PALAEORAINFALL VARIATIONS DURING THE LATE HOLOCENE IN TROPICAL SOUTHERN INDIA: A POSSIBLE SOLAR INFLUENCE?

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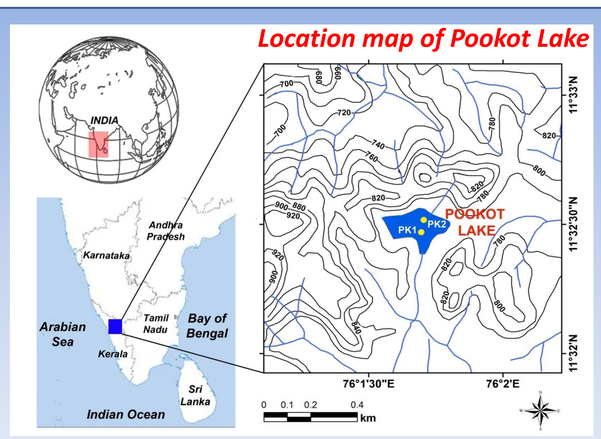
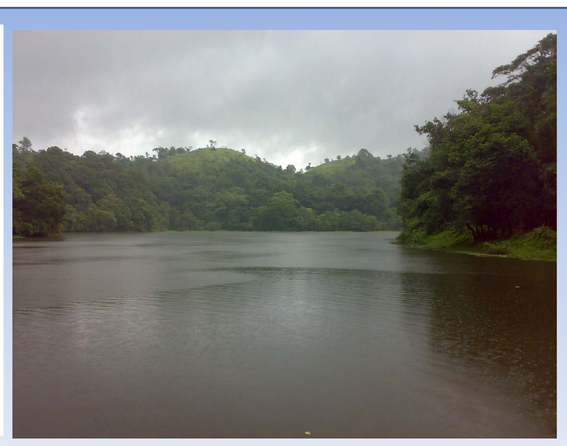
INTRODUCTION

Lake sediments are excellent archives of palaeoclimatic changes. Pookot Lake (PK) is a closed, natural lake situated at an altitude of 775 m in the *Sahyadri* (the Western Ghat), Wayanad district, Kerala, southern India. PK covers an area of 0.085 sq. km and has a maximum water depth of 6.5 m.

Pookot Lake sediments have provided a record of local environmental changes and catchment processes for the past 3100 cal. years and it is one of the few lakes in southern India that have been investigated. Based on the assumption that the rainfall is the most likely dominant driving mechanism behind the variations in the magnetic, particle size, pollen and geochemical properties of lake sediments the environmental history of the site is reconstructed.





The area surrounding the lake is covered by evergreen forest, and is in its natural setting. Its catchment is small. Therefore, the magnetic (and other) properties of PK sediments must be a reflection of natural processes only and be correlatable with the changes in the PK catchment.

METHODS

Sampling

Two undisturbed sediment cores (PK1 and PK2) from the Pookot Lake were collected in November 2007.

The lengths of the cores obtained are 2.4 and 2.2m (PK1 and PK2). The cores were sampled at intervals of 0.5 - 1 cm.

Chronology

Carbon-14 dating by accelerator mass spectrometry was carried out on the organic matter of bulk sediment samples from selected depths.

The ^{14}C ages were calibrated using the code *clam* [1] which runs on open source software 'R' and uses IntCal09.14C calibration curve [2].

Rock Magnetic Measurements

Standard techniques were used for sample preparation [3]. A range of magnetic parameters was determined on the samples: Magnetic Susceptibility (χ_{lf}), Frequency dependent susceptibility (χ_{fd}), Anhysteretic Remanent Magnetisation (χ_{ARM}), Isothermal Remanent Magnetisation (IRM), and Inter-parametric ratios.

