Ecohydromorphology of river environments of the das Velhas River upstream of Rio das Pedras hydroelectric dam, MG, Brazil

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Abstract

This paper presents the applicability of ecohidromorphology assessment in differentiating ecophysical structure of river habitats of Rio das Velhas river basin upward of Rio de Pedras dam, Minas Gerais, Brazil. It also presents the identification of the factors that conditioning the ecophysical structure of river habitats. This review associated with biological and physico-chemical conditions of the waters aims to assess the ecological integrity of the river systems and also validate the characterization of water bodies identified on a large scale in the Rio das Velhas basin.

Keywords: ecohidromorphology, habitat quality, ecological integrity

Introduction, scope and main objectives

The destruction and degradation of river habitats are the main problems affecting the ecological integrity of lotic environments. In some situations they may obscure the effects of toxicity and water pollution (Karr et al.1986). The degradation of river habitas show that the approaches adopted in monitoring water quality, although valid and viable, are fragmented and insufficient to promote sustainable use of resources water (Miller et al. 1988, Zalewski and Robarts 2003).

A substantial change in these approaches comes from the interaction between hierarchical levels or scales and the perspective of ensuring the ecological integrity of aquatic environments. Far from an anthropocentric view of utilities usage patterns of water resources the ecological integrity considers the interaction among physicochemical and biological conditions of water and sediment and also ecohidromorphological characterization of habitat (DQA 2000; Parsons, Thoms and Norris 2001; AQEM 2002; INAG 2008; USEPA 2013). So, the ecological integrity studies aim to assess the state of conservation of the aquatic environment from the deviations between local, impacted and pristine locations (Barbour and Stribling 1990; Karr and Chu 1999). The pristine sites represent the reference condition that has as minimum criteria the presence of extensive riparian vegetation, expressive

diversity of substrates, natural and stable margins, and level of stable waters (Hughes and Larsen 1986 Reynoldson et al. 1997).

Habitat interacts the landscape and the dynamics of geomorphological and sedimentological processes and factors at different hierarchical levels of scale. These levels of scale approach ranging from large-scale, represented by the region and the drainage basins, to small scale, represented by the various ecophysical attributes that characterize habitats in river segments and sites. Habitat serves as an explanatory factor of fluvial biodiversity (Elton 1966 Southwood 1977 1988 cited Hidrew and Giller 1992), since they are closely related (Raven et al. 1998 cited Barbour et al. 1999). Thus the assessment of habitat quality is critical in assessing the ecological integrity of the aquatic ecosystem in order to establish the factors that explain the relationship between them. Understanding these relationships, far from expanding the understanding of the processes that determine changes in water quality, bases the control and management of fluvial processes and vice versa. It acts as a criterion in defining objectives focused on the management of water resources and on the evaluation of the results of management programs (Barbour and Strinbling 1990). Harper, Smith, Kempt and Crosa 1998). This approach is embodied in various evaluation programs and monitoring of water resources such as those of European Union countries, the Environmental Monitoring and Assesssment Program (EMAP) of the USEPA, the National Water-Quality Assessment Program (NAWQA) of the USGS, from environmental agencies Britain and from Australian River Assessment System (AusRivAS). In the state of Minas Gerais, Brazil, this approach is based on the rule DN COPAM / CERH-MG nº001 / 2008.

This paper aims to show the applicability of ecohidromorphological assessment in identifying the physical factors that influence the spatial differences in watershed upstream of the electricity production Rio de Pedras dam. This review integrates research on development on the ecological integrity of the basin. In association with the physical and chemical conditions of the waters and sediments and the composition and structure of aquatic communities, this research seeks to validate the typology of watercourses on a large scale (Castro et al 2014). This project aims to contribute to the improvement of methodologies that support the management of aquatic ecosystems and advances in compliance with the DN COPAM / CERH-MG nº001 / 2008.

Methodology/approach

The watershed upstream of the Rio de Pedras dam is located in the upper course of the Rio das Velhas hydrographic basin, in Sãn Francisco aquatic ecoregion (Castro et al. 2014). The sampling network encompassed 11 sites (five in the Rio das Velhas river and six in its major tributaries) representative of the different lotic types (Castro et al 2014), ecophysical conditions and of anthropogenic interference (Fig. 1). The ecohydromorphological assessment covered the river segment (about 100m long) and the river reach (about 10m long).

