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Environmental assessment of the integrity of streams in urban green parks

Green areas in urban spaces are highly relevant environments in promoting the population's quality of life, as they provide leisure, recreation, thermal comfort, and contact with nature. This study aimed to evaluate the degree of human alterations in streams in three urban green parks in the city of Dourados, MS, Brazil, through the survey of visual, physical, and chemical parameters. The results presented after applying the Rapid Assessment Protocol for Habitat Diversity (RAP) and measuring water physical and chemical parameters characterized the streams of the three parks as 'altered'. The minimum and maximum values of dissolved oxygen in the water were below the acceptable standards for the aquatic biota, with means of 3.2 to 5.4 mg L-1. The means of light incidence ranged from 51 to 64%, indicating the absence or reduction of riparian vegetation. The pH, temperature, total dissolved solids, and electrical conductivity values did not indicate environmental degradation. These results allowed evaluating the integrity of streams in the parks, which showed alterations due to human actions. Thus, the function of conservation and preservation of biodiversity is not being fully achieved and may negatively interfere with the generation and use of ecosystem services.

Keywords: Urban green areas; Environmental management; Environmental indicators; Water resources.

Avaliação ambiental da integridade de riachos em parques verdes urbanos

Áreas verdes em espaços urbanos constituem ambientes de grande relevância na promoção da qualidade de vida da população, pois proporcionam lazer, recreação, conforto térmico e contato com a natureza. O objetivo deste trabalho foi avaliar o grau das alterações antrópicas nos riachos em três parques verdes urbanos na cidade de Dourados (MS) por meio do levantamento de parâmetros visuais, físicos e químicos. Os resultados apresentados após aplicação do Protocolo de Avaliação Rápida da Diversidade de Habitats (PAR) e mensuração de parâmetros físicos e químicos da água, caracterizaram os riachos dos três parques como 'alterado'. Os valores de mínima e máxima de oxigênio dissolvido na água estiveram abaixo dos padrões aceitáveis para a biota aquática, com médias de 3,2 a 5,4 mg.L^{-1}. As médias de incidência luminosa variaram de 51 a 64%, indicando ausência ou redução da vegetação ciliar. Os valores de pH, temperatura, sólidos totais dissolvidos e condutividade elétrica não indicaram degradação do ambiente. Com estes resultados foi possível avaliar a integridade dos riachos nos parques, que apresentaram alterações em função das ações antrópicas. Dessa forma, a função de conservação e preservação da biodiversidade não está sendo integralmente atingida, podendo interferir negativamente na geração e uso de serviços ecossistêmicos.

Palavras-chave: Áreas verdes urbanas; Gestão ambiental; Indicadores ambientais; Recursos hídricos.

Topic: **Desenvolvimento, Sustentabilidade e Meio Ambiente**

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INTRODUCTION

Urban green areas are extremely important for the quality of life. They act simultaneously on the physical and mental health of humans, absorbing noises and attenuating the heat of the sun. On the psychological level, it attenuates human's feeling of oppression in relation to large buildings, constitutes an effective filter of solid particles suspended in the air, contributes to the formation and improvement of the aesthetic sense, among many other benefits (LOBODA et al., 2005).

Urban parks are considered spaces that enable sports, well-being, leisure, and are of great importance for subjects related to environmental education, nature conservation, and sources of ecosystem services (MUÑOZ et al., 2017).

According to the Millennium Ecosystem Assessment (MEA, 2005), ecosystem services (ES) bring direct and indirect benefits and can be classified into four categories, namely: provisioning, regulating, supporting, and cultural services.

In the classification scheme presented by Andrade et al. (2009), adapted from Groot et al. (2002), parks have the ecosystem function of information and can offer ecosystem services called cultural services, including ecotourism and recreation, education, sense of location, cultural heritage, among others. They are considered difficult to define and evaluate because they are associated with human values. In addition to cultural services, parks can also offer regulating services, as they consist of areas that assist in maintaining air quality and climate regulation in large urban centers (ANDRADE et al., 2009).

Food provision, urban flood and temperature regulation, noise reduction, air purification, moderation of extreme events, waste treatment, climate regulation, seed dispersal and pollination, recreation and cognitive development, and animal refuge are among the wide range of ES offered in urban green areas (BAGGETHUN et al., 2012).

