Intra-annual thermal patterns in the main rivers of the Sabie Catchment, Mpumalanga, South Africa

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Abstract

Water temperatures serve as indices of catchment condition, being a function of a multitude of variables acting as both drivers and buffers, at different temporal and spatial scales. Data loggers were used to record time series of hourly water temperatures within the Sabie, Sand and Marite Rivers of the Sabie catchment, Mpumalanga, South Africa. Two years of hourly water temperatures were scaled up to provide daily statistics of water temperatures, which provided information on intra-annual thermal variability as well as how this changed along the longitudinal axis of the Sabie River. In general, mean and maximum water temperatures, and thermal variability, increased with downstream distance in the Sabie River. Water temperatures in the two main tributaries of the Sabie River, viz. the Marite and Sand Rivers, displayed higher maxima and lower minima than corresponding sites in the Sabie River. Further research on the role of hyporheic water and the contribution of tributaries is proposed, together with additional long-term collection of water temperature time series.

Keywords: water temperatures; Sabie River; intra-annual variability

Introduction

A river's annual thermal regime is one of its most important water quality parameters, being a key component in determining the distribution of aquatic communities (Nikolsky, 1963; Smith 1979; 1981; Ward 1985; Weeks et al., 1996; Sullivan et al., 2000; Caissie et al., 2001; Dunham et al., 2003). Furthermore, most of the chemical, physical and biological properties of water are temperature-dependent (Smith, 1981). The link between abiotic process and biotic pattern is an important river management consideration, if biodiversity is to be maintained within river systems. A fundamental step in this process is characterising and understanding water temperature patterns, particularly as an environmental gradient from the headwaters downstream.

Water temperatures are a function of many variables operating at different spatial and temporal scales, and may serve as an index of catchment condition (Poole and Berman, 2001; Johnson, 2003). Drivers of a river's thermal regime (for example, solar radiation, surface friction and tributary flows) are in dynamic equilibrium with thermal losses through heat transfer processes, such as evaporation (Bartholow, 1989). Thermal gains or losses to a river are in turn "buffered" by factors such as the degree of riparian shading (Gray and Edington, 1969), flow volumes, channel form and the contribution of the hyporheic zone (i.e. the stream or rivers alluvium and associated groundwater from the alluvial aquifer) (Poole and Berman, 2001). Differences in flow volume between headwaters and lower reaches result in the thermal lag (i.e. the time difference between water temperature response to air temperatures) becoming more pronounced with downstream distance (Smith, 1972), since water temperatures are inversely related to flow volumes and the buffering effects of flow volumes on water temperatures become more pronounced with downstream distance. A consequence of this dynamism is that water temperature varies along the longitudinal axis of a river, on a seasonal and daily basis (Webb and Walling, 1985; Allan, 1995), with diurnal fluctuations superimposed on seasonal and annual cycles (Webb and Walling, 1985).

In spite of many thermal characteristics of rivers being regarded as universal, South Africa's rivers have their own distinct characteristics. Ward (1985), in comparing the thermal characteristics of Northern Hemisphere vs. Southern Hemisphere rivers, concluded that what makes Southern Hemisphere rivers distinct from Northern Hemisphere rivers is "a matter of degree rather than of kind", i.e. South African rivers may have parallels in the Northern Hemisphere, but a greater proportion of these will be more variable than in the Northern Hemisphere. Chiew et al. (1995) have demonstrated that Southern African rivers, like Australian rivers, have extreme flow regimes, displaying twice the world average of flow variability. There is currently renewed interest, particularly in the Northern Hemisphere, in understanding the thermal regime of rivers and streams, due to anticipated alterations to the natural thermal regimes of many rivers (Johnson, 2003). This may be a consequence of impoundments, changes in land use, and climate change (Mohseni et al., 1999), which lead to changes in flow regimes. Altered flow regimes typically lead to a reduction in the range of temperature variation, even though mean temperatures may remain unchanged (Gray and Edington, 1969; Smith 1972; Wootton, 1992). Changing the thermal regime of a river significantly alters a component of the environment for which river organisms are adapted (tolerances and life cycle cues) (Appleton, 1976; Ward, 1985). Water temperature variability has been positively correlated with species diversity (Vannote et al., 1980). The importance of variability in maintaining ecosystem health and integrity is now well recognized (Richter et al., 1997); when variability is lost, there may be a consequent impoverishment of biological communities (Smith, 1972).

A limited understanding exists of the temperature conditions of natural rivers (Smith 1979; Johnson, 2003), especially in the Southern Hemisphere (Ward, 1985). This is certainly true of the rivers of the Sabie catchment, to a lesser degree for the intra-annual water temperature dynamics (Jewitt et al., 1998), and to a greater degree for the inter-annual cycles. The Sabie River is of particular

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