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Method of ^{210}Pb geochronological to estimate sedimentation rate in water reservoir in the Brazilian semiarid region

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A R T I C L E I N F O

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A B S T R A C T

Dams are important reservoirs in semiarid regions providing the needs of the population and agricultural activities in an area in which intermittent rivers predominate. These reservoirs are subject to erosion processes that can cause sedimentation and affect the quality of the water in them. The method of dating sediments using ^{210}Pb is well known and is used to establish a precise chronology of the sediments in places where abrupt changes in sedimentation conditions do not occur. The study aims to determine the sedimentation rate in five main tributary points of the dam located in the semiarid region of the state of Pernambuco, Brazil, using the geochronologic dating of the sediments by measuring ^{210}Pb activity. The method used was the Constant Rate of Supply (CRS) model. Dating coincides with the date of the conclusion of the construction of the dam. The sedimentation rate grew with the increase in depth and presented a decline in the sediments' rate and flow over time. The most recent results presented a decrease in sedimentation rates. The highest sedimentation rates were identified at points located at the entrance to the dam, which could be explained by the reduction in the average drainage velocity due to the existence of the reservoir itself.

Keywords: CRS model, agricultural activities, erosion, water resources.

Introduction

Dams are extremely important reservoirs in semiarid regions, complementing rainwater harvesting to provide for the needs of the population and agricultural activities in an area in which intermittent rivers predominate. These reservoirs are subject to the same impacts of erosion that affect rivers. The removal of the vegetation, improper management of the soil, and the accelerated urban occupation of the areas surrounding rivers and dams directly influence the hydrologic, hydraulic, and sedimentologic regimes, in addition to the quality of its surface waters (Bellinaso & Paiva, 2007).

Accelerated sedimentation rates can cause serious problems, including floods, the diminishing of favorable conditions for navigation, and a reduction in the reservoirs' lifespan, the last of which is quite severe for semiarid regions. The costs to dredge the riverbed, lake, or reservoir are high. For this reason, preventive measures, together with appropriate sedimentologic practices, are recommended (Scapin et al., 2007; Hennig & Mota, 2018).

As a preventive measure, the knowledge of sediment production in the surrounding areas of the reservoir, as well as of the rate at which these sediments reach the riverbed, is necessary. These data serve as a basis for the dimensioning and operation of hydraulic works, which interfere definitively with the costs incurred to implement and maintain such systems. The costs involved in their monitoring are also quite high, for this reason, measuring fields, especially in small river basins, is scarce (Bellinaso & Paiva, 2007).

One highly precise measure for the quantification of the sediments is the use of the ^{210}Pb decay measurement in samples collected in the field (Appleby & Oldfield, 1978; San-Miguel et al., 2004; Shuchun et al., 2009; Ahn et al., 2010). This technique is based on determining the content of ^{210}Pb within the sediments. The presence of an excess of ^{210}Pb activity ("unsupported" ^{210}Pb) at a determined depth of the sediment profile may well be the result of the accumulation of the solid material over time. The accumulation rates are calculated as of the decline in ^{210}Pb activity due to the depth at which the sediment was collected. Bearing in mind that ^{210}Pb decays with a half-life of approximately 22.3 years, the decrease in its activity according to the depth of the sediment can provide an indication of the sediment's accumulation rate in each area, as well as its relationship with exogenous factors, such as agricultural activities (Godoy et al., 1998a; Souza, 2007; Shuchun et al., 2009; Lima et al., 2014; Godoy, 2018).

The method of dating sediments using ^{210}Pb is well-known and is used to establish a precise chronology of the sediments in places where abrupt changes in sedimentation conditions do not occur (Appleby & Oldfield, 1983; Godoy et al., 1998a; Godoy et al., 1998b; Souza, 2007; Godoy, 2018). There are three models for the dating of sediments using the ^{210}Pb technique (Constant Flux, Constant Sedimentation model-CFCS, Constant Initial Concentration-CIC, and Constant Rate of Supply-CRS). The CIC and CRS models were the most suitable to estimate the sedimentation rate under the conditions of this study. The Constant Initial Concentration (CIC) model presupposes that the incorporation of unsupported ^{210}Pb into the sediments occurs at a constant flow. Also, the sedimentation rate at a given point is constantly based on CFCS, taking over a quiet environment and not mixed with constant sedimentation rate and flow of unsupported ^{210}Pb constant either during the period of the sedimentary formation (Noller, 2000; Goya, 2011). Dating by the CIC model is secure in stable environments, with an accumulation of uniform sediment rates. Under these conditions, the ^{210}Pb activity, named A, at a depth z (cm), is expressed by Equation 1.

$$A = A_0 \cdot e^{-\lambda \cdot z / w} \qquad \text{Eq. (1)}$$

where: A_0 = unsupported lead activity; λ = radioactive decay constant of ^{210}Pb; w = sedimentation rate (cm year^{-1}).