In addition to cultural ES, urban parks with green areas and water bodies also have supporting services, considered as those necessary for the production of other ecosystem services. They differ from the other categories insofar as their impacts on humans are indirect and/or occur in the long term. In this case, we can mention primary production, atmospheric oxygen production, soil formation and retention, nutrient cycling, water cycling, and habitat provision (ANDRADE et al., 2009).

Watercourses, streams, and ponds are usually components of the landscape of urban green areas, playing an important landscape and biological role. These resources are usually neglected in management plans and actions in green areas and, therefore, suffer from the impacts of human actions and inefficient urban planning. Rivers and streams, also known as lotic environments, are ecosystems that have undergone environmental interventions and alterations in their landscape resulting from human actions, causing loss of quality and integrity, in addition to interfering with the sustainability of their communities (CARVALHO et al., 2014; KARR, 1999). As a consequence, there is a rise in water temperature, removal of riparian vegetation from water resources, reduction of channels, and disruption of habitats for aquatic species, thus reducing interactions between rivers and their drainage basin (BERNHARDT et al., 2005; CALLISTO et al., 2002).

Water ecosystem stressors have a varied nature and intensity and play a relevant role in the destruction and degradation of habitats. This interference, which occurs at different levels, acts in different ways on the components of the biotic and abiotic environment (CARVALHO et al., 2014). Thus, there is an urgent need to seek rapid assessment methods that help in understanding the global standards that determine the quality of lotic systems, as well as the sustainability between economic development and environmental preservation.

Economic activities, the cohesion of society in general, and human well-being are directly dependent on ES, obtaining direct or indirect benefits. In this sense, a dynamic-integrated approach must be taken into account, considering ecological, social, and economic aspects for sustainable management of ecosystems, allowing the continuity of the services generated by them. Thus, knowing the ecosystems and their ecological dynamics is essential, mainly considering the properties of variability and resilience for integrated analysis (ANDRADE et al., 2009).

Rapid assessment protocols (RAPs) are tools that add environmental quality indicators referring to the physical and biological aspects of the fluvial ecosystem, which can be used as an instrument for the assessment of lotic environments. RAPs are reference documents that bring together methodological procedures applicable to the rapid, qualitative, and semi-qualitative assessment of a set of variables representing the main components and geomorphic and sedimentological factors, which condition and control the ecological processes and functions of fluvial systems (CALLISTO et al., 2002; RODRIGUES et al., 2008). They evaluate, in an integrated way, the characteristics of a stretch of the river according to its state of conservation or environmental degradation, and their main characteristics are economic viability and easy application (CARVALHO et al., 2014).

As a complement to RAP, physical and chemical parameters are essential in the environmental assessment of water resources, as they allow for more accurate and safe measurement and assessment of environmental conditions. Monitoring water quality using physical and chemical analysis provides support for environmental protection policies and decision-making regarding environmental management actions (CALLISTO et al., 2002; CARVALHO et al., 2014; RODRIGUES et al., 2008).

The three urban parks in Dourados were chosen for environmental assessment because they do not meet the necessary conditions of refuge and environmental preservation. The negative impacts of human actions are much more noticeable than the positive impacts that these green areas should provide.

The lack of proper management, among other aspects, stands out in the parks. Thus, the survey of environmental indicators in the parks could promote municipal public policies, as well as direct management and maintenance actions, based on strategic planning that could culminate in their efficient management.

Given the problem mentioned above, this study aims to evaluate the conditions of the Arnulpho Fioravante, Antenor Martins, and Rego D'Água urban environmental parks in terms of human interference in the streams, diversity of habitats in the streams, and the monitoring of physical parameters and water chemicals.

MATERIALS AND METHODS

Study areas

The environmental diagnosis was carried out in three green parks: Antenor Martins - latitude 22º13’51.17”S longitude 54º49’55.43” O altitude 411 meters, area 23,5 hectare; Rego d’água - latitude 22º14’55.16”S longitude 54º48’57.99” O altitude 396 meters, area 12,5 hectare; Arnulpho Fioravante - latitude 22º14’55.16”S longitude 54º48’57.99” O altitude 396 meters, area 73 hectare, which are located in the urban perimeter of the city of Dourados, MS, Brazil, and belong to the Água Boa stream microbasin. These locations were selected because they have important water resources for refuge and maintenance of urban biodiversity (Figure 1).

