

Circumstance: a proposal to discuss urban waters

Circunstância: uma proposta para discutir as águas urbanas

Circunstancia: una propuesta para discutir las aguas urbanas

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Abstract

Most Brazilian cities have suffered from floods and landslides during the rainy season, making clear the ills caused by disrespecting urbanization of natural conditions and the limitations of conventional drainage solutions. They cannot face the problem nor its growing aggravation because of weather changes. Facing this situation imposes new solutions based on diffuse measures of rainwater management, which depend on the participation of local populations and, therefore, on the understanding of what an urban hydrographic basin is and how the dynamics of the water inside it works, aspects fundamental aspects of basic environmental education to recover the quality of life in cities. This article presents the concept of circumstance, related to the portion of a watershed that can be directly and daily observed, as the basis of a proposal to horizontalize knowledge about the functioning of water in urbanized basins and expand discussions on urban water, articulated to the various scales involved therein. The article also presents a report on the circumstances of a sub-basin in Belo Horizonte, illustrating how it can be mobilized in practice.



Keywords: Urban Waters; Hydrographic Basin; Environmental Education; Recovery of degraded areas; Political organization through urban waters.

Resumo

A maioria das cidades brasileiras tem sofrido com enchentes e deslizamentos nos períodos chuvosos, deixando claro as mazelas provocadas por urbanizações desrespeitosas das condições naturais, bem como as limitações das soluções convencionais de drenagem, incapazes de enfrentar o problema e tampouco seu crescente agravamento em vista das mudanças climáticas. O enfrentamento dessa situação impõe novas soluções baseadas em medidas difusas de manejo de águas pluviais, que dependem da participação das populações locais e, portanto, da compressão do que é uma bacia hidrográfica urbana e de como funciona a dinâmica da água em seu interior, aspectos fundamentais da educação ambiental básica para recuperação da qualidade de vida nas cidades. Este artigo apresenta o conceito de *circunstância*, relativo à parcela de uma bacia hidrográfica passível de ser observada de forma direta e cotidiana, como base de uma proposta para horizontalizar o conhecimento acerca do funcionamento da água nas bacias urbanizadas e ampliar as discussões sobre águas urbanas, de forma articulada às diversas escalas aí implicadas. O artigo também apresenta um relato sobre a circunstanciação de uma sub-bacia em Belo Horizonte, ilustrando o modo como ela pode ser mobilizada na prática.

Palavras-chave: Águas Urbanas; Bacia Hidrográfica; Educação Ambiental; Recuperação de áreas degradadas; Organização política a partir das águas urbanas.

Resumen

La mayoría de las ciudades brasileñas han sufrido inundaciones y deslizamientos de tierra durante la temporada de lluvias, evidenciando los males causados por la urbanización que no respeta las condiciones naturales, así como las limitaciones de las soluciones de drenaje convencionales, incapaces de enfrentar el problema ni su creciente agravamiento ante los cambios climáticos. Enfrentar esta situación impone nuevas soluciones basadas en *medidas difusas de gestión del agua de lluvia*, que dependen de la participación de las poblaciones locales y, por tanto, de la comprensión de qué es una cuenca hidrográfica urbana y cómo funciona la dinámica del agua en su interior, aspectos fundamentales de educación ambiental básica para recuperar la calidad de vida en las ciudades. Este artículo presenta el concepto de circunstancia, relacionado con la porción de una cuenca que puede ser observada directa y cotidianamente, como base de una propuesta para horizontalizar el conocimiento sobre el funcionamiento del agua en cuencas urbanizadas y ampliar las discusiones sobre el agua urbana, articuladas a las varias escalas involucradas en el mismo. El artículo también presenta un informe sobre las circunstancias de una subcuenca en Belo Horizonte, ilustrando cómo se puede movilizar en la práctica.

Palabras clave: Aguas Urbanas; Cuenca Hidrográfica; Educación Ambiental; Recuperación de áreas degradadas; Organización política desde las aguas urbanas.