Fig. 1: Location map of the contribution basin Stones River Reservoir, MG Brazil, with the sampling network.
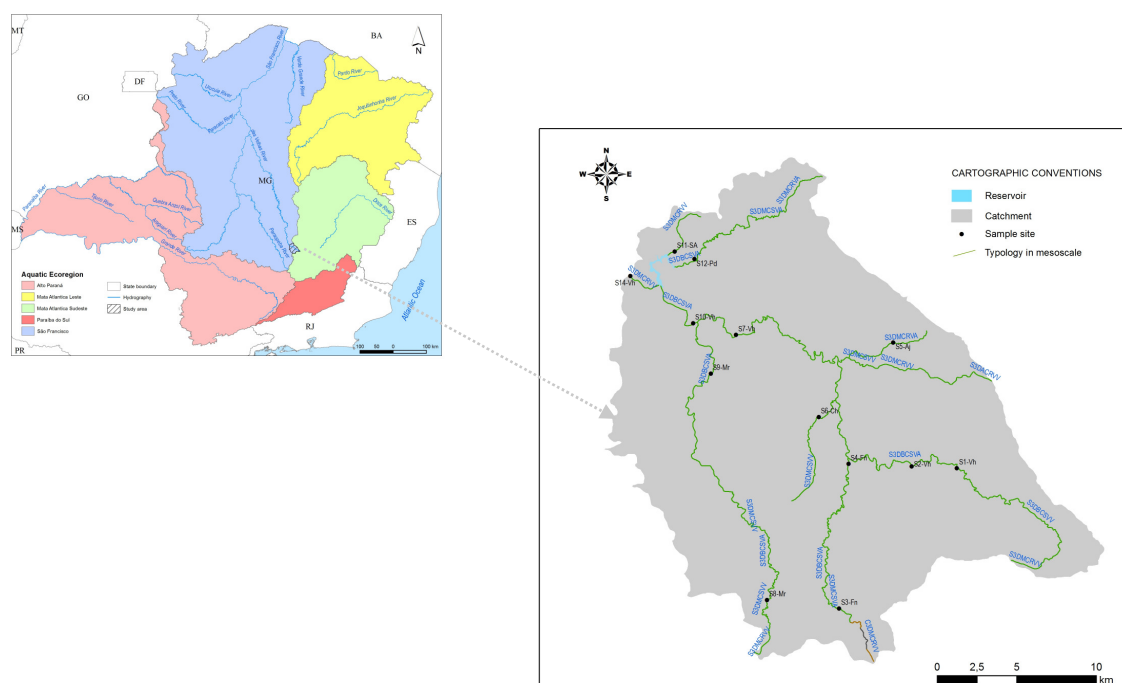
The studies were conducted in the dry season from June to August 2013 and 2014. This period offer wide availability of biotopes, due to reduced flow and lower incidence of disturbance factors (Junqueira *et al.* 1998). This favors the development of aquatic biota attached or associated with substrates in the channel bed.

In the 11 sites the ecohydromorphological assessment are supported by interpretation and in situ records of a set of descriptors and their habitat variables to distinguish the habitat attributes in the dimensions of the bed, the channel margin and in surrounding environment (Ferreira and Castro 2005a, 2005b; Castro *et al.* 2005). They are: (i) sedimentological and geomorphology attributes (e.g. morphological units that form the river environment such as channel type, the presence of inner bars, the type and morphology of the bed depending on the particle size and roughness, and the quality and distribution of rock substrates and unconsolidated sediments); (ii) characteristics associated with river waterflow (e.g. alternation between rapids and pools, channel flow condition); (iii) characteristics associated with vegetation (e.g. type and distribution of strata, natural condition taking into account the anthropogenic pressures, stability and protection of banks by vegetation); (iv) visual changes in waters and substrates; (v) characteristics of aquatic communities (biological forms of macrophytes; percentage of area covered by aquatic vegetation and the periphyton, occurrence of macroinvertebrates and fish); (vi) use of water and use and land use. Methods of measurement of the variables included discriminative measures (to define the presence of certain features or functions) and evaluative measures (semi-quantitative, to measure the magnitude of the changes in the environment).

The evaluation also included the descriptor synthesis - Global Quality of Habitat with the following geomorphologic and sedimentologic variables: available, embeddedness and pool substrates; riffle and pool variability; sediment deposition; channel flow status; channel alteration and sinuosity; frequency of rifles; bank stability, vegetative protection and riparian vegetative zone width. These variables were evaluated on a scale of 1 to 20. The overall assessment corresponded to the sum of the scores and their percentages, grouped into the following classes: good (> 80%), good (80-61%), regular (60-41%), poor (40 to 21%) and poor (≤ 20%) as Barbour *et al.* (1999) with adaptations. Data analysis also included the cluster analyses by method UPGMA and euclidean distance (Ludwig and Reynolds 1988, Valentin 2000). This analysis was used to detect the general standards of association among the sample sites, in function of the regulating factors of these associations.

