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ScienceDirect
Dendrochronologia 26 (2008) 165–171
DENDROCHRONOLOGIA
www.elsevier.de/dendro

ORIGINAL ARTICLE

Tree-ring characterization of *Araucaria columnaris* Hook and its applicability as a lead indicator in environmental monitoring

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Received 17 April 2007; accepted 8 July 2008

Abstract

Tree-rings have frequently been used for dating of trees and to determine annual growth increments and forest dynamics, but little is known in tropical conditions about their utilization for environmental monitoring. This paper presents the results of *Araucaria columnaris* tree-ring characterization by wood anatomy and X-ray densitometric analysis and the determination of Pb concentration. Core samples from twelve araucaria trees were extracted from two sites exposed to air pollution due to intense traffic of vehicles and industrial activities. The tree-rings distinctly presented radial variation in early-latewood thickness and density, and characteristics of juvenile and mature wood. Anatomical and X-ray densitometric analysis were useful to delimit the tree-ring boundaries and to date the tree-rings, as well as to prove the annual formation. The lead concentration in annual araucaria tree-rings, analyzed with graphite furnace atomic absorption spectrometry, indicated the seasonal presence of the heavy metal in the environment during the 30 years studied, although the Pb did not affect tree growth.

Keywords: Dendrochronology; Dendrochemistry; *Araucaria columnaris*; Environmental monitoring; Pb determination

Introduction

The intense use of natural resources by modern society, mainly in the last century, has resulted in significant environmental impact. One of the remarkable examples is the detection of polluted areas of low environmental quality, due to the discharge of chemicals. CETESB (2003a) defined a polluted area as being a "place or land where there is clear evidence of pollution or contamination caused by the introduction of any substances or residues that have been deposited, accumulated, stored, buried or infiltrated in a planned way, accidental or, even, natural". To determine the processes of contamination, a number of methodologies of environmental monitoring have been developed, using chemical analysis and live organisms (Hagemeyer, 2000).

Since the decade of the 60s, several researchers (Sheppard and Funk, 1975; Hagemeyer, 1993; Fukuoka and Kishi, 1995; Taniguchi et al., 1995; Watmough, 1999; Punshon, 2003) have carried out studies using analyses of heavy metal contents in annual tree-rings, due to its stability in the increment layers of several tree species.

In Brazil, since the decade of the 70s, land contamination has been recorded in areas close to industrial centers, and efforts were made to minimize the impact of

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doi:10.1016/j.dendro.2008.07.002

human activities on the environment (CETESB, 2003b). However, the tools of environmental monitoring have not included the application of tree-rings, due to the lack of research in tropical dendrochronology applied to dendrochemistry (Tomazello Fo. et al., 2001).

The objective of this work is to analyze the potential of the *Araucaria columnaris* tree-rings as indicators of environmental contamination, by the characterization of wood anatomy and determination of Pb content, establishing a chronological survey of pollution.

Materials and methods

Araucaria trees and site characterization

In the present study, *A. columnaris*-trees were selected at the "Campus Luiz de Queiroz" of ESALQ/University of Sao Paulo, which had been planted in 1970. The araucarias are elegant ornamental pine trees, with typical columnar growth pattern, tortuous stem and green branches of 2 m length, common characteristics of the species (Rodrigues, 1996).

Two study sites were selected. Site A is close to the main avenue, one of the principal accesses to the city and to highways, and is characterized by intense flow of vehicles and strong anthropogenic influence. Site B is located about 150 m away from site A, and is characterized by reduced flow of vehicles and lower anthropogenic pressure, with trees of *A. columnaris*, planted behind *Pinus* sp. and *Eucalyptus* sp. adult trees used as wind-breaks (Fig. 1).

The climate is characterized as subtropical humid, type Cwa according to Köppen, with humid summer and dry winter. The period of October–March contributes 977 mm, of the total of 1257 mm of annual mean precipitation. The mean temperature oscillates between 17 °C in the coldest month (July) and 24.5 °C in the hottest month (January). April–October present hydric stress and November–March have excess of water in the soil (Sentelhas and Pereira, 2000).