INTRODUCTION

The repeated experience of risk situations leads to insensitivity and abuse. This is precisely what seems to characterize the perception of urban waters by the majority of the population: we have become accustomed to disasters while waiting for a magical solution based on large-scale public works that, although ineffective, are technically legitimized and even wished for. Centralized, conservative measures, which are hardly ever discussed with those directly affected by them, have led to mistakes reoccurring and alternatives not being considered. But water itself can teach us if we observe closely how it behaves: always unstoppable and diverse.

The circumstance proposed here aims to foster such an understanding in the technical or scholarly field and, above all, in the knowledge shared with non-experts, *i.e.*, all inhabitants of urbanized drainage basins. Assuming that water necessarily puts these inhabitants in a relationship with each other and with (urban) nature, water is a potential fulcrum of a process of learning, awareness, and collective action.

As a preliminary definition to be elaborated forward, circumstance designates a minimum physical unit for analyzing and calculating runoff, infiltration, or catchment and, simultaneously, a minimum territorial unit for engaging inhabitants in a network of decisions and actions. Regarding the first aspect, a circumstance can correspond to a larger or smaller hydrological unit, such as a sub-basin, a watershed, or a micro-watershed; regarding the second one, it goes beyond these notions. Knowing one's circumstance means knowing how water works in one's place and understanding what determines its concrete manifestations instead of perceiving it only in the extreme forms of alienated consumption and catastrophic events.

The concept of circumstance elaborated in a reciprocal process of theoretical reflections and public outreach, which started in 2015. Since then, the research and outreach project Águas na Cidade (AnC, Waters in the City) has collaborated with public schools and social movements to develop devices that support learning from and with urban waters. These devices are representations, dialogue tools, interfaces, and methods focusing on pedagogic materials for primary and secondary education. The project's main objective is to arouse interest in the population for this issue and for imaginative thinking about restoring good environmental conditions, assuming that such restoration is a collective, decentralized task in which diffuse small measures are at least as important as large-scale ones (Rosa, 2017).

All this was motivated by the realization that most people learn the sequence of the hydrological cycle at school without relating it to their concrete, everyday experiences. For most, there is no automatic link between the scheme of precipitation, runoff, storage, and evaporation presented in textbooks and the flooding on their doorstep. A concept was required that bridged the gap between



these everyday experiences and the technical-scientific approaches of hydrology. The idea of circumstance emerged precisely to close this gap from a theoretical as well as a methodological and pedagogical point of view.

The text is, therefore, organized in three sections besides this introduction. 'Circumstances in the fractal geometry of basins' is a brief discussion of the concept vis-à-vis current notions of drainage basins and their physical subdivisions. 'An epistemology of the circumstance' explores the same idea, considering its relation to individual and collective everyday experience. Finally, 'Outreach to Cercadinho' is an account of the work carried out by the AnC project in an urban basin in Belo Horizonte, illustrating how circumstantiation may be mobilized in practice.

Circumstances in the fractal geometry of basins

What can be done to restore the city's environmental quality and achieve a reconciled coexistence with water? Local actions are urgently needed to reduce the harmful impacts of stormwater that our predatory patterns of urbanization have brought about. Moreover, local studies and actions open up possibilities, perhaps unique, for attempts at collective autonomy in urban spaces. But where to start?

Local actions based on water management go far beyond mitigating isolated phenomena because waters are, by nature, related to broader contexts. They already bring with them, as a matter of course, the cross-scale structure characteristic of hydrographic networks: the São Francisco River receives water from the Velhas River, which in turn receives water from the Arrudas basin, which receives water from the Cercadinho watershed, which receives water from the Ponte Queimada micro-watershed, which receives waters from smaller or local subdivisions. Conversely, rainwater seeps into the ground, forming the water table and springs, or runs off the surface of concave terrain, forming smaller streams, which become more significant as they reach lower levels until they join a mainstem, which eventually flows into the ocean.