The curve to determine the sedimentation rate is obtained by means of a logarithm graph of the concentration of ^{210}Pb activity versus the depth of the sediment layer. In this graph, the slope corresponds to -λ/w.

The age of the sediment, on the other hand, can be calculated using Equation 2, which represents the law of radioactive decay.

$$A = A_0 \cdot e^{-\lambda \cdot t} \qquad \text{Eq. (2)}$$

In such a way that *t* is calculated by Equation 3.

$$t = -1/\lambda \cdot \ln(A/A_0) \qquad \text{Eq. (3)}$$

The other model used for dating sediments, in this study, was the Constant Rate of Supply (CRS). This model assumes a constant unsupported ^{210}Pb flux to the sediment but permits the sediment supply to vary (Appleby & Oldfield, 1978; Ravichandran et al., 1995; Silva et al., 2009). In this sense, the age of a given section, for a given depth (x) in relation to the surface, will be expressed by Equation 4.

$$t = 1/\lambda \cdot \ln\{A_{(\infty)} / [A_{(\infty)} - A_{(x)}]\} \qquad \text{Eq. (4)}$$

where: t= age (in years) of a given sedimentary layer; λ = decay constant of ^{210}Pb; $A_{(\infty)}$ = total integrated activity of ^{210}Pb (mBq cm^{-2}) from the profile (from the surface to the maximum depth to be dated); $A_{(x)}$ = residual integrated activity of ^{210}Pb (mBq cm^{-2}).

By contrast, according to Joshi (1991) and Honorato (2002), the integrated activity is expressed by Equation 5.

$$A(\infty) = \sum_{i=1}^{n} \rho_i x_i . c_i - (0,5.\rho_i x_i . c_i) \qquad \text{Eq. (5)}$$

where: n = number of sedimentary column sections; ρ_i = dry density of ith of the sedimentary layer (g cm^{-3}); x_i = corrected thickness of the ith sedimentary layer (cm); c_i = activity of ^{210}Pb in excess in the ith sediment layer (mBq g^{-1}).

The corrected thickness of the ith sedimentary layer (x_i) is expressed by Equation 6.

$$x_i = m_t / (\pi \cdot r^2 \cdot \rho_u) \qquad \text{Eq. (6)}$$

where: m_t = total humid mass of the sedimentary layer (g); r = radius of the sedimentary layer (cm); ρ_u = total humid density of the sediment (g cm^{-3}).

The humid density of the sediment itself can be calculated by Equation 7.

$$\rho_u = \rho_s - 1{,}422 \cdot \phi \qquad \text{Eq. (7)}$$

where: ϕ is the porosity of the sediment layer, which is expressed by Equation 8.

$$\phi = \{(m_{H_2O} / \rho_{H_2O}) / [(m_{H_2O} / \rho_{H_2O}) + (m_s / \rho_s)]\} \quad \text{Eq. (8)}$$

where: m_{H2O} = water mass present in the sediment (g), (humid sediment mass – dry sediment mass); m_s = mass of dry sediment (g); ρ_{H2O} = water density (g cm^{-3}); ρ_s = dry sediment density.

The sediment flow is expressed by Equation 9.

$$\varphi = [\lambda \cdot A_{(x)}] / c_i \quad \text{Eq. (9)}$$

Finally, the sedimentation rate is calculated by dividing the sediment flow by the dry sediment density (Sanches et al., 2000).

Therefore, the present study aims to determine the sedimentation rate of the Saco I Dam, in a semiarid region of northeast, Brazil, using the dating method of ^{210}Pb contained within the sediments.

This study can serve as a reference for other reservoirs with similar configurations, and the obtained data can serve as a basis for decision-making in public policies geared toward water use in the region.

Material and Methods

Study Area

The study was conducted in the Saco I Dam, on the hydrographic basin of the Pajeú River, located in the municipality of Serra Talhada, Pernambuco, Brazil. The total area of the tributary river basin running into the Saco I dam covers 137.07 km², which corresponds to a river basin of the fourth order, according to that determined in the morphometric characterization performed in this study. The coordinates for Saco I dam are 38˚17'9.01"W and 7˚56'42.7"S (Figure 1).

