Abstract

Stream-dwelling macroinvertebrates are used as bioindicators of water quality worldwide because they possess many traits associated with different levels of environmental stresses. These bioassessment methods that use macroinvertebrates require a good understanding of the ecology of taxa that are used as indicators in the context of the systems that they occupy. The rivers and streams of subtropical southwest Bhutan and surrounding regions represent an interesting case study for the application of bioassessment methods. Rivers and streams are subject to extremely high flow rates during the monsoon period, and the extent to which this high flow influences both the water quality, and the macroinvertebrates, needs to be assessed. Therefore this study aimed at improving the understanding of the application of the water quality index and other basic biotic metrics applied to rivers and streams in the region.

A rapid field-based bioassessment methodology was employed for macroinvertebrate sample collection at six sites of five different streams in southwest Bhutan. These streams corresponded to different levels of disturbance. Disturbances were identified as impacts of natural land erosion, agricultural practices and local settlement, relative to undisturbed streams. All streams were subjected to seasonal high stream flow as a major predictable environmental event or disturbance during monsoon. Sampling was performed on monthly basis for the period of 10 months between monsoons to account for both spatial and temporal (seasonal) variation.

Measured physicochemical parameters showed some variation among the investigated streams and this variation was mainly related to stream type, associated with predictable monsoonal disturbance and anthropogenic influences. For example, undisturbed sites showed significantly lower conductivity than all other sites as this stream is sourced from higher elevation flowing through forested areas with deeper and wider stream channels.

Investigated streams showed a diverse range of macroinvertebrates, but the community composition varied both spatially and temporally in different streams. Spatial variation was largely encountered by the particular stream type, surrounding land use patterns.
and variation observed in physicochemical parameters. For example, findings indicated that an agriculture site had the highest family richness, and an undisturbed site had the highest number of individuals, while a second undisturbed site had the highest Shannon-Weiner diversity value. Family richness and diversity remained low at the settlement site and a second agriculture site. Temporal variation was mainly influenced by time since the end of the monsoon. For example, dry season was characterized by significantly higher abundance, richness and diversity as compared to wet season. But the changes caused by the predictable environmental event (e.g. monsoon) pose no long-lasting impact on the population recolonization or recovery process.

Abundance patterns and, to some extent, size-frequency distribution data revealed that macroinvertebrate populations recover after the predictable seasonal environmental event (i.e. monsoon), largely through rapid recovery or recolonization process, adaptive life-history characteristics or evolved behavioural traits (e.g. voltinism, diapause, short life cycles and continuous reproduction). Smaller seasonal upstream tributaries that formed during monsoon and connected to main streams are also likely to play an important role for the recolonization process. In this connection, sound knowledge of the adaptive life-histories of macroinvertebrates and pathways of recolonization, may be used to predict the overall persistence and resilience of a stream community.

Site-wise water quality was assessed with reference to the Hindu-Kush Himalaya (HKH) biotic score (HKHbios). The water quality classification that were derived from all capture data, matched the pattern expected for the different streams. The two undisturbed sites showed the highest integrity of water quality as compared to other sites. The highest impairment was observed at the site influenced by settlement. Although agriculture sites and land erosion site were anticipated higher impairments of water quality, the current study showed acceptable range of water quality status within the study areas.

The month to month Average Score Per Taxon (ASPT) at any one site was variable. There was no consistent pattern of differences among the six sites and no clear seasonal pattern. Scores allocated for some highly sensitive taxa that were rarely
encountered in the samples (e.g. Neoephemeridae), contributed to the index variation thereby providing unreliable estimates of water quality.

An assessment of HKH score variability was performed relative to field sampling efforts associated with rapid bioassessment (i.e. sample size, different field sampling techniques and experience of samplers). The index was not strongly influenced by variation in sample size and field sorting techniques, and thus usable macroinvertebrate based information could be provided with minimum costs and time involvement. However, there was considerable variation among individual samplers in the index scores derived from single samples, suggesting experience of samplers is important.

Finally, the current study suggests that high stream flow events during monsoon, and its consequences on the drift of several species play a pivotal role in benthos recovery/or recolonization process in the subtropical streams of southwest Bhutan. More importantly, the biological indices of water quality assessment will depend on the abundance patterns and seasonality of macroinvertebrates. Significant influence on the trend of monthly-based HKH scores was largely attributed to some highly sensitive families. For example, the family Neoephemeridae did not necessarily indicate a distinct preference for very good water quality in this study, suggesting that high scores and weights allocated to some families in the HKH taxa list might not be always applicable to all Bhutanese streams. Another difficulty encountered during the index calculation was that some sampled families (n=9) were not assigned scores in the HKH taxa list, suggesting there is need for supplementary research to improve the predictive ability of the HKH scoring system. A separate solely Bhutan-based Biotic Score, similar to Nepalese Biotic Score (NEPBIOS), is recommended here for enhancing the bioassessment program in the country.

Therefore, the science-based information obtained from this research can serve as baseline information for future research, and such studies are also important to determine whether the bioassessment studies using the existing HKH score remain consistent and applicable to other parts of Bhutan.