Such a mainstem conventionally defines the most comprehensive hydrographic unit regarding water dynamics: the river basin. It means the land drained by a river and its tributaries and limited by morphological water-dividing features, *i.e.*, hilltops, saddles, and ridges. As for hydrographic units at more minor scales, *i.e.*, the smaller portions of a river basin, nomenclature is less straightforward. Roughly speaking, the sub-basin is the drainage area of a tributary to the mainstem. Its territorial extension can vary greatly, depending on the terrain and the analysis approach. There are, for example, sub-basin delineations covering a thousand hectares and others covering thirty thousand, whereas the term micro-basin, as used in Brazilian Portuguese, designates areas that are always smaller than ten thousand hectares, defined according to hydrological and ecological criteria (Teodoro *et al.*, 2007, pp. 140–142).



However, more critical than these definitions is the understanding that they are always relative, not absolute. Depending on the scale of analysis, the same portion of a territory can be delineated as a sub-basin, a catchment, a watershed, a sub-watershed, or other related term. “Each catchment area is interconnected with another catchment area of a higher hierarchical order, constituting, in relation to the latter, a sub-basin. Therefore, the terms basin and sub-basin are relative” (Teodoro *et al.*, 2007, pp. 138–139).

Since the 1990s, this network of interactions formed by waters, with virtually infinite sub-portions that function analogously at different scales, has been studied using fractal geometry. ‘Fractals provide a workable new middle ground between the excessive geometric order of Euclid and the geometric chaos of roughness and fragmentation’ (Mandelbrot, 1989, p. 3). The use of fractal theory for the description, modeling, and analysis of complex shapes is because it allows the ‘chaotic’ behavior of systems such as river basins to be grasped mathematically (Silveira, 2006, pp. 18–21).

Fractal geometry allows working with rough surfaces of complex reliefs at different scales, drawing on geometric patterns that vary within well-defined boundaries. Studies carried out by La Barbera and Rosso (1987), Tarboton (1988, 1990), Beer and Borgas (1993), Rinaldo (1993), and Silveira (2006) show that fractal logic provides the key to accessing rainwater management by extrapolating the calculation of flows, infiltrations, storage capacity, etc. It provides pathways for mathematically analyzing the chain of water-driven events within basins, with estimates accurate enough to inform hydrological calculations and to plan interventions.

To put it more simply, within a basin, one can consider a multitude of subdivisions whose patterns and geometric attributes can be analyzed mathematically and are, therefore, predictable to a certain extent, which is crucial for intervention projects, particularly for consistent local actions. Moreover, the pattern of a small portion can be inferred for the rest of the basin. One can move through different scales of observation, visualizing the various orders of interaction and interdependence. This allows an understanding of how an urban watershed is externally connected to a larger watershed — for example, covering an entire metropolitan area — and how it is internally structured at the scale of a neighborhood or block. These minor portions constitute the circumstances.

The so-called circumstantiation means the watershed delineation at the scale of the circumstances. From a technical point of view, it is similar to procedures used for larger scales, *i.e.*, it entails the identification of ridge lines, drainage lines, and pour points to configure micro-units of outflow, for which we are using topographic representations with contour lines every one meter. Once the circumstances are delineated, we classify them by occupation categories and lay them over satellite images using QGIS. This, in turn, generates data to feed software such as the Storm Water Management Model (SWMM), enabling rough calculations of stormwater runoff, infiltration, retention, and detention. The process also allows for testing



diffuse compensatory measures in a digital environment and obtaining consistent data on their effectiveness in each circumstance.

Nevertheless, as already mentioned, circumstance is based on a socio-spatial approach. A strictly physical approach to watershed delineation and subdivision focuses on the capacity of each portion to generate runoff (the amount of water drained depending on shape, relief, and soil), while circumstantiation also considers socio-spatial determinants. One fundamental requirement in this respect is to consider the history of the occupation of the territory. Another one is to consider that the size of a circumstance depends on the possibility of grasping it through direct, everyday observation. Circumstantiation is done in a way that potentially enables each urban inhabitant to identify the circumstance of their dwelling, the other dwellings that share it, and its articulation with other portions of the urban hydrographic network.