Rapid assessment protocol

The methodology used to analyze visual parameters was the application of the Rapid Assessment Protocol for Habitat Diversity (RAP – Appendix 1), adapted from Callisto et al. (2002), considering the protocols proposed by the Environmental Protection Agency of Ohio, USA (EPA, 1987) and Hannaford et al. (1997). They were applied at four points in each park. Twenty-two parameters were analyzed in this RAP; the first 10 parameters sought to evaluate the characteristics of the stretches and the environmental impacts originated from human activities, while the other parameters (11 to 22) sought to evaluate the habitat conditions and levels of conservation of the natural environment. The environment characterization occurs through the numerical valuation of the parameters, considering the following scores: 5 points (natural parameter), 3 points (slightly altered parameter), 2 points (medium altered parameter), and 0 points (severely impacted parameter). The sum of the constituent parameters was performed in the end, resulting in an assessment of the environment that can be impacted (0 to 41), altered (41 to 60), or preserved (>61). RAP was applied at four points in each park by five independent researchers to increase the data variability, mainly due to the analysis subjectivity.

Physical and chemical parameters

Five samples and four replicates or points were collected along the streams to sample the physical and chemical variables. The evaluation of variables was carried out in situ, using the equipment Hanna HI 9828 multiparameter, ITLD 260 lux meter, and Hanna HI 9146 oximeter. The following parameters were measured: the potential of hydrogen (pH), electrical conductivity (µS cm^{-1}), temperature (°C), dissolved oxygen (mg L^{-1}), and total dissolved solids (mg L^{-1}). The integrity of the riparian vegetation was evaluated through the light incidence on the water column, measured in LUX. The formula **lx% = (*LUX_N* . 100) / *LUX_{MAX}*** was applied per sampling point to transform the values of light incidence (LUX) into the relative light incidence, where **lx%** is the relative light incidence, ***LUX_N*** is the light incidence value in LUX for each sampling point, and ***LUX_{MAX}*** is the light incidence value in a contiguous area without vegetation cover with maximum light incidence.

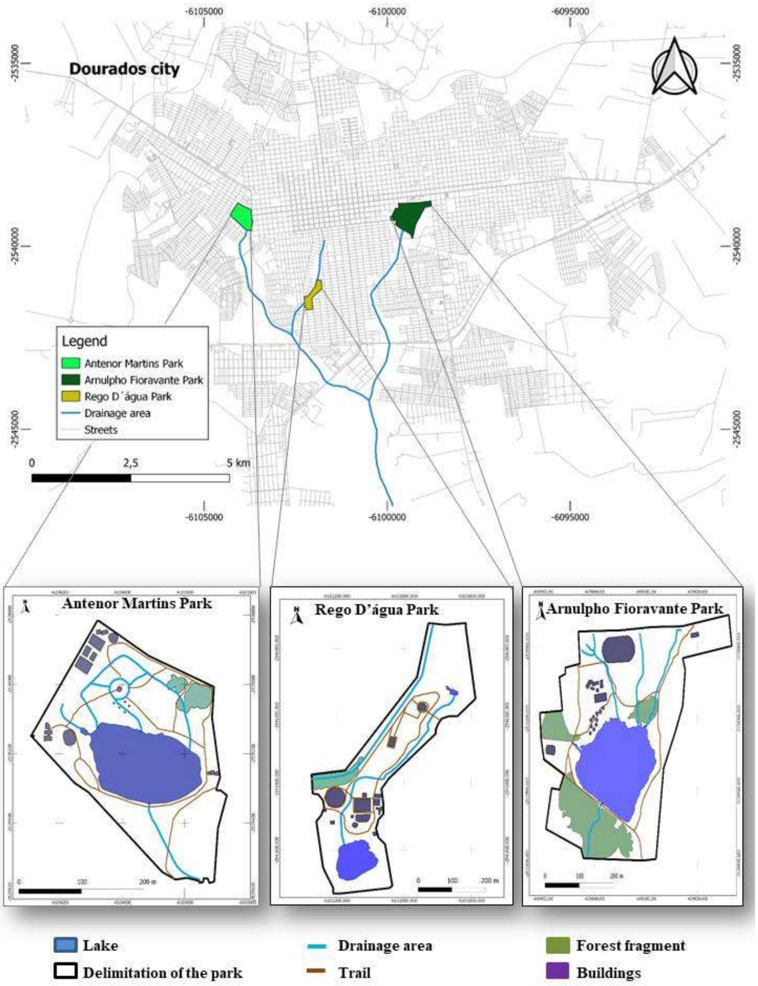

Figure 1: Urban perimeter of Dourados, MS, Brazil, delimitation of the Água Boa stream microbasin and characterization of urban green parks.