Results

The analysis of ecophysical attributes of the bed, the banks and the environment in the vicinity of the collection sites expressed by variables descriptor - Global Quality of Habitat - has shown that ecohydromorfological conditions of river reaches ranged from good to bad (Fig. 2). The sites with the worst conditions are in the Funil stream (S4-Fn), Maracujá river (S8-Mr and S9Mr) and Rio das Velhas River (S10-Vh).

These conditions resulted from the low sinuosity channel and variability of rapids and pools associated with anthropogenic interference by reducing riparian vegetation. In S8-Mr sites and S9Mr the results are also due to the high-deposition of sediments coming from the headwaters of the basin. The variable supply of substrates indicated a variety of inorganic substrates that have varying particle size distribution (gravel, pebble and sand) and organic substrates (stems, leaves and roots) with the potential for colonization by aquatic biota (Figure 3). Such records, the sum of significant frequency of rapids, variety of substrates in the wells and stable banks covered by vegetation stood out on sites of watersheds and streams Ajuda, Santa Ana and Rio de Pedras.

The S1- Vh and S10- Vh sites both located on the Rio das Velhas River, near the headwaters of the basin and the nearby Rio de Pedras reservoir, respectively, were the more distanced in habitat quality terms. The first showed good quality, as opposed to second with bad quality (Fig. 2). Regarding the basins, Maracujá river distanced itself from the others (Fig.4B), reflecting changes in habitat quality, mainly due to high deposition of sediments (Fig. 3).

Fig. 2: Global Quality ecohidromorfológica habitat stretches of river basin contribution Stones River Reservoir, MG, Brazil. Dry season of 2013 and 2014
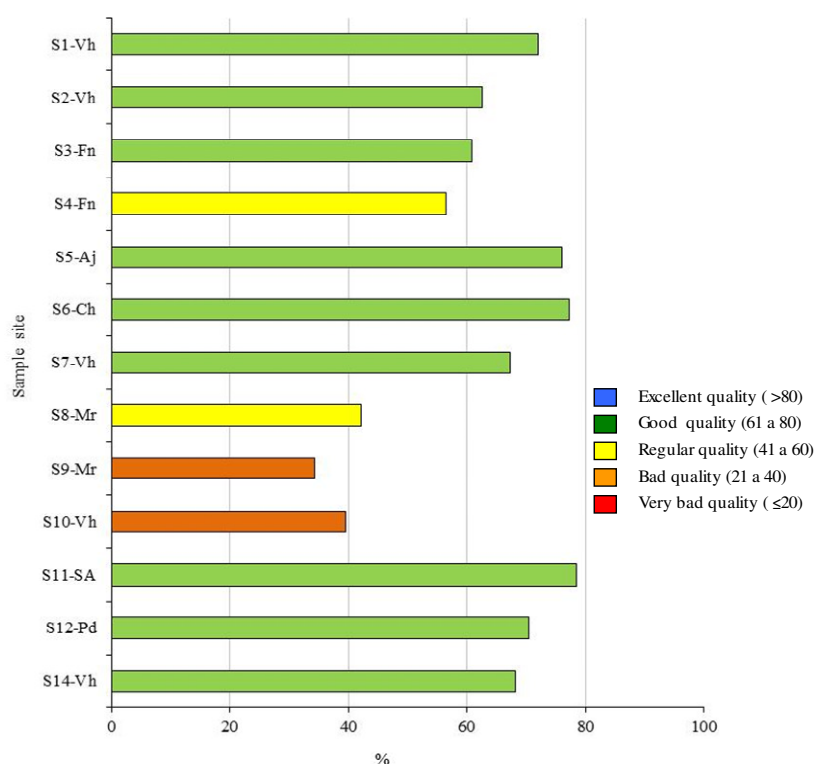