An epistemology of the circumstance

'I am myself plus my circumstance, and if I do not save it, I cannot save myself,' says the Spanish philosopher José Ortega y Gasset (1961, p. 45). He complements the phrase by advising us to do good to our place of origin and 'to look for the meaning of what surrounds us' (ibidem). The circumstance to which Ortega y Gasset refers and whose deep knowledge would give meaning to the human world is not just a territory, nor is it restricted to the physical world. But what matters here is his emphasis on the small scale as our only possibility of concrete apprehension of reality.

Only parts do exist in fact; the whole is an abstraction of the parts and it depends on them. [...] For the person for whom small things do not exist, the great is not great. We must try to find for our circumstance, such as it is, and precisely in its very limitation and peculiarity, its appropriate place in the immense perspective of the world. We must not stop in perpetual ecstasy before hieratic values, but conquer the right place among them for our individual life. In short, the reabsorption of circumstance is the concrete destiny of man. (Ortega y Gasset, 1961, pp. 44-45).

At the same time, the philosopher encourages us to go beyond the realm of the directly observed or observable. By acquiring 'complete consciousness of his [or her] circumstances,' a human being 'communicates with the universe' (Ortega y Gasset, 1961, p. 41). It is an epistemology of direct, attentive, loving observation of the circumstance, leading to transit through broader scales. This concept is proposed here to feed and popularise the discussion on urban waters.



However, there is one caveat. Ortega y Gasset favors moral and psychological aspects of the relationship between individual and circumstance, whereas the concept proposed here is more concerned with the material, collective, and political dimensions. What matters is the city's construction as a history and a way to recover its socio-spatial circumstances, not the mystique of place so often worshipped in architecture and urbanism, as if subordination, exclusion, and socio-spatial injustice were secondary. Love for a place or a sense of belonging cultivated at the expense of socio-spatial awareness is mere ideology.

Thus, as hydrographic networks articulate different scales, learning from water must also articulate direct observation with knowledge of greater territorial scope since problems that appear in one circumstance often originate in another. Only a combination of concrete experience and systematic research makes it possible to get to know each circumstance in depth, to understand the sources of conflicts between water and urbanization, and to put into practice a reconciled coexistence with urban waters. The AnC project team has used this reading of Ortega y Gasset's proposition to advance an epistemology and pedagogy around urban waters, performed in real urban contexts and partnership with the people there.

Since consideration of a watershed beyond the scale of the circumstance always requires some degree of abstraction and representative devices, we have prepared a series of tools to articulate the micro-scale of direct observation with the macro scale of systematic studies. For example, the chain of interconnected events within a watershed during heavy rainfall can be reproduced in a digital environment, at least for aspects such as flood flow, flood elevation, and permeability rates. This helps to understand and interpret a dimension of the phenomena that would not be apprehensible by direct observation. In contrast, direct observation offers the unparalleled experience of a place and its human and non-human riches. And even if a phenomenon never repeats itself in precisely the same way in different circumstances, a deep understanding of a small part puts the agents in connection with the whole basin or hydrographic network. It provides insight across scales that most people only glimpse in exceptional events (as when they see the images of the mud dumped by Samarco in Mariana polluting Regência Beach, Espírito Santo's surfing paradise).