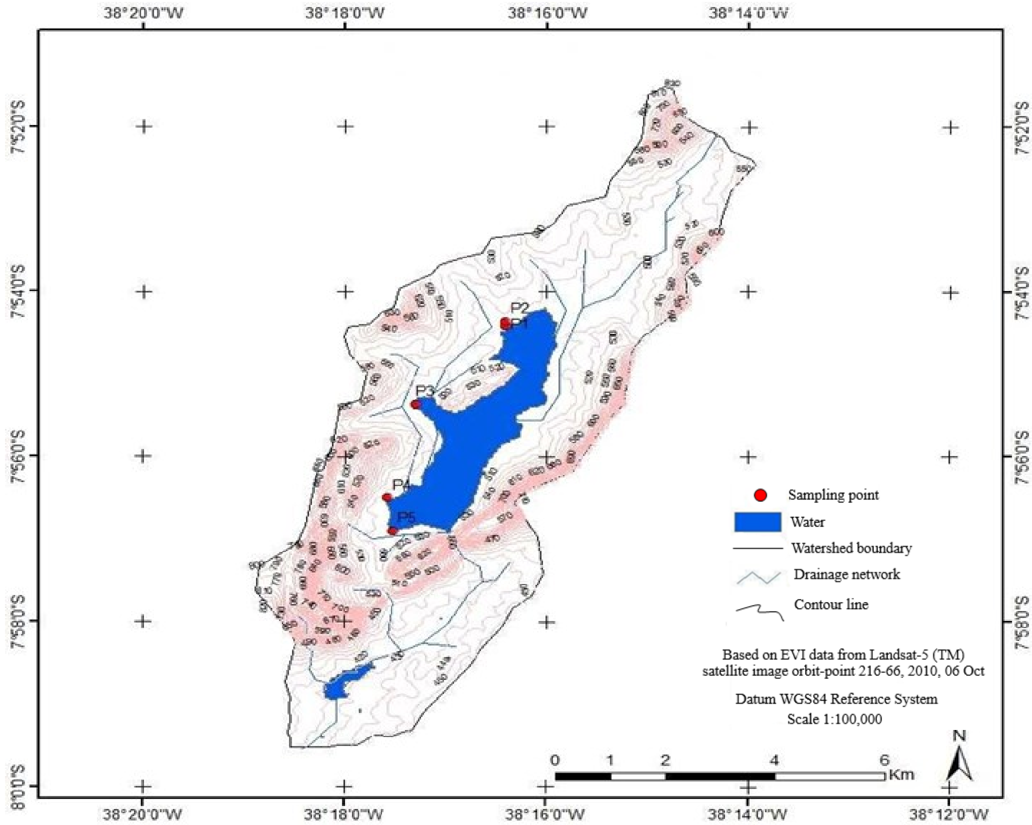

Figure 1. Scheme of soil sampling points (P1. P2, P3, P4, P5) on the edges of the Saco I dam area, Serra Talhada, Pernambuco State, Brazil. Font: Ferreira t al. (2023).

According to data from FUNDAJ (2009), the reservoir's construction was completed in 1936, for human water supply and irrigation. It covers an area of 5.65 km² and has an accumulation capacity of 36,000,000 m³. It is one of the main bodies of water accumulation in the municipality (Feitosa, 2006).

Data survey

To define the sample collection points in the dam, a study of the map of the hydrographic river basin was performed and, by visiting the region itself, it was possible to identify the five main tributary points of the dam, which fit the characteristics of the collection of sedimentary samples (Figure 1). These points were defined on only one side of the dam since the other side of the dam is limited due to a large rock structure and is not fed by any tributaries. The coordinates of the sample collection points are described in Table 1. In addition to these criteria, the Systematic Distribution Scheme of the Sample Collection Points (square grid) was done according to the Environmental Agency of the State of São Paulo (CETESB, 1999), which allows for good representativeness of the area.

Table 1. Layer depth, geographic coordinates, and landscape altitude of the sediment sampling points at the Saco I dam, Serra Talhada, Pernambuco State, Brazil. Font: Ferreira t al. (2023).

Layer depth (cm)	Coordinates	Altitude (m)
P1(0-5) P1(5-10	S 07º 54’ 25,5” W 38º16’25,1”	505
P2(0-5) P2(5-10)	S 07º 54’ 22,5” W 38º16’25,0”	503
P3(0-5) P3(5-10)	S 07º 55’ 22,9 W 38º17’18,4”	493
P4(0-5) P4(5-10)	S 07º 56’ 30,8” W 38º17’35,4”	487
P5(0-5) P5(5-10)	S 07º 56’ 54,4” W 38º17’32,5”	502

At each point, undeformed sediment samples core at depths of 0-10 cm were taken in three different sample collections. For this, the present study used a sampler made up of a combination of metal cylinders, together with a PVC tube with a diameter of 5 cm adapted to its base.

