# ECOHYDROMORPHOLOGY OF RIVER ENVIRONMENTS OF THE DAS VELHAS RIVER UPSTREAM OF RIO DE PEDRAS HYDROELECTRIC RESERVOIR, MG, BRAZIL

# ECOHIDROMORFOLOGIA DE AMBIENTES FLUVIAIS DA BACIA DE CONTRIBUIÇÃO DO RESERVATÓRIO RIO DE PEDRAS, MG, BRASIL

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## Abstract
This paper presents the applicability of ecohydromorphology assessment in differentiating ecophysical structure of river habitats of Rio das Velhas river basin that contributes to the Rio de Pedras reservoir, Minas Gerais, Brazil. It also presents the identification of the factors 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 system and also to validate the characterization of water bodies identified on a large scale of the Rio das Velhas basin.

**Keywords***:* ecohydromorphology, habitat quality, ecological integrity

## Resumo
Este trabalho apresenta a aplicabilidade da avaliação ecohidromorfológica na diferenciação da estrutura ecofísica de habitats fluviais, da bacia de contribuição do reservatório Rio de Pedras, Minas Gerais, Brasil, bem como na identificação dos fatores que as condicionam. Esta avaliação associada às condições biológicas e físico-químicas das águas visa avaliar a integridade ecológica dos sistemas fluviais e validar a tipificação de cursos de água identificados em escala ampla na referida bacia.

**Palavras-chave***:* ecohidromorfologia, qualidade do habitat, integridade ecológica.

## 1 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 habitats show that the approaches adopted in monitoring water quality, although valid and viable, are fragmented and insufficient to promote sustainable use of water resources (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 and utilitarian pattern of water resources usage, the ecological integrity considers the interaction among physicochemical and biological conditions of water and sediment and ecohydromorphological characterization of habitat as well (LUA, 1998; DQA, 2000; PARSONS *et al.*, 2001; AQEM, 2002; INAG, 2008; LANUV, 2012; USEPA, 2013; GELLERT *et al.*, 2014). Therefore, 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; FELD, 2004; LORENZ *et al.*, 2004). Pristine sites represent the reference condition that have as minimum criteria the presence of extensive riparian vegetation, expressive diversity of substrates, natural and stable margins, and stable water levels (HUGHES and LARSEN, 1986; REYNOLDSON *et al*., 1997).

These hierarchical levels of scale varies 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 *apud* HIDREW and GILLER, 1996), since they are closely related (RAVEN *et al*., 1998 *apud* 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. Far from expanding the understanding of the processes that determine changes in water quality, the understanding of these relationships bases the control and management of fluvial processes. In recent decades, numerous hydromorphological assessment methods, with difference in their purposes, scales, and approaches, have been developed to support river management and restoration (BELLETTI *et al*., 2015).

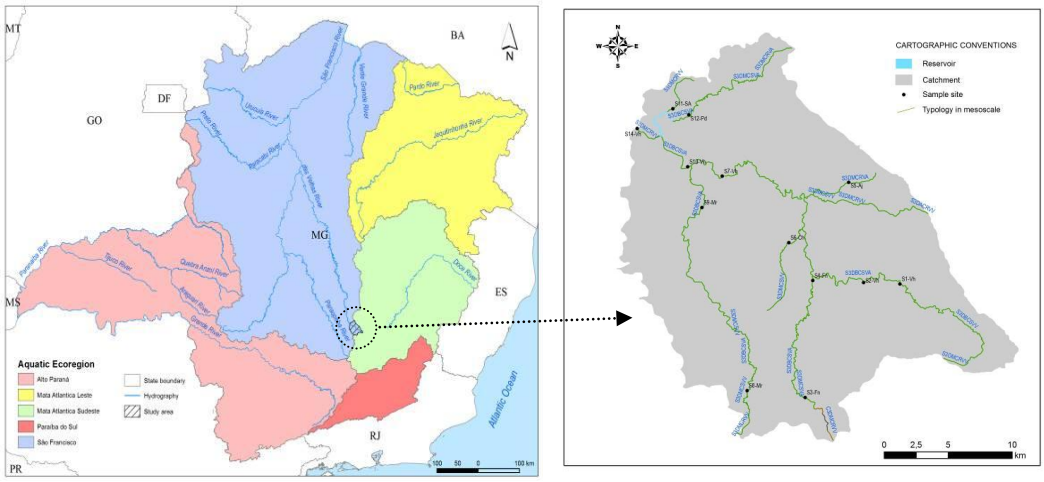
Such methods act as criteria for defining objectives focused on the management of water resources and for the evaluation of the results of management programs (BARBOUR and STRINBLING, 1990, HARPER *et al*., 1998). This approach is embodied in various evaluation programs and monitoring of water resources 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 nº 001 / 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 hydroelectricity plant of Rio de Pedras reservoir. This review integrates undergoing research 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 in large scale (CASTRO *et al.,* 2014). This project also 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.