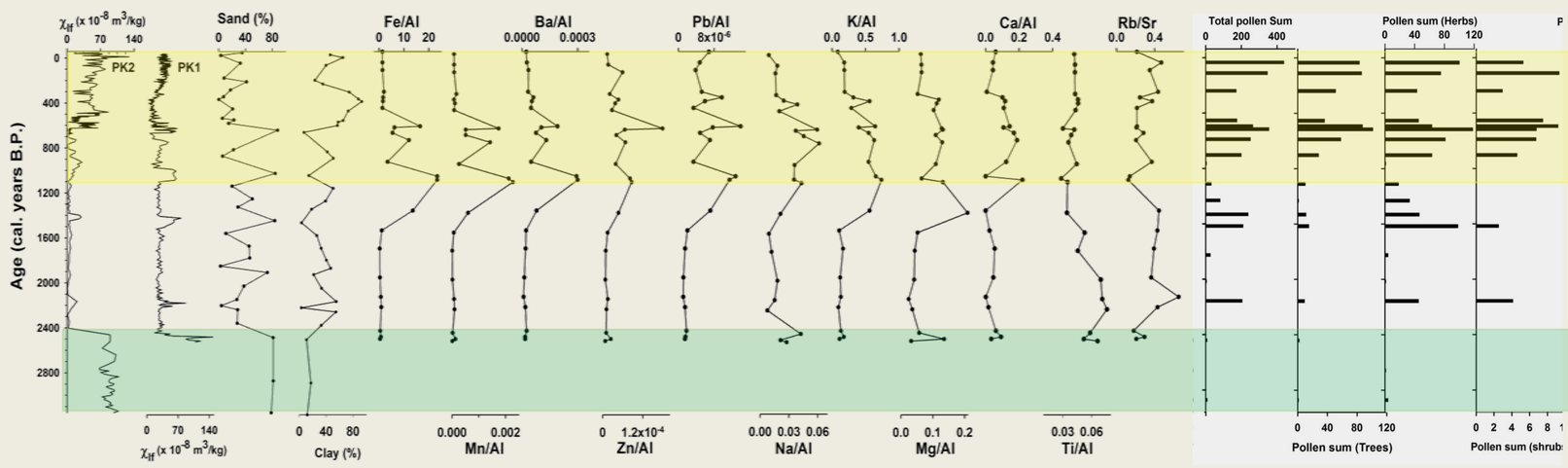
Geochemical Analysis

Samples were digested using standard methods. Major elements (Na, K, Ca, Fe, Mg, Al,Ti), minor elements (Mn, Cu, Zn, Ti, P, Rb, Sr, Ba, Pb) and rare earth elements (La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb,Lu) were analyzed using an inductively coupled plasma mass spectrometer .

Pollen Analysis

Standard procedures were followed to extract the pollen and spores from the sediment samples.

RESULTS



~ 1100 cal. years B.P. to Present: Detrital influx to the lake exhibited wide variations during this period. Overall it showed an increasing trend. The precipitation was overall high. However it was interspersed with a few 'low precipitation intervals'.

~ 2400-1100 cal. years B.P.: This period was characterised by very low detrital influx and catchment erosion as evident from low values for concentration dependent magnetic parameters, lower sand content, lower metal/Al ratios and very low pollen content. This indicates low rainfall during this period except for a few brief intervals during which rainfall was high. The lake might have dried up frequently during this period.

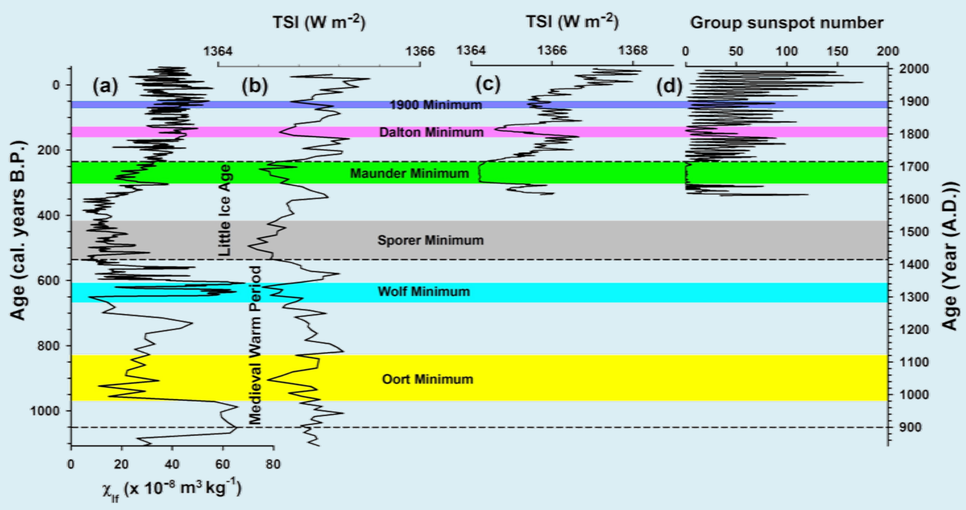
~ 3100-2400 cal. years B.P.: This period was characterised by very high detrital influx of sediments to the lake resulting from intense catchment erosion. Generally high values for magnetic parameters, metal/Al ratios and pollen content. High rainfall caused by intensified monsoon might carry more magnetic minerals to the lake.