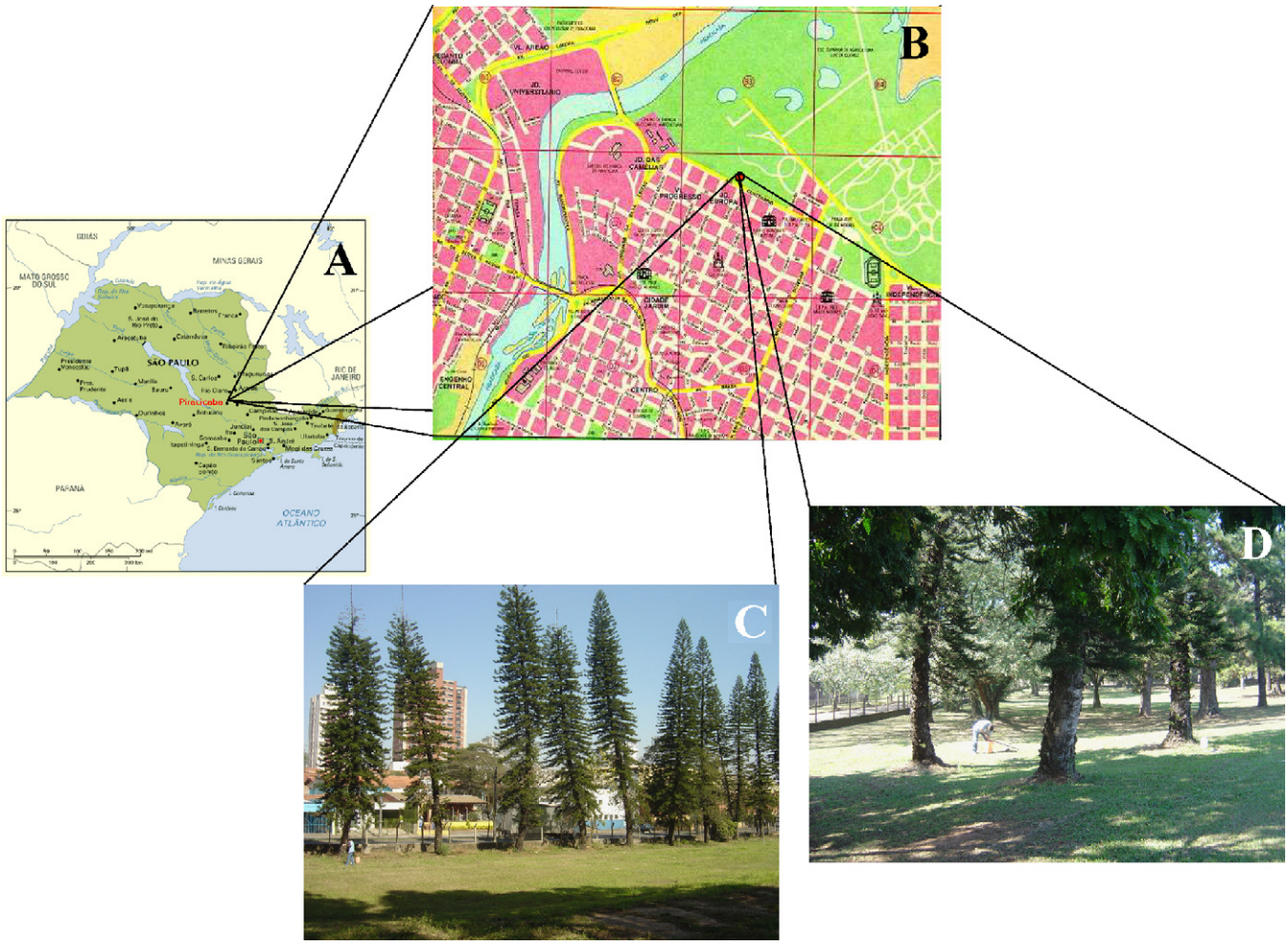

Fig. 1. Location of the State of Sao Paulo-Brazil and the studied area (A), with the indication of the University campus map (B), respective sites A (C) and B (D) presenting general aspects of the *A. columnaris* trees.