Fig. 3: Global ecohidromorfológica habitat quality in streams portions of the basin contribution Stones River Reservoir, MG, Brazil. Dry season of 2013 and 2014.
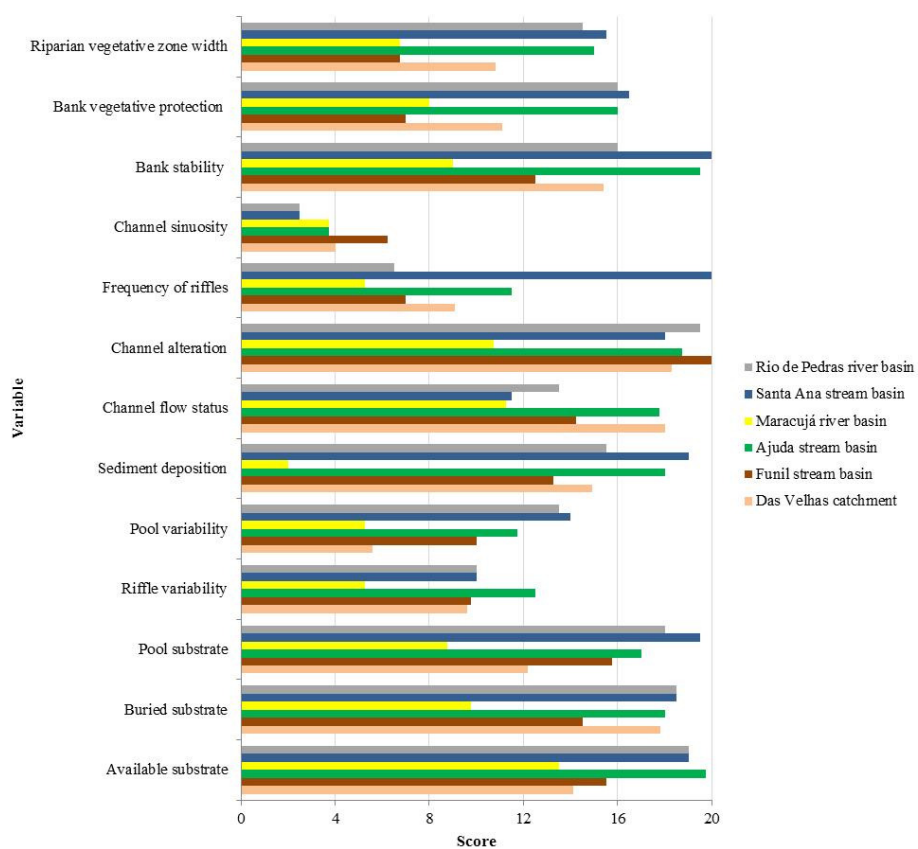
The variations in global ecohydromorfological quality reflected different groups among sites (Fig. 4a). Two groups are devident in general association patterns: one represented by the sites with better quality and the other for those with poorer quality.

Fig. 4: Grouping of collection sites (a) and their contribution basins (b) of Stones River Reservoir, MG, Brazil, based on global ecohidromorfológica quality of habitat. Dry season of 2013 and 2014.

(a)

