	6.8
	ARM8	4.4	1.6	3.5	4.5
	ARM7	3.0	1.0	5.8	3.8
	ARM6	3.6	1.4	6.0	4.0
	ARM5	4.4	2.0	6.6	4.0
	ARM4	6.3	2.4	7.5	7.0
	ARM3	11.2	7.7	3.7	11.7
	ARM2	9.9	8.5	8.5	10.2
	ARM1	5.7	2.0	7.1	5.8
	ARM14	9.6	5.4	10.1	9.9
	ARM23	5.6	2.0	5.7	5.2
	ARM13	18.2	13.2	15.0	17.7
	ARM24	14.0	9.4	11.7	8.7
Main R. median		5.7	2.4	6.9	6.8
Secondary Reservoir	ARM15	5.5	2.3	...[A]	6.0
	ARM16	15.3	11.9	...[A]	14.2
	ARM17	30.0	18.4	...[A]	18.7
	ARM18	17.0	41.1	46.4	49.1
	ARM19	32.1	20.6	29.7	29.7
	ARM20	17.6	26.9	13.7	12.4
	ARM21	26.9	17.9	24.1	29.5
	ARM22	43.9	40.0	41.7	29.0
S. R. median		22.3	19.5	29.7	23.9

[A]Not measured.

Table S2. Carbon and silica concentrations measured in sediment samples, carbon burial rate and carbon and silica depositional rates measured at sampled sites during each of the four field campaigns.

Location	Site	Carbon in sediment (%C)				Silica in sediment (%SiO$_2$)				Carbon burial rate (mg C·m^{-2}·d^{-1})				Carbon deposition rate (mg C·m^{-2}·d^{-1})				Silica deposition rate (mg·SiO$_2$·m^{-2}·d^{-1})			
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Up stream	ARM12	0.36	2.24	1.74	0.44	19.16	28.04	42.65	34.37	10.1	290	280	50	1210	3264	16,579	17,051	539	3635	6855	3927
	ARM11	2.28	0.27	0.19	0.1	27.79	52.39	47.41	67.33	283.3	38.7	37	9	5172	21,307	30,963	14,822	3453	7513	9123	6117
	ARM10	5.9	1.94	0.08	6.51	94.13	37.14	46.96	5.45	112.1	187	20	2978	1810	4469	24,574	5683	1789	3586	11883	2493
Xingu Reservoir (Main Reservoir)	ARM9	1.83	1.77	4.51	2.92	38.60	43.25	33.6	36.32	265.1	211	905	242	3661	22,083	24,505	7870	5591	5149	6745	3008
	ARM8	2.22	0.55	10.32	1.13	36.02	27.23	22.29	30.5	190.9	118	3329	228	2544	20,395	18,284	14,513	3097	5844	7191	6141
	ARM7	1.11	3.14	54.26	3.09	45.33	56.99	1.68	44.07	46.9	390	352,625	187	1664	15,097	14,673	13,262	1916	7071	10918	2670
	ARM6	0.39	1.62	0[H]	2.66	46.74	47.17	53.27	44.04	21.9	220	0	433	3740	25,392	35,242	29,185	2621	6416	10705	7169
	ARM5	1.30	0.54	42.98	1.24	46.67	45.40	8.12	54.6	39.3	91.8	52,942	156	4392	24,177	38,415	16,280	1411	7715	10002	6881
	ARM4	0.36[AB]	2.44	5.7	4.23	19.16[AB]	42.83	26.14	78.46	32.1	536	969	230	3230	25,623	25,559	16,067	1710	9403	4444	4262
	ARM3	0.36[AB]	0.23	0.3	0.11	19.16[AB]	54.16	63.09	42.69	47.3	24.6	11	20	3994	63,425	26,372	27,414	2515	6208	2338	7710
	ARM2	0.25	0.04	0.32	0.04	53.04	55.81	62.12	58.59	17.2	5.24	58	7	5280	16,698	79,932	17,311	3657	7315	11286	10476
	ARM1	0.68	0.37	0.65	0.52	57.82	47.76	33.85	42.22	29.5	110	175	61	2368	22,747	24,006	6699	2512	14201	9129	4985
	ARM14	9.77	0.26	1.16	8.25	7.66	51.68	56.98	18.57	1528	20.4	287	1628	2444	2286	40,262	6244	1198	4057	14099	3664
	ARM23	10.15	7.88	52.59	7.69	10.99	37.84	1.75	30.19	1784	724	97,367	424	…[G]	1947	3034	1451	1932	3475	3240	1663
	ARM13	2.6[AC]	0.69	8.05	0.71	23.5[AC]	53.28	12.29	45.78	327	80.6	3426	48	…[A]	5818	58,980	6182	2953	6224	5230	3096
	ARM24	11.00	4.31	0.06	4.71	11.78	23.96	52.05	29.67	922	500	3.54	214	1508	2717	3995	1216	987	2778	3070	1347
Secondary Reservoir	ARM15	2.91	0.31	5.51[D]	0.43	17.42	43.86	43.86[D]	34.08	172	25.0	761	23	2023	2229	2435[D]	3655	1029	3542	6055[D]	1818
	ARM16	8.60	8.29	8.91[D]	50.12	14.23	14.05	14.23[D]	3.95	518	1167	1940	15,341	2810	2070	3550[D]	2440[E]	857	1978	3099[D]	1209[E]
	ARM17	2.6[AC]	6.62	10.64[D]	7.96	23.5[AC]	14.59	23.5[D]	18.49	212	1494	2114	656	34,452	3258	18,855[D]	1882	1918	3293	4668[D]	1523
	ARM18	3.30	4.71	5.77	2.35	8.33	24.70	13.88	23.18	774	368	1408	101	8211	4465	38,563	1412	1953	1931	3387	996
	ARM19	2.6[AC]	9.81	18.27	37.63	23.5[AC]	11.50	28.29	5.57	143	2022	2227	7729	4050	1670	6430[F]	1436	1292	2370	3448[F]	1144
	ARM20	14.11	6.94	24.45	65.36	8.53	14.53	15.03	1	1179	817	2543	48,236	6781	1692	2852	604	713	1710	1563	738
	ARM21	12.38	4.06	22.67	2.48	6.97	10.32	13.98	23.25	1067	643	14,877	126	8487	2057	14,295	1479	601	1635	9174	1183
	ARM22	2.6[AC]	1.38	3.37	1.81	23.5[AC]	15.04	27.89	45.25	381	232	471	54	11624	1522	23,212	2061	3444	2534	3894	1362