## 2 METHODOLOGY/APPROACH

The watershed upstream of the Rio de Pedras reservoir is located in the upper course of the Rio das Velhas hydrographic basin, in São 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 anthropogenic interference (Map 1). The ecohydromorphological assessment covered a river segment (about 100m long) and a river reach (about 10m long).

**Map 1. Location map with the sampling network of the contributing basin to Rio de Pedras Reservoir, MG Brazil.**




Source: Authors.

The studies were conducted during the dry season from June to August 2013 and 2014. The dry period compared to the rainy season offer wide availability of biotopes, due to reduced flow and smaller incidence of disturbance factors (JUNQUEIRA *et al.,* 2000), which enables the display of biophysical characteristics and particularly the banks of the channel bed that favors the development of aquatic biota attached or associated to substrates.

The ecohydromorphological assessment of the 11 sites is supported by in situ records of a set of descriptors and habitat variables and their interpretation to distinguish among habitat attributes in the dimensions of the bed, the channel margin and in the surrounding environment (FERREIRA and CASTRO, 2005a, 2005b; CASTRO *et al.,* 2005). The descriptors and variables 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 water aspects and substrates; (v) characteristics of aquatic communities (biological forms of macrophytes; percentage of area covered by aquatic vegetation, presence of periphyton, and occurrence of macroinvertebrates and fish); (vi) water and land use. Methods for obtaining descriptors and variables included discriminative measurements (to define the presence of certain features or functions) and evaluative measurements (semi-quantitative, aiming to

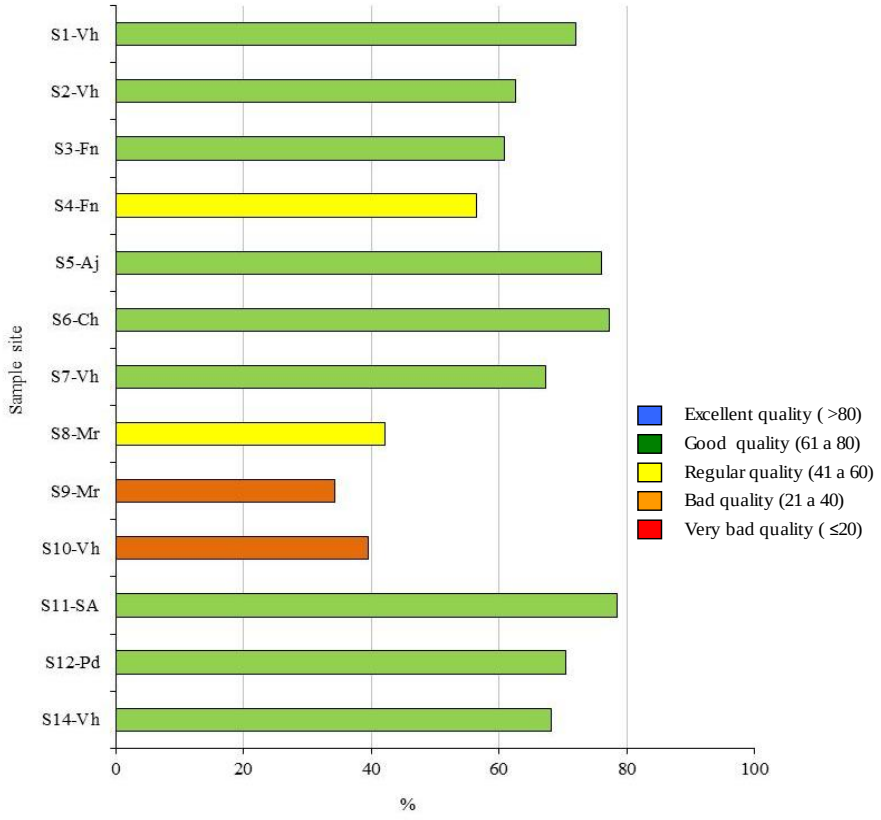
measure the magnitude of the changes in the environment).