Analyses of the samples to determine ^{210}Pb

Firstly, the sediment density was determined through the known volume and the mass (different from as usual done by Equations 6, 7, and 8, which were used only to calculate the sedimentation rate at 2.5.1). The profile of the collected sediment in the PVC tube was cut at each 2 cm and transferred to a PVC recipient in a ring form, with pre-set height, diameter, and weight. After, the sample was covered with a screen, and the combination of humid soil, cylinder, and the screen was weighed and air-dried for eight days. After determining the mass and volume of the dry material, the density was calculated.

Later, the sediment samples were ground and passed through 2 mm mesh sieves, placed in a porcelain crucible (with a pre-defined weight), weighed, and calcinated at 450°C, for 72 hours. After calcination, the ashes were stored in duly identified polyethylene recipients.

The determination of ^{210}Pb activity in the sediments was performed using the ionic exchange method, as defined by Godoy et al. (1998b), whose stages are described below.

Leaching

After calcination, the ashes of sediment samples were weighted to determine their total mass. A subsample of 2g of ashes was leached with 100 ml of HBr 0.5 M, 1.0 g of hydroxylamine hydrochloride, and 1 mL of lead carrier solution (20 mg $Pb^{2+}mL^{-1}$), for 12 hours (Godoy et al., 1998a).

Percolation in ion exchange resins

The solution was set to percolate in a column containing BIO-RAD DOWEX 1-X8 50-100 ion exchange resin. During the procedure, the ^{210}Pb was kept in the resin, while the initial solution was eluted. After elution, the ^{210}Pb solution was removed from the resin using 50 mL of HNO_3 1M. The solution was heated until fully dried. Next, 50 mL of deionized water, five drops of methyl red, and ammonium acetate at 40% were added to adjust the pH level from 4.5 to 5.0. After, 2 mL of sodium chromate was added at which time the lead precipitated into lead chromate.

c) Deposit of the precipitate

After cooling the samples, the solutions were filtered (by vacuum), retaining lead chromate using quantitative filter papers. Next, the precipitate was left to be dried for 10 minutes (at 100ºC) and weighed to determine the lead’s yield recovery (100% = 31.4 mg $PbCrO_4$). Nevertheless, before performing the β count, the precipitate was covered by contact paper. After this step, 35 days were needed for the ^{210}Pb to enter radioactive equilibrium with ^{210}Bi. The β counts of the precipitate were performed in a Canberra proportional Tennelec S5E detector, with a low background. Each image was analyzed in triplicate for three hours.

Statistically, each sample was analyzed in triplicate, using three subsamples for each sample, a total of nine measurements. The results represented the arithmetic average of the concentration of calculated activities and their respective standard deviations. The accumulated deviation was calculated as a result of the sum of the standard deviations.

Calculation of the activity of ^{210}Pb

The concentration of the ^{210}Pb activity in Bq L^{-1} was determined using the following Equation 10 (Jia and Torri, 2007):

$$A_{Pb-210} = \frac{C_A - C_B}{R_Q.Q.\varepsilon_\beta.(1-e^{-\lambda Bi.t})} \quad \text{Eq. (10)}$$

where: C_A is the sample count rate, count per minute (cpm); C_B is the background count rate (cpm); R_Q is the yield (%); Q is the quantity of the sample used in the analysis [mass (kg) or volume (L)]; ε_β is the efficiency of the β count of bismuth; λ_{Bi} is the constant of ^{210}Bi decay = 0.1383 d^{-1}; t is the time spent between the precipitation of the lead chromate and the number of days.

Data modeling

To determine the age of the sediment column and the sedimentation rate the CIC and CRS models were applied. There is no standard for the optimum thickness for core sectioning, and the literature shows that thicknesses of 2 cm and 7 cm have been used. However, a thickness of 1 cm does not show fully accurate results. The evaluation of the dating and the sedimentation rate of the sediment profile was performed for the concentration of ^{210}Pb activity at each 2 cm according to Godoy et al. (1998a), using the CRS model, as it was deemed the most appropriate model considering that the dam is fed by tributaries from several bodies of water.

Results and Discussion

The excessive ^{210}Pb activity in the sediments, in general, increased with the depth at all sample collection points (Table 2). The determination of ^{210}Pb concentrations in the sediments was performed using the ionic exchange method as suggested by Godoy et al. (1998a).

Table 2. The ^{210}Pb activity determined in the sediment samples at the tributary points of the Saco I dam, located in the town of Serra Talhada, Pernambuco State, Brazil. Font: Ferreira et al. (2023).