Outreach to Cercadinho

The AnC project has already addressed several watersheds in Belo Horizonte, with multiple partnerships with public schools and other groups. Here, I will limit myself to describing one of these cases: the research and outreach activities in the watershed of the Cercadinho stream. They began in 2020 in collaboration with the Escola Estadual Manuel Cassasanta (EEMC), the Escola Municipal Efigênia Vidigal (EMPEV), and the environmental grassroots organization Cercadinho-Nascente Ponte Queimada. The main objectives of these activities — as well as of previous ones — are (1) Broadening and democratizing understanding of the concrete manifestations of the hydrological cycle and the impact of urbanization on this



cycle; (2) Building non-hierarchical interactions that value and mobilize people's prior knowledge and facilitate their access to formal knowledge; (3) Researching, testing and disseminating diffuse compensatory stormwater management measures; (4) Fostering the collective autonomy of local groups through the production of dialogical-interactive interfaces and tools.



Figure 1: Activities with EMPEV's students: workshops with satellite images, models, maps, and excursions. (The AnC Project Collection).

Two paths of research and experimentation intersect in these goals. The first concerns the engagement of the local population in exploring the origins of water-related phenomena in their watershed and in each particular circumstance, articulating technical knowledge with the knowledge built from direct observation and daily experience. We have been carrying out several activities with our partners in Cercadinho to achieve this. With the grassroots organization, for example, we structured a subject for the undergraduate course in Architecture and Urbanism, which gave rise to a set of illustrated directives for a riparian parkland with green corridors linking it to headwaters preservation areas and to Serra do Curral, following the idea of the so-called Trama Verde-Azul (Green-Blue Weave) envisaged in the Master Plan of the Metropolitan Region of Belo Horizonte. At EMPEV, fortnightly meetings with students and teachers are underway as part of the Integrated School Programme, focusing on topographical representation. Through activities using physical models and field visits around the school (Figure 1), we seek to demystify technical language, which is often a barrier to communication between 'lay' groups and experts or official bodies. These activities are prepared according to a method developed in earlier phases of AnC for the production of educational materials of a dialogical type (Santos, 2020; Figure 2). Instead of ready-made teaching proposals, we provide various tools for dialogue to provoke 'genuine questions' (Mortimer; Scott, 2003), from which teaching programs and sequences of activities appropriate to each case are built collectively.



Figure 2: Watershed Delineation Kit and Circumstances Puzzle (The AnC Project Collection).

The second path, somewhat technical, concerns methods of analyzing the circumstances and researching compensatory measures for urban drainage and stormwater management (mainly retention, detention, and infiltration) to feed discussions, decisions, and actions by local groups. To this effect, we began our studies of the Cercadinho watershed by reconstructing the history of its occupation, using as sources the survey of the Cercadinho Farm, recorded on an 1896 map, and an inventory of land development projects between 1970 and 2020. We also compiled a chronology of public works based on the Reports of the Mayors of Belo Horizonte. Furthermore, we analyzed the physical and environmental conditions of the watershed via the interfaces between relief, hydrography, pedology, and urbanization, identifying land use, subdivision patterns, road system, types of paving, networks for water supply, sewage, and electricity, as well as permeability, vegetation and declivities. Based on this data set, we did the circumstantiation described before (Figure 3).

In the case of Cercadinho, we first explored this whole process and then chose the circumstance where EMPEV is located to start the work at the micro-local level. As most students live nearby, the EMPEV circumstance offered the opportunity to get closer to the local community and engage in a circumstance-based pedagogical process. Analyzing this circumstance revealed the reasons for the flooding problems inside the school. We thus decided to propose to the Secretaria de Obras da Prefeitura de Belo Horizonte (Belo Horizonte City Council's Department of Works) an experiment to set up rain gardens, green roofs, infiltration ditches, and retention and detention basins in the school's catchment area. The experiment will test these devices' efficacy and the circumstantiation method's accuracy while also providing on-site educational material to familiarize the local population with these options further. In the Cercadinho area, mainly thanks to the activities with the EMPEV, circumstantiation enabled participants to identify the sources of concrete and potential problems and to understand the nexus of events within their watershed.