The evaluation also included the descriptor synthesis - Global Quality of Habitat, estimated with the following geomorphologic and sedimentologic variables: 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: excellent(> 80%), good (80-61%), regular (60-41% ), bad (40 to 21%) and very bad (≤ 20%) (adapted from Barbour *et al.,* 1999). Data analysis also included cluster analyses (UPGMA and euclidean distance methods) (LUDWIG and REYNOLDS, 1988, VALENTIN, 2000). This analysis was used to detect the general standards of association among the sample sites in function of regulating factors.

## 3 RESULTS

The analysis of ecophysical attributes of the river bed, the banks and the environment in the vicinity of the sampling sites expressed by the descriptor variables and their synthesis - Global Quality of Habitat - has shown that ecohydromorfological conditions of river reaches ranged from good to bad (Graphic 1). The sites with the worst conditions were found for the Funil stream (S4-Fn), Maracujá river (S8-Mr and S9Mr) and Rio das Velhas river (S10-Vh).

**Graphic 1. Global ecohydromorphological habitat quality in stretches of Rio de Pedras Reservoir river basin, MG, Brazil. Dry season of 2013 and 2014**




Source: Authors.

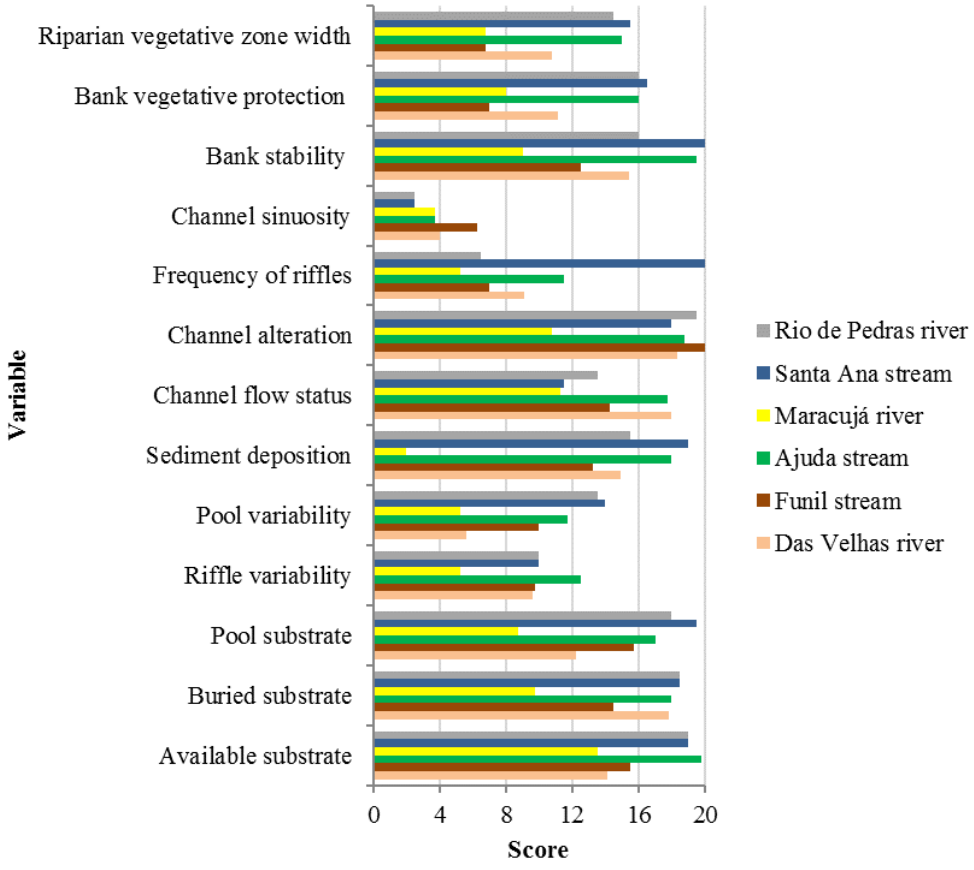
These conditions resulted from the low sinuosity channel and variability of rapids and pools associated with riparian vegetation reduction by anthropogenic interference. In