Points/Depth (cm)	^{210}Pb excess activity (Bq kg^{-1})	Cumulative deviation
P1 (0-2)	30.93	0.73
P1 (2-4)	21.33	1.73
P1 (4-6)	36.21	2.37
P1 (6-8)	22.29	2.37
P1(8-10)	16.88	0.91
P2 (0-2)	22.42	0.00
P2 (2-4)	20.88	1.46
P2 (4-6)	15.34	0.18
P2 (6-8)	19.20	0.55
P2(8-10)	6.83	0.18
P3 (0-2)	20.81	6.83
P3 (2-4)	24.74	1.82
P3 (4-6)	24.81	6.26
P3 (6-8)	19.39	1.18
P3(8-10)	15.72	1.46
P4 (0-2)	16.24	0.36
P4 (2-4)	14.95	0.36
P4 (4-6)	11.21	1.09
P4 (6-8)	11.98	0.00
P4(8-10)	5.93	3.01
P5 (0-2)	15.46	0.36
P5 (2-4)	16.11	0.18
P5 (4-6)	8.33	4.57
P5 (6-8)	11.21	0.55
P5(8-10)	9.41	1.28

The CRS model was deemed the most appropriate to determine sediment flux and sedimentation rate (Table 3) considering that the dam is fed by tributaries from several bodies of water. The region presents a low annual rainfall, but this did not appear to be related to the increase or reduction in the sedimentation rates within the dam (Table 3).

Table 3. Dating year with ^{210}Pb, sediment flow, and sedimentation rate determined by the CRS model within the Saco I dam, Serra Talhada, Pernambuco State, Brazil. Font: Ferreira t al. (2023).

Points/Depth (cm)	Corresponding year (CRS Model)	Sediment flow (g cm^{-2} y^{-1})	Sedimentation rate (cm y^{-1})
P1 (0-2)	2004	0.03	0.02
P1 (2-4)	1998	0.07	0.06
P1 (4-6)	1977	0.08	0.06
P1 (6-8)	1952	0.17	0.12
P1(8-10)	-	0.28	0.18
P2 (0-2)	2000	0.03	0.02
P2 (2-4)	1988	0.05	0.04
P2 (4-6)	1974	0.10	0.07
P2 (6-8)	1932	0.10	008
P2(8-10)	-	0.32	0.23
P3 (0-2)	2000	0.02	0.02
P3 (2-4)	1987	0.04	0.03

P3 (4-6)	1981	0.05	0.05
P3 (6-8)	1954	0.08	0.07
P3(8-10)	-	0.12	0.10
P4 (0-2)	2004	0.01	0.01
P4 (2-4)	1987	0.04	0.03
P4 (4-6)	1976	0.07	0.06
P4 (6-8)	1927	0.09	0.07
P4(8-10)	-	0.21	0.18
P5 (0-2)	2001	0.02	0.02
P5 (2-4)	1989	0.04	0.04
P5 (4-6)	1972	0.12	0.10
P5 (6-8)	1955	0.10	0.10
P5(8-10)	-	0.15	0.12

By applying the data concerning ^{210}Pb activity within the CRS model the sedimentation rate increased with depth at each point. It was relatively constant between the points, mainly in the more superficial depths, varying in the greater depths. In total, the sedimentation rate varied from 0.01 cm year^{-1} to 0.23 cm year^{-1}.

In all analyzed sample collection points, growth in sedimentation rate with an increase in depth could be expected. However, when considering the sedimentation rate and the sediment flow, it could be observed a decline in these parameters over time. The occurrence of a greater sedimentation rate identified at points P1, P2, and P4 on the 8-10 cm layer it is likely due to their positions being more susceptible to the entrance of sediments associated with the reduction in the average velocity of the final drainage caused by the presence of the reservoir itself. These three points were aligned with each other (Figure 1).

Comparing the sedimentation rate of the Saco I dam with that of other lakes using the CRS model (Finlayson & Kenyon, 2007; Shuchun et al., 2009; Bezerra & Mozeto, 2011; Damatto et al., 2011) it could be observed that the Saco I dam presented a sedimentation rate that was within the expected range for the Guchenghu Lake (China), for the flooded plateau of the Paraguay River (Black Lagoon), and for the flooded plateau of the Paraguay River (Castle Lagoon). The Nuga Nuga (Australia), Taihu (China), and Puruzinho (Western Amazon) Lakes presented higher sedimentation rates than those found in the Saco I dam.