Source: our own elaboration. [A]Initially assigned zero because no sediment sample was in the dredge after executing the sediment sampling procedure. While discussing zero values one of us—statistician J. P.P. Dias—made the rather disconcerting assertion that "zero values had to be measured", a condition with which we complied from there on. [B]Plugged with a low value measured upstream at site ARM12. [C]Median of 18 samples collected during this survey from 18 sites. [D]Site not measured because of boggled air logistics one day before survey commencement. Plugged with interpolated figure based on moving averages of measured sites. [E]Traps, whether tampered with or lost, were not found upon retrieval. Plugged with interpolated figure based on moving averages of measured sites. [F]Traps were not found, possibly carried away by the strong water flow. Plugged with interpolated figure based on moving averages of measured sites. [G]Trap was lost. [H]Below detection limit of the analytical balance.

Table S3. Carbon burial efficiencies (%) at measured sites during the four field surveys and medians of sampled environments.

Environment		Site	CBE1	CBE2	CBE3	CBE4
Upstream (median 1.3)		ARM12	0.83	8.88	1.69	0.29
		ARM11	5.48	0.18	0.12	0.06
		ARM10	6.19	4.18	0.08	52.4
Main Reservoir (median 1.4)	Main and Secondary Reservoirs (median 3.7)	ARM9	7.24	0.96	3.69	3.07
		ARM8	7.50	0.58	18.2	1.57
		ARM7	2.82	2.58	2403	1.41
		ARM6	0.59	0.87	0.00	1.48
		ARM5	0.89	0.38	138	0.96
		ARM4	0.99	2.09	3.79	1.43
		ARM3	1.18	...	0.04	0.07
		ARM2	0.33	0.03	0.07	0.04
		ARM1	1.25	0.48	0.73	0.91
		ARM14	62.5	0.89	0.71	26.1
		ARM23	...	37.2	3209	29.2
		ARM13	...	1.39	5.81	0.78
		ARM24	61.1	18.4	0.09	17.6
Secondary Reservoir (median 16.3)		ARM15	8.50	1.12	31.3	0.63
		ARM16	18.4	56.4	54.6	629
		ARM17	0.62	45.9	11.2	34.9
		ARM18	9.43	8.24	3.65	7.15
		ARM19	3.53	121	34.6	538
		ARM20	17.4	48.3	89.2	7986
		ARM21	12.6	31.3	104	8.52
		ARM22	3.28	15.2	2.03	2.62

...non existent data.