S8-Mr and S9Mr sites, the results are also due to the high deposition of sediments coming from the headwaters of the basin. A variety of inorganic substrates that have diverse particle size distribution (gravel, pebble and sand) and organic substrates (stems, leaves and roots) with the potential for colonization by aquatic biota were noticed (Graphic 2). Significant frequency of rapids, variety of substrates in the pools and stable banks covered by vegetation stood out on the sites of watersheds and streams of Ajuda, Santa Ana and Rio de Pedras.

The S1-Vh and S10-Vh sites are both located in the Rio das Velhas river, near the headwaters of the basin and nearby Rio de Pedras reservoir, respectively. They were the more differentiated in terms of habitat quality. The first one showed good quality, as opposed to the second with bad quality (Graphic 1). The Maracujá river distanced itself from the others (Graphic 3a), reflecting changes in habitat quality, mainly due to high deposition of sediments (Graphic 2).

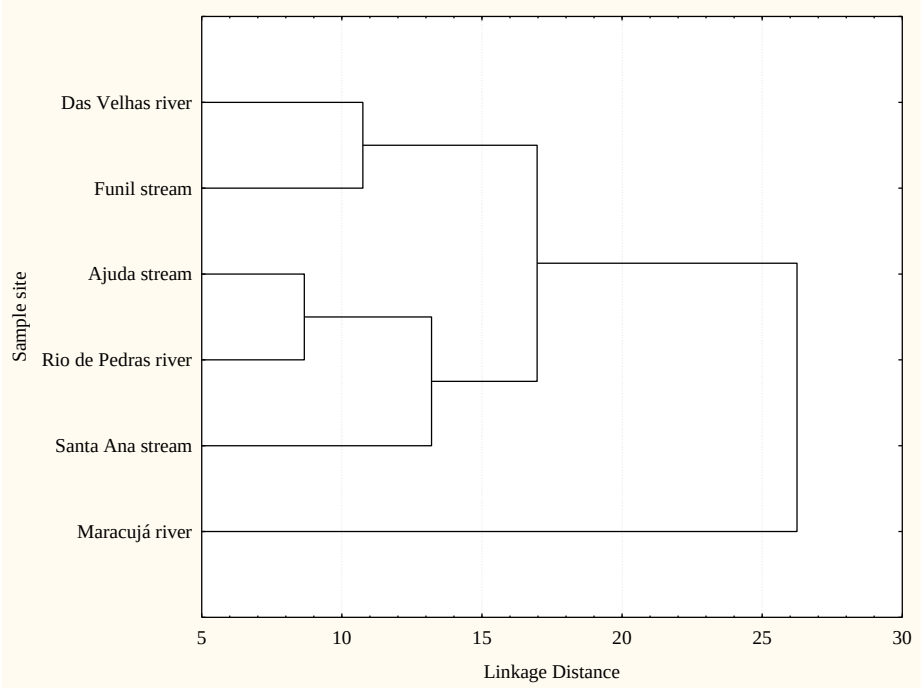
The variations in global ecohydromorfological quality reflected different groups among sites (Graphic 3b). Two groups are devident in general association patterns: one represented by the sites with better quality and the other for those with poorer quality.

