Stable isotopes in the source waters of the Yamuna and its tributaries: seasonal and altitudinal variations and relation to major cations

Tarun K. Dalai, S. K. Bhattacharya and S. Krishnaswami*

Abstract:

Water samples from the Yamuna and its tributaries, one of the major river systems draining the Himalaya, have been analysed for their stable oxygen and hydrogen isotopes during three seasons (summer, monsoon and post-monsoon). The data show clear seasonal and altitudinal variations; waters from higher altitudes and those collected during monsoon season are characterized by relatively depleted isotopic composition. Regression analysis of δD–δ18O data of samples collected during summer and monsoon seasons shows that the slope of the best-fit lines are nearly identical to those of precipitation at New Delhi for the same period. The similarity in their slopes suggests that the isotopic composition of precipitation contributing water to these rivers are reasonably well preserved in both monsoon and non-monsoon seasons, however, during the non-monsoon period both rainfall and river waters carry signatures of evaporation. The ‘deuterium excess’ in river waters during the three seasons though overlap with each other, the values during October are higher. This can be understood in terms of recycled moisture contributions to precipitation. The ‘altitude effect’ for δ18O in these waters is determined to be 0–11‰ per 100 m, a factor of about two less than that reported for the Ganga source waters from similar altitudinal range. The variability in altitude effects in rivers draining the Himalaya seems to be controlled by the ‘amount effect’ associated with the monsoon. The significant spatial variability in altitude effect in these river basins, which are a few hundred kilometers apart, suggests that reconstruction of palaeoelevation in the Himalaya, based on δ18O-altitude gradients, would depend critically on its proper assessment in the region. This study has established a relationship between total cation abundance and δ18O in waters of the Yamuna mainstream; total cations (corrected for cyclic components) double for a 1–4 km decrease in altitude as the Yamuna flows downstream. Copyright © 2002 John Wiley & Sons, Ltd.

KEY WORDS stable isotopes; Yamuna River; deuterium excess; altitude effect; weathering; Himalaya

INTRODUCTION

Studies of oxygen and hydrogen isotopes in rivers and their tributaries have many applications such as identification of source(s) of water, assessment of mixing proportions among them and estimation of evaporation loss during their transit (Ingraham, 1998). In addition, comparison of stable isotope data of river waters with those of precipitation and groundwaters from the same region has been used to evaluate infiltration of river water to subsurface aquifers and delineate the role of evapotranspiration in the regional precipitation budget (Payne, 1983; Gat and Matsui, 1991; Krishnamurthy and Bhattacharya, 1991; Ingraham, 1998). In this context, the streams and rivers draining the Himalaya have not received due attention despite their importance in regional and global water budgets and in their role in geochemical cycles of elements. These streams and rivers, for example, are the source waters for a number of major global river systems, such as the Ganga, the Brahmaputra and the Indus. In a reconnaissance study of stable isotopes in the Ganga headwaters, Ramesh and Sarin (1992) observed that their δ18O–δD relationship is quite similar to the Global Meteoric Water Line (GMWL) and demonstrated an ‘altitude effect’ resulting from decrease of δ values with...