As regards the sediment flow (Table 3), the value for point P1 varied from 0.03 g cm^{-2} year^{-1} to 0.28 g cm^{-2} year^{-1}; point P2 varied from 0.03 g cm^{-2} year^{-1} to 0.32 g cm^{-2} year^{-1}; point P3 varied from 0.02 g cm^{-2} year^{-1} to 0.12 g cm^{-2} year^{-1}; point P4 varied from 0.01 g cm^{-2} year^{-1} to 0.21 g cm^{-2} year^{-1}; point P5 varied from 0.02 g cm^{-2} year^{-1} to 0.15 g cm^{-2} year^{-1}. In total, the sediment flows varied from 0.01 g cm^{-2} year^{-1} to 0.32 g cm^{-2} year^{-1}.

Comparing the sediment flow found in the Saco I dam with that from other locations in the world (Table 4), the values identified for the Saco I dam were lower than those found for the Taihu Lake (China) (Finlayson & Kenyon, 2007; Shuchun et al., 2009; Bezerra & Mozeto, 2011; Damatto et al., 2011), demonstrating that the sediment flow of the Saco I dam is within the occurrence variance found in other lakes.

Table 4. Comparison of the sedimentation rates and sediment flow at Saco I dam, Brazil, with that of other lakes in regions of the world, using the ^{210}Pb method. Font: Ferreira t al. (2023).

Local	**Sedimentation rates (cm year^{-1})**	**Sediment Flow**
Lake Nuga Nuga, Australia (Finlayson & Kenyon, 2007)	0,3	not determined
Lake Guchenghu, China (Shuchun et al., 2009)	0,056 to 0,167	not determined
Taihu Lake, China (Shuchun et al., 2009)	0,34	0,10 to 0,56 (g cm^{-2} yea^{-1})
Lake Puruzinho, Western Amazon (Damatto et al., 2011)	0,5	not determined
Paraguay River floodplain, Lagoa Negra (Bezerra & Mozeto, 2011)	0,05 to 0,5	not determined
Paraguay River floodplain, Lagoa Castelo (Bezerra & Mozeto, 2011)	0,03 to 0,7	not determined
Saco I dam (Brazil)	0,01 to 0,23	0,01 to 0,32 (g cm^{-2} year^{-1})

At the five sediment collection points, the increase in the sedimentation rate is directly proportional to the increase in depth (Figure 3). This behavior is expected for ^{210}Pb in nature and is also reported in findings (Cazotti et al., 2002; Souza et al., 2007; Figueirêdo et al., 2011; Souza et al., 2011). Figures 2 to 7 show a reduction in both the sedimentation rate and sediment flow when these parameters are considered in relation to time.

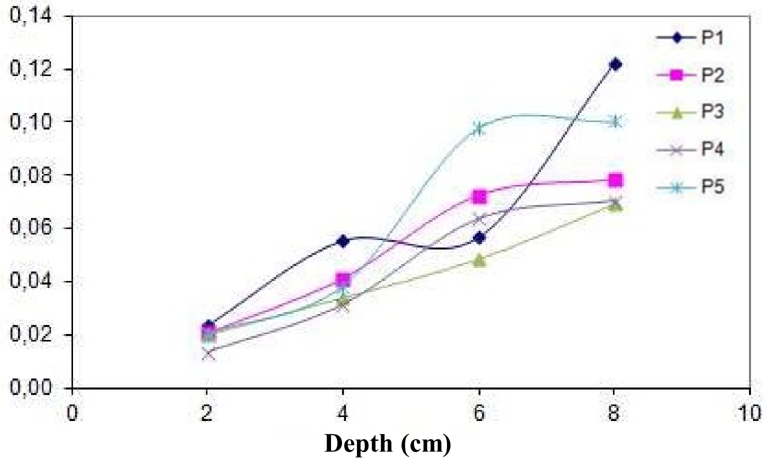

Figure 2. Sedimentation rate (cm year^{-1}) in relation to the depth at points P1, P2, P3, P4, and P5 after applying the CRS model. Font: Ferreira t al. (2023).

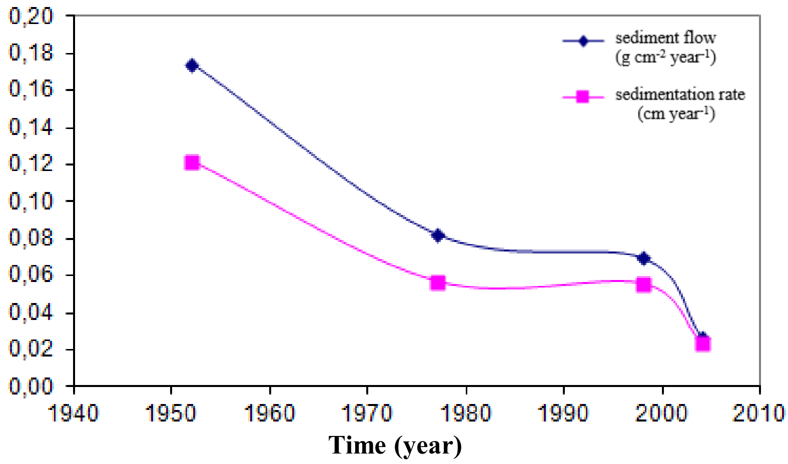

Figure 3. Sedimentation rate (cm year^{-1}) and sediment flow (g cm^{-2} year^{-1}) in relation to the time, at point P1, determined by the CRS model. Font: Ferreira t al. (2023).

