



# Palaeoenvironment shifts during last ~ 500 years and eutrophic evolution of the Wular Lake, Kashmir Valley, India

Rayees Ahmad Shah<sup>1,2</sup> · Hema Achyuthan<sup>2,3</sup> · Aasif Lone<sup>2,4</sup> · Pankaj Kumar<sup>5</sup> · Asif Ali<sup>2</sup> · Abdur Rahman<sup>1</sup>Received: 12 March 2020 / Accepted: 23 August 2020  
© The Japanese Society of Limnology 2020

## Abstract

Multi-proxy analysis of lake sediments provides high-resolution and reliable palaeoclimate records. The present study aims to investigate the palaeoenvironmental changes and eutrophic evolution of the Wular Lake, Kashmir Valley spanning the last ~ 500 years. Based on the multi-proxy analysis and supported by radiocarbon chronology, two prominent environmental phases were identified. From 74 to 45 cm, the sedimentation corresponds to the late 15th to early sixteenth century suggests the influence of cold, Little Ice Age (LIA) with nutrient-poor lacustrine environmental conditions. The following climate phase (28–9 cm) reflects the 19th and early twentieth century warmer and wetter environmental conditions. Enhanced TOC and N nutrient inputs in the lake sediments observed during the top 25 cm are likely contributed by anthropogenic sources owing to rapid and sustained anthropogenic land-use of watershed environments. This increase in the lake nutrients has been caused due to intense agriculture and horticulture practices leading to the lake eutrophication.

**Keywords** LIA (Little Ice Age) · Palaeolimnology · Eutrophication · Wular Lake · Kashmir Valley

## Introduction

The insufficiency of high-resolution proxy records in the Kashmir Himalayan region restricts the understanding of hydro-climatic variations in long-term perspective. The reduction in the precipitation caused by fluctuating seasonal

monsoon rains and westerly disturbances is the main cause of droughts and flooding in the area (Singh et al. 2016). Using tree rings, several studies (Huges and Davies 1987; Hughes 1992, 2001; Borgaonkar et al. 1994; Ram 2012; Singh et al. 2016) have been carried out from the Kashmir Valley for palaeoclimate reconstruction. These studies were mainly carried out from high-altitude regions. However, most of these studies were location and season-specific and used instrumental data recorded by the nearest meteorological station and often don't observe positive relations with all the months of the selected season. Lake archives have filled a major gap in paleoclimate reconstruction by providing records spanning from decadal to centennial resolution. The lakes in the Himalayan region observe a high rate of sediment accumulation and thus can preserve very high-resolution proxy data for palaeoclimate reconstruction. Previous studies suggest that the regions around the Wular Lake were impacted by three phases of dry climate conditions roughly corresponding to the Bond event 7, 3 and 4 (Bond et al. 1997; Shah et al. 2020a) indicating significant control of westerly disturbances over the Kashmir Valley during the Early Holocene Epoch. Further the recent studies (Babeesh et al. 2019; Lone et al. 2019) have reported paleoclimate variation and carbon sequestration in the Kashmir Himalayan lake sediments during the late

Handling Editor: Giri Kattel.

**Electronic supplementary material** The online version of this article (<https://doi.org/10.1007/s10201-020-00639-7>) contains supplementary material, which is available to authorized users.

✉ Rayees Ahmad Shah  
shahrayees04@gmail.com

<sup>1</sup> Geoscience Division, Physical Research Laboratory, Ahmedabad 380009, India

<sup>2</sup> Department of Geology, Anna University, Chennai 600025, India

<sup>3</sup> Institute for Ocean Management, Anna University, Chennai 600025, India

<sup>4</sup> Department of Earth and Environmental Sciences, Indian Institute of Science Education and Research, Bhopal 462066, India

<sup>5</sup> Inter-University Accelerator Center, New Delhi 110067, India