(b)
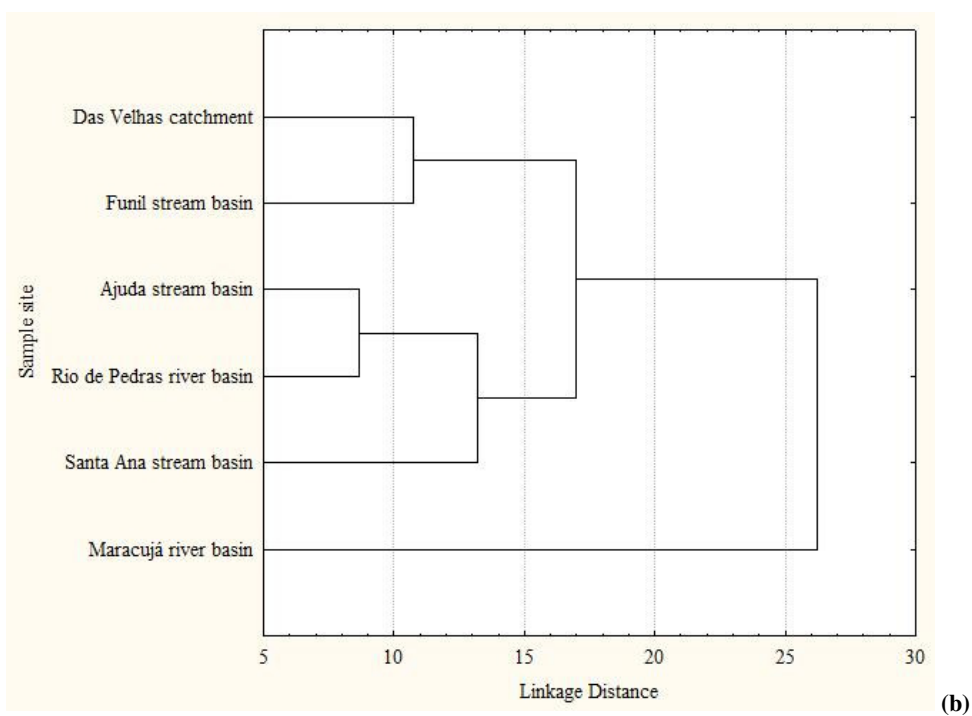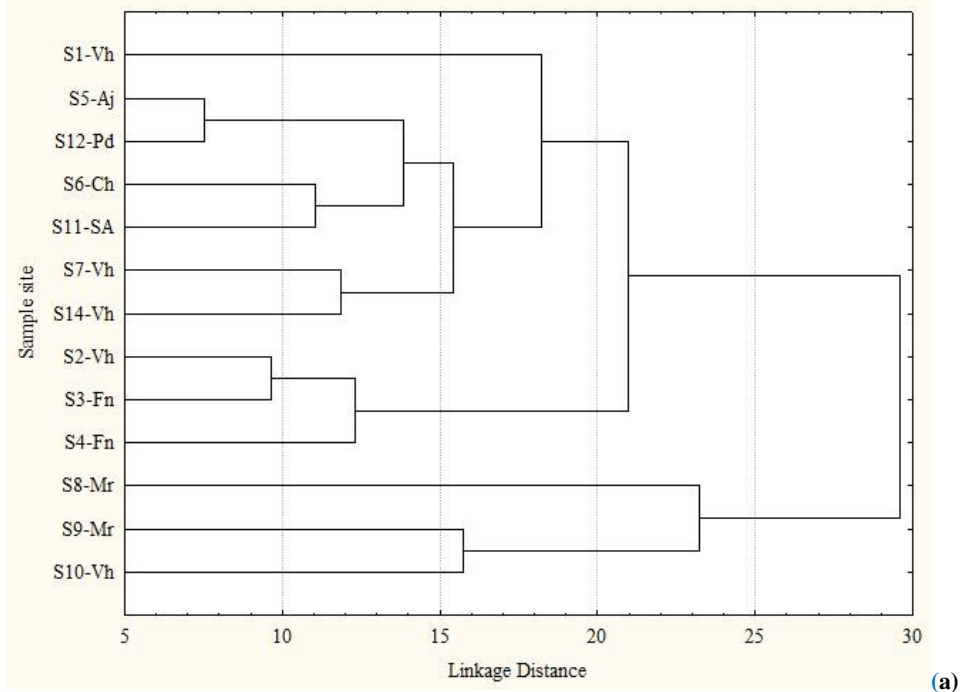
Discussion

Lotic environments are dynamic systems composed of a mosaic of habitats that reflected in its ecological integrity. The differences in habitat ecohydromorfphological quality of the studied sites reflected in this integrity.

The study area is located in the upper portion of the course of the Rio das Velhas River basin in altitude of 800m, with a predominance of river segments characterized by a mean slope, sinuosity low and expressive suppression of vegetation on the banks of the canal and surrounding environment due to human pressures. The combination of these factors contributes to intensify the erosion and transport of sediment load, with consequent siltation of waterways. This fact is Indeed notably observed in the basin of the Rio Maracujá river, especially in its headwaters, due to high deposition of sediments in the channel, translated by poorer quality ecomorphological among the surveyed sites. Lopez (2009) corroborates this dynamic with the research carried out on a path in the region of Três Marias, MG.

Most physical heterogeneity in terms of substrate supply, sequence of pools and rapids in the basins of Socorro and Santa Ana streams and Rio de Pedras river contribute to a wide variety of habitats ensuring the maintenance of river biodiversity (Howe 1997). The substrates characterized by inorganic particles of mineral composition, shape, size, surface area, texture and interstitial spaces, associated to organic substrates influencing the attachment and colonization of plants and invertebrates (Allan 1996).

Conclusions/outlook

The ecohydromorphological quality in surveyed river sections ranged from good to bad. In differentiating the bad conditions it was crucial to low variability of pools and rapids, the reduced number of bends in the river segments associated with anthropogenic interference by reducing riparian vegetation. Instead, those with good quality have significant rate of rapids, variety of substrates in the wells and stable banks covered by vegetation.

Studies have shown the applicability of ecohydromorphological assessment in differentiating ecofísica structure of the habitat and identify factors that affect. It provides additional information to the biological and physico-chemical conditions of the waters to assess the ecological integrity of the river systems without limitation of the anthropocentric view of the water utilities use patterns.

This review promotes interactive and interdisciplinary scientific research that contribute to accelerate advances in the understanding of the dynamics and functioning of river environments, in order to be incorporated in the assessment, monitoring, management and restoration of stream ecosystems.

Acknowledgements

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