Data processing

Analysis of variance was applied to verify a statistically significant difference between parks, both for the values of the Rapid Assessment Protocol (RAP) and for the values of physical and chemical parameters at a 5% probability (<0.05). Then, Tukey's test was applied to the same variables at a 5% probability (<0.05).

RESULTS AND DISCUSSION

The RAP application allowed obtaining results from the assessment of habitat diversity. According to the final score of the 22 analyzed parameters, the streams of the three parks were classified as "altered" (Figure 1). However, the analysis of variance was statistically significant between parks ($F_{2,45} = 5.05$; $p < 0.05$), with a higher value for the Antenor Martins Park (Figure 2).

In all parks, the main parameters that indicated alterations in environmental characteristics were 2, 3, 4, 11, 12, 13, 14, 19, 20, 21, and 22, which correspond respectively to erosion near and or on the banks of the river and aggradation of its bed, human alterations, vegetation cover and bed shading, types of bottom, extent and frequency of rapids, types of substrate, presence of riparian vegetation, stability of banks, extent of riparian vegetation, and presence of aquatic plants (Figure 2).

Parameters
1. Type of occupation of the river banks (main activity)
2. Erosion near and or on the river banks and silting of the river bed
3. Anthropogenic changes
4. Vegetation cover and shading of the river bed
5. Water odor
6. Water greasiness
7. Water transparency
8. Odor of sediment from the bottom of the river bed
9. Bottom oil from the bottom of the river bed
10. Type of river bed bottom
11. Characteristics of the bottom of the river bed
12. Extension of riffles stretches
13. Frequencies of riffles stretches
14. Substrate types
15. Mud deposition
16. Sedimentary deposits
17. Changes in the river channel
18. Water flow characteristics
19. Presence of riparian vegetation
20. Margin stability
21. Extent of riparian vegetation
22. Presence of aquatic plants

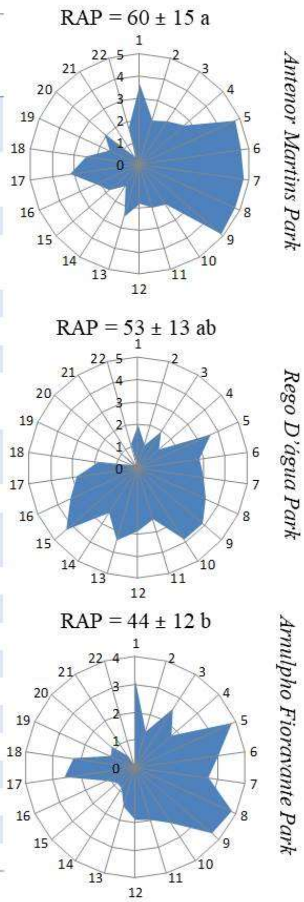

Figure 2: Parameters used in the Rapid Assessment Protocol for Habitat Diversity and mean ± standard deviation of the parameters measured in urban green parks. Standard deviations followed by the same lowercase letter in the graph do not differ statistically by Tukey's test at a 5% probability.

The human actions identified in the streams that caused the degradation of the streams and contiguous areas are commonly related to the lack of planning and public maintenance of the urban perimeter. Streams located in the urban environments are more susceptible to sewage discharges, which exert strong pressures on the environment, thus altering the levels of water quality parameters (CALLISTO et al., 2002; CARVALHO et al., 2014).

Table 1: Result of analysis of variance and physical and chemical values of stream water (mean ± standard deviation) and reference values (RV) according to current regulations.

	ANOVA		Antenor Martins			Rego D'água			Arnulpho Fioravante			RV
	$F_{2,21}$	*p*										
pH	66.6	<0.05	6.0	±	0.3c	7.4	±	0.2a	6.9	±	0.2b	6–9*
μS. cm^{-1}	20.7	<0.05	141	±	4.3b	192.9	±	2.6a	178	±	31.2a	<100***
°C	2.8	0.084	25	±	0.4a	24	±	0.5a	26	±	0.3a	<40**
mg.L^{-1}	3.2	0.060	5.0	±	0.8a	5.4	±	0.3a	4.4	±	0.6a	>6.0*
lx$_{\%}$	1.2	0.31	52	±	53.6a	51	±	22.9a	64	±	35.8a	-
mg.L^{-1}	24.1	<0.05	70	±	2.0b	103.8	±	1.3a	82.9	±	11.5b	<500*