Down-core variations of χ_{lf}, Al-normalised elemental concentrations, % sand , % clay and pollen data for Pookot Lake sediment core and their climatic interpretation.

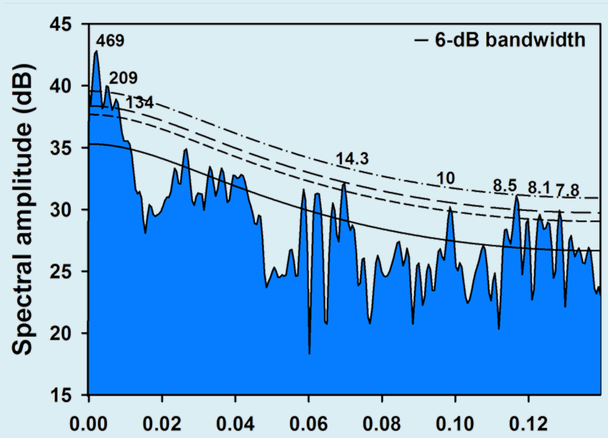
SOLAR INFLUENCE ON MONSOON

The χ_{lf} and TSI curves closely match with each other. It appears that rainfall in the region is influenced by the Sun, with periods of high sunspot activity and Total Solar Irradiance (TSI) characterized by high rainfall (= high χ_{lf}) and *vice versa.*

During the Maunder (1645-1715 AD) and Spörer (1416-1534 AD) Minima, which bracket the Little Ice Age, TSI was low. These periods were characterized by low χ_{lf} values. During the Medieval Warm Period (900-1400 AD) when TSI was high, χ_{lf} values generally exhibit an increasing trend, save for the two intervening periods of solar minima - the Wolf Minimum (1282-1342 AD) and the Oört Minimum (980-1120 AD) - for which conspicuous decreasing trends in χ_{lf} values are documented.



Comparison of the Pookot Lake sediment magnetic susceptibility (χ_{lf}) of the past 1117 years **(a)** with: Reconstructed Total Solar Irradiance (TSI) based on cosmogenic radioisotopes [4] **(b),** TSI reconstructed based on sunspot numbers [5] **(c)**, and Group sunspot numbers **(d)**. Note the similarities in the broad trends of χ_{lf} and TSI curves, with periods of high TSI being associated with high χ_{lf}.



Results of spectral analysis for Pookot Lake sediment χ_{lf} data using REDFIT 3.8 software

The prominent periodicities documented in the record are 469, 209-134, 14.3, 10, 8.5, 8.1, 7.8, 21.6, 17.1 and 11.5-11.9 years, many of which have a solar origin. Most of these periodicities are related to the Sun, and also documented in tree ring $\Delta^{14}C$ record of Damon and Peristykh (2000) [6], which are also solar modulated. Most of these periodicities are also documented in other paleoclimatc records from the region.

The Sun-Indian monsoon connection has been well documented by many other studies. If precipitation is the main controlling factor behind catchment erosion and detrital influx of sediments to the Pookot Lake, it may be argued that the influence of the Sun on monsoon is significant in this region.

CONCLUSIONS

- Pookot Lake sediments have provided a palaeoenvironmental record of the region for the past 3100 cal. years.
- The variations in the magnetic, particle size, pollen and geochemical parameters reflect changes in the local environment that is linked probably to rainfall and/or changes in the water table.
- The detrital influx to the Pookot Lake, and hence rainfall in the Pookot catchment, have varied significantly during the past 3100 years. Noteworthy are the following features:

  (a) ~ 3100 to 2400 cal. years B.P.: The detrital influx and catchment erosion was very high, indicating a strong monsoon (the highest value of χ_{lf} in this section of the cores);

  (b) 2400 to 1100 cal. years B.P.: Low and steady rainfall interspersed with brief spells of strong monsoon as detrital influx and catchment erosion was uniform and low;

  (c) ~ 1100 cal. years B.P. to Present: There was high catchment erosion indicating a shift to strong monsoonal conditions. Although the monsoon was generally strong during this period, there were short low-rainfall intervals in between.
- The precipitation in the area is influenced by the Sun; periods of high sunspot activity and total solar irradiance are characterized by high rainfall and *vice versa*. Rainfall in the region was relatively low during the Little Ice Age and high during the Medieval Warm Period.
- Rainfall in the region exhibits a number of periodicities with a prominent 10-year period, most of which are solar origin.

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