**Graphic 2. Scores of the variables that compose global ecohydromorphological habitat quality in streams of the Rio de Pedras Reservoir basin, MG, Brazil. Dry season of 2013 and 2014.**

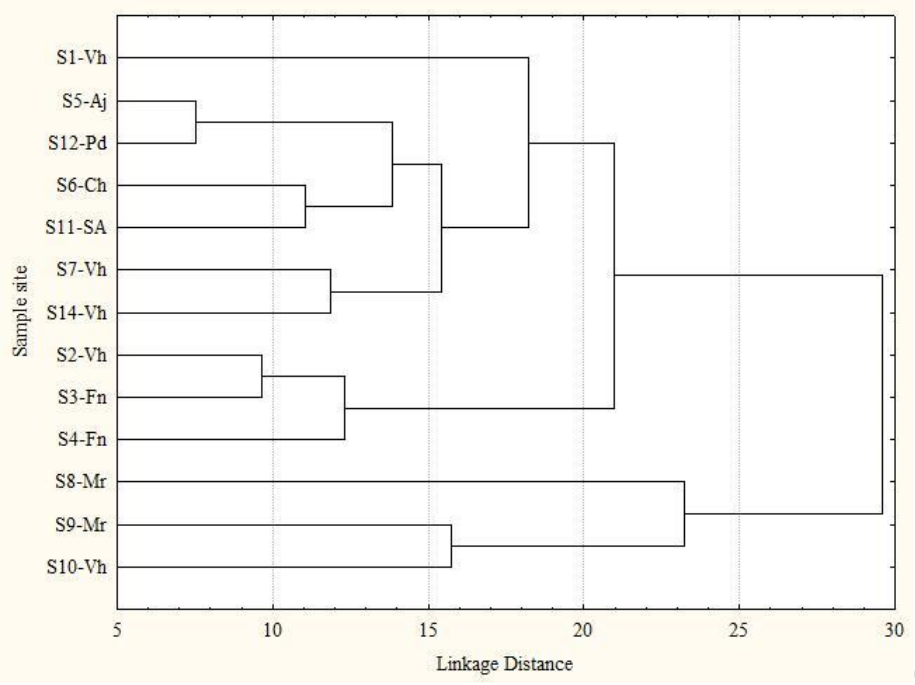



Source: Authors.

**Graphic 3. Grouping of collection sites (a) and their contribution basins and (b) sampling sites of Rio de Pedras Reservoir, MG, Brazil, based on global ecohydromorphological quality of habitat. Dry season of 2013 and 2014.**




**(a)**




**(b)**

Source: Authors.

## 4 DISCUSSION

Lotic environments are dynamic systems composed by a mosaic of habitats that reflect their ecological integrity. The differences in habitat and ecohydromorfphological quality of the studied sites resulted in their level of integrity.

The study area is located in the upper course of the Rio das Velhas river basin in altitude of 800m, with a predominance of river segments characterized by a mean slope, small sinuosity and expressive suppression of vegetation on the banks of the canal and surrounding environment due to anthropogenic 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 Maracujá river, especially in its headwaters, due to high deposition of sediments in the channel, resulting in the poorer ecohydromorphological quality among the surveyed sites. LOPEZ (2009) corroborates this dynamic with the research carried out on a river stretch 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 as suggested by Howe (1997). The substrates characterized by inorganic particles (mineral) composition, shape, size, surface area, texture and interstitial spaces, associated to organic substrates influence the attachment and colonization of plants and invertebrates (ALLAN, 1996).

## 5 CONCLUSION

The ecohydromorphological quality in surveyed river sections ranged from good to bad. In the differentiation of bad quality stretches, the determining factors were the small variability of pools and riffles, the small number of curves in the segments associated to the anthropogenic interference by reducing riparian vegetation. Instead, those with good quality have significant rate of rapids, variety of substrates in the pools and stable banks covered by vegetation.

Studies have shown the applicability of ecohydromorphological assessment in differentiating ecophysical structure of the habitat and identifying causing factors. It provides additional information to the biological and physico-chemical condition of the waters to assess the ecological integrity of the river system without the limits of the anthropocentric and utilitarian point of view of water use.

This review emphasizes interactive and interdisciplinary research that intends to contribute to advance 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.

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