SOIL EROSION AND SEDIMENTATION RATES OF A SMALL EUTROPHIC LAKE IN SOUTHERN CHILE ESTIMATED BY Pb-210 ISOTOPIC ANALYSIS

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This study attempts to quantify the soil erosion and sedimentation rates (estimated through ^{210}Pb) in a disturbed small lacustrine basin in relation with its land use history. The drainage basin of the San Pedro lake (4.5 km^2) is situated in the Nahuelbuta Mountain Range in south-central Chile (36°51'S; 73°05'W). The lake has a surface of 0.87 km^2, a maximun depth of 18 m and an average depth of 10.3 m.

A 50 cm long, 7 cm diameter core sample was obtained by scuba diving from the central and deeper part of the San Pedro lake. The absence both physical and biological disturbation of sedimentary record through the core was evaluated by X-ray inspection. Subsequently, the core was extruded vertically and cut into 1 cm slices. For each subsample routine measurements of dry density (drying at 105°C) and organic carbon (loss on ignition at 550°C) were made. ^{210} Pb (22.3 yr) activity of each subsample was calculated by measuring the activity of the first daughter isotope ^{210}Po (138.4 days) using alfa spectrometry [1]. The supported ^{210}Pb was estimated from the constant values of the three deepest samples. Ages and sedimentation rates of the core were determined using the constant rate of supply (CRS) model [2, 3, 4].

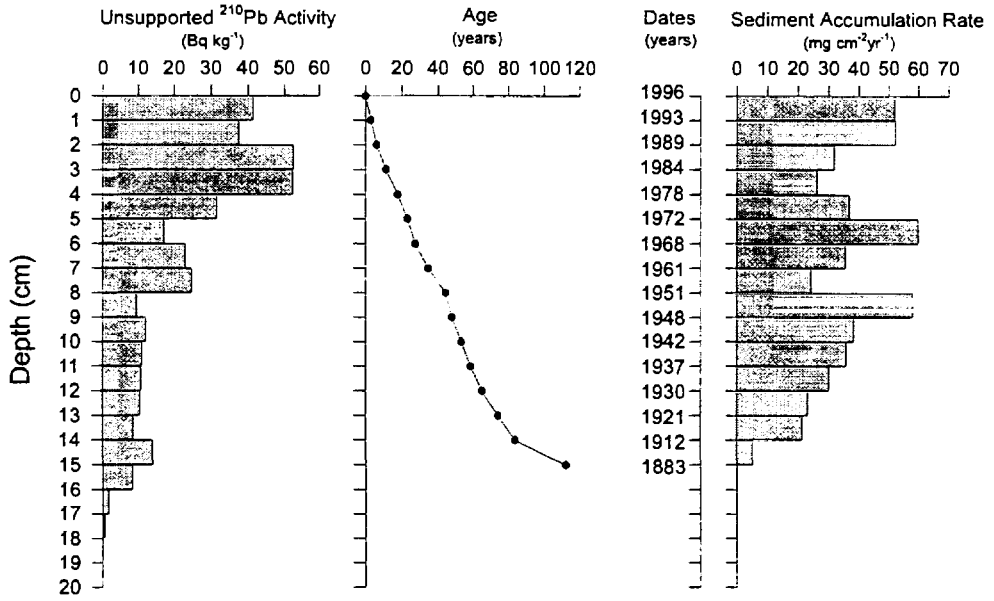

FIG. 1. Unsupported ^{210}Pb activity, chronological model and sediment accumulation rate plotted against depth in San Pedro Lake core.

Unsupported ^{210}Pb, age-depth relationship and sediment accumulation rate profiles are presented in Fig. 1. The total residual unsupported ^{210}Pb load in the core is 0.07569 Bq cm^{-2} equivalent to a ^{210}Pb flux rate of 23,57 Bq m^{-2} yr^{-1}. Unsupported ^{210}Pb activity does not decline smoothly with depth, proving changing sedimentation rates. The Unsupported ^{210} Pb profile yielded a date at 15 cm of 113 years (Fig. 1). The net sediment accumulation has varied by more than an order of magnitude, from 5,20 mg cm^{-2} yr^{-1} in 1883 to 60,00 mg cm^{-2} yr^{-1} in 1968. The temporal variation of sedimentation rates shows three clearly different sedimentary events. The first one began ca. 1883 (5,20 mg cm^{-2} yr^{-1}) having its maximum intensity in the late 1940s (58,10 mg cm^{-2} yr^{-1}). Subsequently, early in the 1950s (24,30 mg cm^{-2} yr^{-1}) another episode began, reaching its highest rates in the late 1960s (60,00 mg cm^{-2} yr^{-1}). Finally, the last event started around 1978 (26,10 mg cm^{-2} yr^{-1}), continuing until the present decade during which an extreme value of 52,00 mg cm^{-2} yr^{-1} was observed (Fig. 1). Applying linear interpolation between the oldest date, obtained with ^{210}Pb at the 15 cm depth (1883), and the top of the core, corresponding to the year 1996 when the core was taken, a mean sedimentation rate of 1.33 mm yr^{-1} was estimated. Based on mass accumulation analysis considering the last 113 years (3,35 mg cm^{-2}), a mean sediment accumulation rate of 29.66 mg cm^{-2} yr^{-1} was derived.

It is possible to obtain a first approximation of erosional tendencies in a lake using the lake bed and catchment areas together with sedimentation rates [5, 6]. The estimated erosion rates fluctuated between 0.10 t ha^{-1} yr^{-1} during relatively pristine environmental conditions and 1.16 t ha^{-1} yr^{-1} at the beginning of urban development in the catchment. Relating the erosional record to the land use history suggests that the sediment yield from the San Pedro Lake catchment has been strongly influenced by human activity. The most dramatic historical land uses changes (deforestation of native forest, intensive agriculture and urban development) appear clearly registered in the sediment column.

REFERENCES

[1] HASANEN, E., 1977. Dating of sediments, based on Pb210 measurements. Radiochemical and Radioanalytical Letters, 31:207-214.

[2] GOLDBERG E.D., 1963. Geochronology with lead-210. In: Radioactive Dating. International Atomic Energy Agency. Vienna: 121-131.

[3] APPLEBY, P.G. & OLDFIELD, F., 1978. The calculation of lead-210 dates assuming a constant rate of supply of unsupported 210Pb to the sediment. Catena, 5:1-8.

[4] APPLEBY, P.G. & OLDFIELD, F., 1992. Application of Lead-210 to sedimentation studies. In: Uranium-series disequilibrium. Applications to earth, marine and environmental sciences 2th. Edition. (M. Ivanovich and R. Harmon Eds.) Oxford Science Publication. 910 pp.

[5] DEARING, J., HAKANSON, H., LIEDBERG-JONSSON B., PERSSON A., SKANSJO, S., WIDHOLM, D. & EL-DAOUSHY F., 1987. Lake sediments used to quantify the erosional response to land use change in southern Sweden. Oikos 50:60-78.

[6] DEARING, J., 1991. Lake sediments records of erosional processes. Hydrobiologia 214:99-106.

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