Legends: Potential of hydrogen (pH), electrical conductivity (µS cm^{-1}), temperature (°C), dissolved oxygen (mg L^{-1}), relative light incidence (lx$_{\%}$), and total dissolved solids (mg L^{-1}). *Reference values according to Class 1 of freshwater of Resolution No. 357 (CONAMA, 2005); **Resolution No. 430 on effluent discharge standards (CONAMA, 2011); ***Standards of the Environmental Company of the State of São Paulo (CETESB, 2009). Standard deviations followed by the same lowercase letter in the row do not differ statistically by Tukey's test at a 5% probability.

Table 1 shows that the physical and chemical parameters also presented undesirable values for environmental integrity. Examples are the high values of electrical conductivity and relative light incidence and the depreciated values of water dissolved oxygen. A statistically significant difference was also observed between streams for the parameters pH, conductivity, and total dissolved solids, with higher values for the Rego D'Água Park (Table 1).

The absence of riparian vegetation along the course of the streams is one of the characteristics in their morphology that draws attention. This characteristic was evidenced both in RAP and in the relative light incidence. Two of the RAP parameters that indicated alteration and impact on the stream were directly related to the absence of riparian vegetation. About 50 to 65% of light incidence was registered directly in the water column, indicating the absence of riparian vegetation. According to Law No. 12.651/12 (BRASIL, 2012), which establishes the Forest Code, a riparian forest length of at least 30 meters is required for watercourses of less than 10 meters in width. However, compliance with the law was not observed in the stream stretches.

Riparian vegetation has an important energy resource in small streams, also presenting the functions of thermal regulation of water, retention of allochthonous residues, creation of microhabitats, maintenance of bank stability, among others (BERNHARDT et al., 2005; CARVALHO et al., 2004; CARVALHO et al., 2014; KARR, 1999). Thus, alterations in the channel, such as erosion and aggradation, presence of garbage, odor and oiliness in the water, and bank instability could be mitigated with the presence or recovery of riparian vegetation.

Electrical conductivity levels higher than 100 µS cm^{-1} for small-order streams may indicate impacted environments (CETESB, 2009). The values in the Rego D'Água stream, for instance, reached almost 200 µS cm^{-1}, being above the acceptable limit in all areas. These values may result from the presence of pollutants with high concentrations of salts, such as detergents and agrochemicals. The areas adjacent to the parks have businesses that use this type of product, such as gas stations, car washes, supermarkets, among others, which could be indirectly contaminating the water sources through surface runoff in the sewer grating covers. Conductivity represents an indirect measure of the concentration of pollutants depending on the ionic concentrations, temperature, and amount of salts in the water (SPERLING, 2005).

The pH value in the Antenor Martins Park is at the limit. The criteria for the protection of aquatic life are regulated between pH values 6 and 9, and values above or below this limit may benefit the proliferation of algae or indicate the presence of industrial/domestic effluents (CONAMA, 2005). The potential of hydrogen with values below 6 may also indicate the high decomposition of organic matter and the presence of pollutants (SPERLING, 2005). However, the intrinsic natural characteristics of the water source under analysis always need to be considered.

Water dissolved oxygen (DO) is another essential parameter in the evaluation of stream quality. The streams in all parks showed values close to below the limit recommended by CONAMA Resolution No. 357, indicating the need for urgent measures to control sources of pollution and effluent discharges. According to Sperling (2005), dissolved oxygen is essential for aerobic organisms, being a limiting factor in streams. Bacteria use oxygen in their respiratory processes during the organic matter stabilization, which may cause a reduction in its concentration in the medium. It is the main parameter for characterizing the effects of water pollution by organic discharges. Most demanding fish die with dissolved oxygen around 4–5 mg L^{-1}. CONAMA Resolution No. 357 establishes that this concentration must not be lower than 6 mg L^{-1}.

According to Muñoz et al. (2017), urban parks can offer several ecosystem services (ES), directly or indirectly, such as air purification, retention of suspended solid particles, carbon dioxide absorption, protection against winds and rain, reduction in noise pollution, soil protection against erosion, maintenance of microclimate balance, aesthetic and landscape enhancement, and conservation and knowledge of biodiversity.

In addition, according to Andrade et al. (2009), polluted aquatic environments interfere with primary production, atmospheric oxygen production, and, consequently, eutrophication and loss of aquatic biodiversity, considered support services, essential for the production of other services, and their impacts are indirect and/or occur in the long term. Furthermore, inappropriate and unplanned water use harms provisioning services.