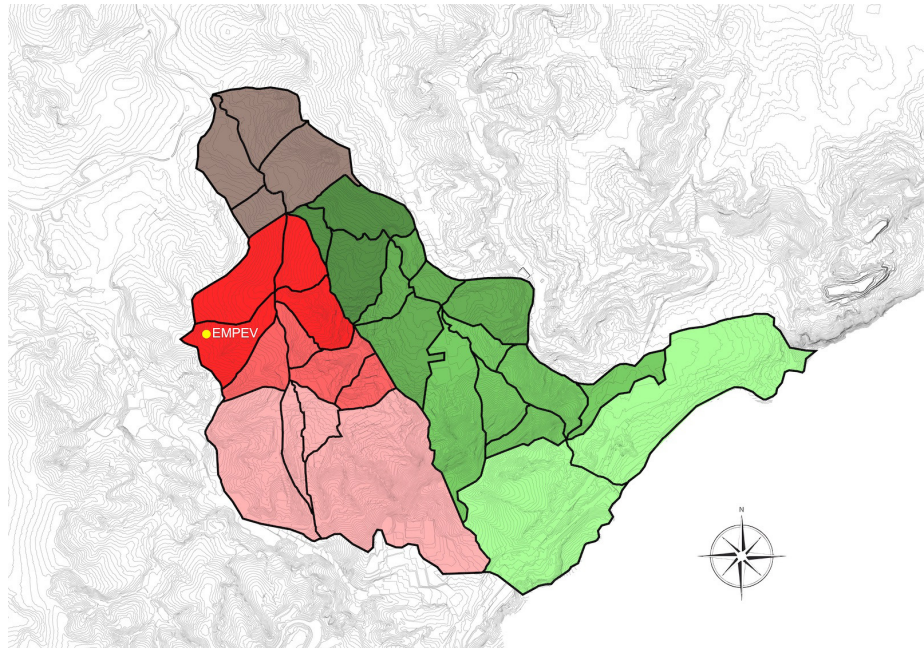


Figure 3: Circumstantiation of the Cercadinho watershed. (The AnC Project Collection)

CLOSING REMARKS

The scale and steady worsening of problems associated with urban waters require responses beyond conventional large-scale solutions. More than that, they require broadening the participation of the inhabitants of urbanized watersheds since putting such measures in place is impossible without the massive support of the population. It is crucial to spread knowledge about urban basins' water dynamics and alternatives for their management.

As a concept and a set of pedagogical procedures, the circumstance is a device for such a spread. Being a basic unit for working on the issue of urban waters, the circumstance enables the construction of democratic decisions that start at the micro-local level, as opposed to decisions legitimized only by technical criteria and defined from macro-logical perspectives, which tend to abstract or ignore local nuances (Pinheiro, 2022). Once all the circumstances of a watershed and the network of interactions between them have been identified, they can be taken as a reference for the discussion of coordinated solutions. For example, they may help define representations in basin committees and other political and administrative instances of the context in question, connecting local issues and decisions to those affecting a more expansive territory.

The experience of the AnC project has revealed a genuine interest in environmental restoration and urban (re)design based on water — among undergraduate students, activists, community leaders, and residents, whether adults or children.

It also shows that primary schools are privileged places to initiate the mobilization of residents towards a process of knowledge and recognition of the micro-local characteristics of watersheds, which enables these groups to face water-related problems and to claim programs, public policies, and resources (Rosa, 2017).

All this leads us to believe in the feasibility of a permanent education and training program for technical advisors working concurrently on the urban redesign of various watersheds, which means opening up the possibility of technical aid provided by architects and urban planners beyond the field of housing.

Finally, it should be emphasized again that water is the most competent teacher in this collective learning process. This is already said by the ancient Chinese oracle I Ching, in hexagram 29 entitled 'The Abyss,' which is formed by doubling the trigram water:

Through repetition of danger, we grow accustomed to it. Water sets the example for the right conduct under such circumstances. It flows on and on, and merely fills up all the places through which it flows; it does not shrink from any dangerous spot nor from any plunge, and nothing can make it lose its own essential nature. It remains true to itself under all conditions. (Wilhelm, 1967, p. 376-377).

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