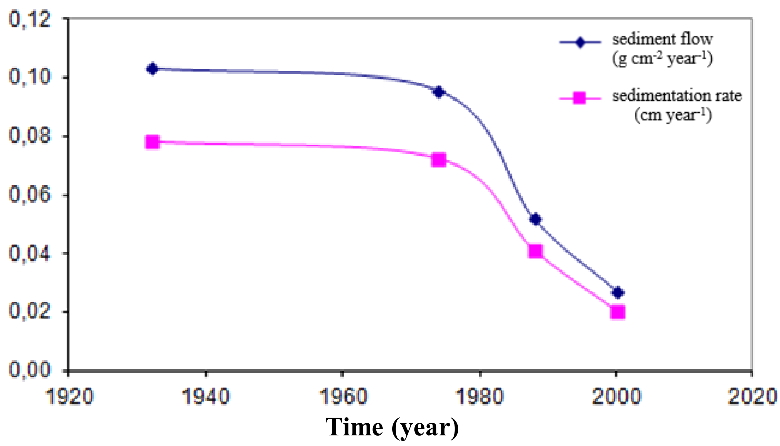

Figure 4. Sedimentation rate (cm year^{-1}) and sediment flow (g cm^{-2} year^{-1}) in relation to the time, at point P1, determined by the CRS model. Font: Ferreira t al. (2023).

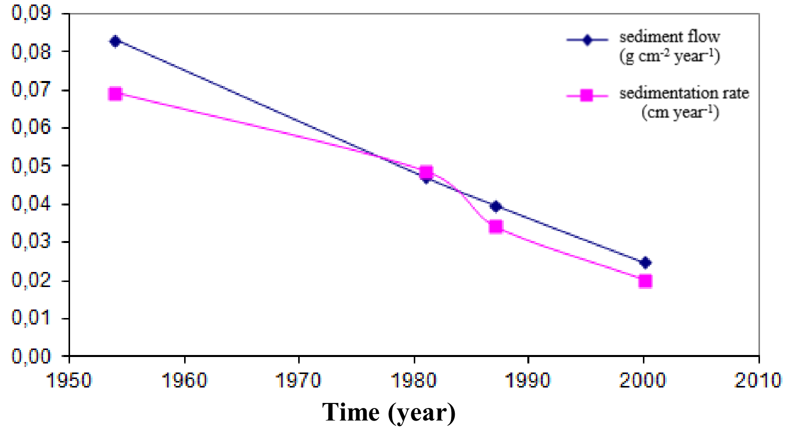

Figure 5. Sedimentation rate (cm year^{-1}) and sediment flow (g cm^{-2} year^{-1}) in relation to the time, at point P1, determined by the CRS model. Font: Ferreira t al. (2023).

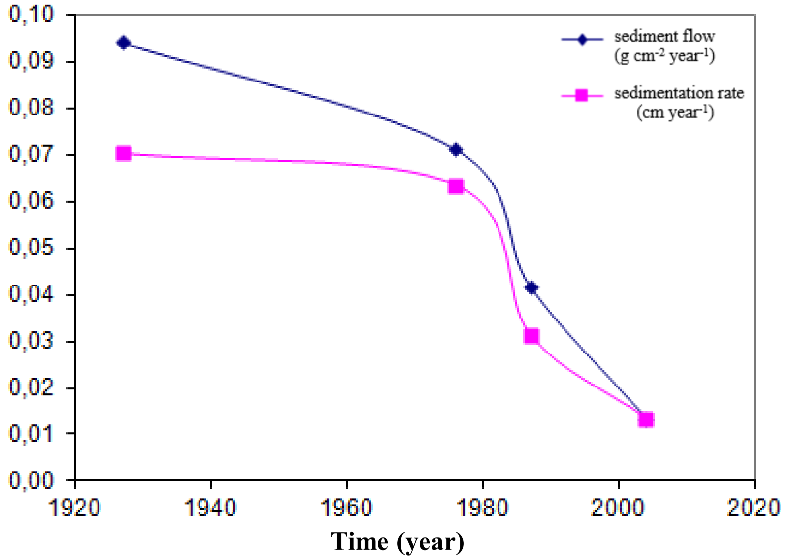

Figure 6. Sedimentation rate (cm year^{-1}) and sediment flow (g cm^{-2} year^{-1}) in relation to the time, at point P1, determined by the CRS model. Font: Ferreira t al. (2023).