The small watercourses, such as the streams analyzed in the present study, bring with them all the material load they received from the urban environment, flowing into the Dourados river, the main responsible for the supply of Dourados and neighboring cities. Thus, these streams should receive greater attention from the population and, especially, from public managers so that preventive measures and mitigation of the measured impacts can be adopted. The cost of water treatment and the health of inhabitants of the region is closely related to the quality of this important resource.

Similar to the results found in the present study, Silva et al. (2020) identified three ecosystem services (regulating, provisioning, and cultural services) in a water source located in the Utinga State Park in the city of Belém, PA, Brazil. The lakes that make up this source suffer anthropic pressures and land use and cover changes. The water quality analysis data showed high concentrations of nutrients such as nitrogen and phosphorus, which lead to macrophyte proliferation and eutrophication. The finding of the reduction of native vegetation increases the surface runoff and the transport of sediments to the lake. All these factors affect the main ecosystem service of this source, which is the water supply.

CONCLUSIONS

Visual, physical, and chemical indicators used to measure environmental quality in streams and contiguous areas of green parks (Dourados, MS, Brazil) pointed to the lack of integrity in the ecosystems.

The Rapid Assessment Protocol for Habitat Diversity (RAP) classified the analyzed water resources as altered, which indicates the degradation of ecosystems and, consequently, may lead to the suppression of the diversity of aquatic fauna and flora and other terrestrial organisms. In addition, RAP indicated fragility in the stream morphometry, leading to erosion, aggradation, and riparian vegetation suppression.

The measured physical and chemical parameters corroborate the aforementioned observations. The used parameters indicated the presence of pollutants in the water and, consequently, low environmental quality for the protection of aquatic diversity. These parameters also showed inadequate quantity and quality to the conditions and standards of water quality necessary to meet the preponderant uses.

Human actions have acted directly in the processes of de-characterization of the natural landscape. These interferences were responsible for the low visual, physical, and chemical water quality and, mainly, the deterioration of the characteristics of the surroundings of the streams present in the parks.

In short, the results presented for the streams corroborate the importance and necessity of continuous environmental assessment for the planning and management of these environments in the landscape of cities. The classification of all parks as 'altered' highlights the need to develop plans, programs, and projects for environmental improvement to benefit the biodiversity residing in the parks and the population of urban centers.

Although the alteration of water physicochemical factors does not directly affect the cultural environmental services of the parks, this condition can lead to the loss and decrease of the environmental services valuation, compromising well-being services, the practice of physical activities, aesthetic and landscape enhancement of the place, and aspects related to biotic factors, which affect the quality of air, water, soil, and vegetation.

REFERENCES

ANDRADE, D. C.; ROMEIRO, A. R.. Serviços ecossistêmicos e sua importância para o sistema econômico e o bem-estar humano. **Texto para Discussão.** IE/UNICAMP, Campinas, n.155, 2009.

BAGGETHUN, E. G.; BARTON, D. N.. Classifying and valuing ecosystem services for urban planning. **Ecological Economics**, v.86, p.235–245, 2012. **DOI:** http://dx.doi.org/10.1016/j.ecolecon.2012.08.019

BERNHARDT, E. S.; PALMER, M. A.; ALLAN, J. D.; ALEXANDER, G.; BARNAS, K.; BROOKS, S.; CARR, J.; CLAYTON, S.; DAHM, C.; FOLLSTAD-SHAH, J.; GALAT,D.; GLOSS, S.; GOODWIN, P.; HART, D.; HASSETT, B.; JENKINSON, R.; KATZ,S.; KONDOLF, G.M.; LAKE, P. S.; LAVE, R.; MEYER, J. L.; O´DONNELL, T. K.; PAGANO, L.; POWELL, B.; SUDDUTH, E.. Synthesizing U.S. River restoration efforts. **Science,** v.308, n.1, p.636-637, 2005. **DOI:** http://doi.org/10.1126/science.1109769

BRASIL. **Lei n.12.651, de 25 de maio de 2012**. Dispõe sobre a proteção da vegetação nativa; altera as Leis nºs 6.938, de 31 de agosto de 1981, 9.393, de 19 de dezembro de 1996, e 11.428, de 22 de dezembro de 2006; revoga as Leis nºs 4.771, de 15 de setembro de 1965, e 7.754, de 14 de abril de 1989, e a Medida Provisória nº 2.166-67, de 24 de agosto de 2001; e dá outras providências. Ministério do Meio Ambiente. Brasília: DOU, 2012.