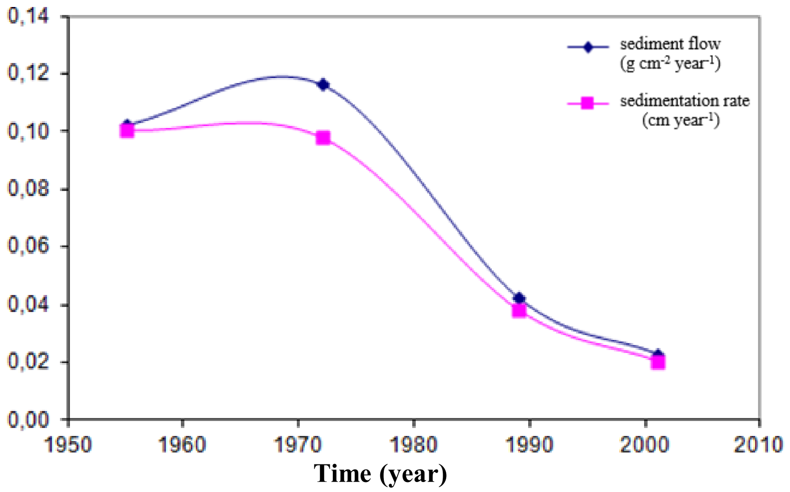

Figure 7. Sedimentation rate (cm year^{-1}) and sediment flow (g cm^{-2} year^{-1}) in relation to the time, at point P1, determined by the CRS model. Font: Ferreira t al. (2023).

An Experimental Station belonging to the Agronomy Research Institute of Pernambuco was implemented in the Saco I dam River basin, for the development of the region in the past. In 1962, tree cotton was grown on it occupying an area of 60 ha and since 1977, a governmental program was defined according to priorities for the region. Other crops also began to be cultivated as herbaceous cotton, forage sorghum, grain sorghum, cowpea, pasture, and native fruits (IPA, 2008).

The results observed show that the highest sediment rates at each collection point occurred from 1927 to 1957 (Table 3), that is the period before and during the greatest exploration and productivity of the Saco I dam basin. This occurred especially as regards agricultural uses in the 1950s and 1960s (IPA, 2008). As it had been previously mentioned, the reservoir's construction was completed in 1936, and a difference of 10 years is admissible for the dating method used in this study (Souza et al., 2012). Thereby, the estimated age of the dam is compatible with the original construction of the reservoir and its correlation with the agronomic history of the area.

According to the results obtained in the present study, a decline in the sedimentation rate could be observed, possibly because of the minimization of agricultural activities developed by the Experimental Station, which are more restricted and controlled nowadays.

It is possible to affirm that the slope of the land does not justify the higher or lower sedimentation rate determined at the points evaluated within the Saco I dam. At point P2, where, according to the identified slope, the terrain is considered flat or almost flat (0.48%), and the soils present low susceptibility to erosion, a higher sedimentation rate was found. By contrast, at point P4, where, according to the identified slope, the terrain is classified as wavy (17.6%) and the soils are moderately susceptible to erosion, the sedimentation rate tended to be lower in the more superficial layers.

At points P1, P3, and P5, almost the same dating could be found for all three points, both in the deepest layer as well as in the most superficial layer of the dam. The sediments at points P2 and P4 proved to be the oldest in the deepest layer and presented a similar dating between them. In the surface layer, the sediments presented nearly the same dating at all points.

Conclusions

At all analyzed points, a growth in the sedimentation rates could be observed with the increase in depth, which was expected. However, when the sedimentation rate and the sediment flow in relation to time were considered, there was a decline in these parameters over time. By dating, it could be verified that the highest sedimentation rates at each collection point occurred from 1927 to 1957, that is, before and during the period of greater agricultural exploration and productivity in the Saco I dam River basin, especially as regards the plantation of cotton. The ^{210}Pb dating determined at points P2 and P4 coincides with the date of completion of the construction of the dam, which confirms the appropriate choice of model for this study. The most recent results presented a decrease in sedimentation rates. The greatest occurrence of the sedimentation rate identified at points P1 and P2, located at the entrance of the dam, could be justified by the reduction in the average speed of final drainage due to the existence of the reservoir itself.

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