CALLISTO, M.; FERREIRA, W. R.; MORENO, P.; GOULART, M.; PETRUCIO, M.. Aplicação de um protocolo de avaliação rápida da diversidade de hábitats em atividades de ensino e pesquisa (MG-RJ). **Acta Limnologica Brasiliensia,** v.14, n.1, p.91-98, 2002.

CARVALHO, E. M.; BENTOS, A. B.; PEREIRA N. S.. Avaliação rápida da diversidade de habitats em um ambiente lótico. **Interbio**, v.8, n.1, p.45-55, 2014.

CARVALHO, E. M.; UIEDA, V. S. Colonização por macroinvertebrados bentônicos em substrato artificial e natural em um riacho da serra de Itatinga, São Paulo, Brasil. **Revista Brasileira de Zoologia**, v.21, n.2, p.287-293, 2004. **DOI:** http://doi.org/10.1590/S0101-81752004000200021

CETESB. Companhia Ambiental do Estado de São Paulo. Significado ambiental e sanitário das variáveis de qualidade das águas e dos sedimentos e metodologias analíticas e de amostragem. In: **Qualidade das águas interiores no Estado de São Paulo**. Série Relatórios. 2009. p.1-43.

CONAMA. Conselho Nacional do Meio Ambiente. **Resolução CONAMA N. 430 de 13 de maio de 2011:** Dispõe sobre as condições e padrões de lançamento de efluentes, complementa e altera a Resolução nº 357, de 17 de março de 2005, do Conselho Nacional do Meio Ambiente. Brasília: DOU, 2011.

CONAMA. Conselho Nacional do Meio Ambiente. **Resolução do CONAMA N. 357**: Dispõe sobre a classificação dos corpos de água e diretrizes ambientais para o seu enquadramento, bem como estabelece as condições e padrões de lançamento de efluentes, e dá outras providências. Ministério do Meio Ambiente. Brasília: DOU, 2005.

EPA. Environmental Protection Agency. **Biological criteria for the protection of aquatic life.** Columbus: Division of Water Quality Monitoring Assessment, 1987.

HANNAFORD, M. J.; BARBOUR, M. T.; RESH, V. H.. Training reduces observer variability in visual based assessments of stream habitat. **Journal of the North American Benthological Society**, v.16, n.4, p.853-60, 1997.**DOI:** http://doi.org/10.2307/1468176

KARR, J. R.. Defining and measuring river health. **Freshwater Biology,** v.41, n.2, p.221- 234, 1999. **DOI:**

http://doi.org/10.1046/j.1365-2427.1999.00427.x

LOBODA, C. R.; ANGELIS, B. L. D.. Áreas verdes públicas urbanas: conceitos, usos e funções. **Ambiência**, v.1, n.1, p.125-139, 2005.

MEA. Millenium Ecosystem Assessment. **Ecosystems and human well-being:** Biodiversity Synthesis. Washington: Island Press, 2005.

MUÑOZ, A. M. M.; FREITAS, S. R.. Importância dos serviços ecossistêmicos nas cidades: revisão das Publicações de 2003 a 2015. **Revista de Gestão Ambiental e Sustentabilidade**, São Paulo, v.6, n.2, p.89-104, 2017. **DOI:** http://dx.doi.org/10.5585/geas.v6i2.853

RODRIGUES, A. S. L.; MALAFAIA, G.; CASTRO, P. T. A.. Protocolos de avaliação rápida de rios e a inserção da sociedade no monitoramento dos recursos hídricos. **Revista Ambiente & Água**, v.3, n.3, p.143-155, 2008. **DOI:** http://dx.doi.org/10.4136/1980-993X

SILVA, D. F.; FURTADO, L. G.; BELTRÃO, N. E. S.; PONTES, A. N.. Pressões ambientais sobre serviços ecossistêmicos hídricos em um manancial em Belém, Pará, Brasil. **Research, Society and Development**, v.9, n.8, 2020. **DOI:** http://dx.doi.org/10.33448/rsd-v9i8.5981

SPERLING, M. V.. **Introdução à qualidade das águas e ao tratamento de esgotos.** 3 ed. Belo Horizonte: Universidade Federal de Minas Gerais, 2005.