

Pluralising the materiality of water: More-than-water, lively waters, water with, and the agency of hydro-social assemblages

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Abstract

This special issue combines insights from an array of theoretical perspectives, including political ecology, Indigenous studies, and more-than-human and feminist geographies to engage with a critical question for water studies: What are the theoretical, empirical and methodological implications of a closer engagement with the matter and properties of water and infrastructure? To answer this question, the contributions draw on a geographically and empirically diverse set of case studies that illuminate a range of articulations of materiality of water and infrastructures in hydro-social assemblages. Collectively, the papers highlight how the materiality of water is inherently plural, as it is co-constituted through its entanglement with other materialities (*water with*), gives rise to emergent materialities through its intra-action with other elements and more than human natures (*more-than-water*), and relies on the labour of living organisms to transform and maintain its function (*lively waters*). Second, the papers show how apprehending and pluralising materiality of water and infrastructure extends conceptualisations of agency, justice and care in hydro-social assemblages. The third thread emerging from this collection of papers is that methods matter for interdisciplinary, community and more-than-human knowledges. We conclude by

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identifying potential areas of interdisciplinary practice and future research on the material matters of water/s and infrastructures that engage with the interplay between ecological, hydrological, technical and social processes.

Keywords

Interdisciplinary engagements, more-than-human waterscapes, hydro-social assemblages, plural materialities, water justice

Introduction

The papers in this Special Issue collectively explore multiple ways of accounting for, and engaging with, the materiality of water and hydraulic infrastructure, to examine how the human and non-human co-constitute social and material worlds. The Special Issue builds on influential work on the material turn in resource geographies (Bakker and Bridge, 2006) and science and technology studies (Barnes and Alatout, 2012), which has contributed radically new conceptualisations of water as socio-natural and socio-technical entity. In *Material Worlds: Resources geographies and the 'matter of nature'*, Bakker and Bridge (2006) ask how and why agential capacities of biophysical worlds matter and consider the implications of (re)materialising critical resource geographies. They propose that the concept of materiality provides a productive entry point to engage with essential questions of agency as a more-than-human property and to advance debates on the construction of nature. Jessica Barnes and Samer Alatout's (2012) Special Issue *Water Worlds* explores multiple ontologies of water emerging from a range of different socio-technical assemblages. Here, ontology refers not only to meanings but also its different 'biophysical makeup', which can be enacted as a 'border, a resource for regeneration, a foundation for empire, a means of nation building, and a material linkage between past and present' (Barnes and Alatout, 2012: 485).

In these literatures water is acknowledged and conceptualised as the fundamental *matter* of social life, constituting, rather than 'just' mediating (as it has been framed in much Western theory), social relations. Building on this foundational work, materiality has been mobilised in geographical scholarship to conceptualise non-humans as 'power brokers' (Meehan, 2014: 215) and to examine historical and geographical processes and dynamic choreographies of power of hybridisation (Menga and Davies, 2020); as an analytical lens to explore water quality assemblages (Mac Afee, 2022); and to inform interdisciplinary approaches to apprehend the materiality of waterborne diseases and (un)healthy bodies in the urban waterscape (Rusca et al., 2017, 2022) or the atmospheres of water evaporation (Jackson and Head, 2022). Other work has re-emphasised the inextricable links between materiality of bodies of water(s) and the bodies of people, with a focus on practices and everyday use (Larrington-Spencer et al., 2021; Strengers and Maller, 2012), the social and cultural meanings of water(s) (McLean et al., 2018), and the importance of Indigenous ontologies of water and 'Living Waters' paradigms for water management (Laborde and Jackson, 2022; Yates et al., 2017). As these literatures show, the liveliness and agency of water(s) has been taken more seriously across geography and allied social science and interdisciplinary conversations in the last decades. Within this special issue we recognise a need to further deepen the theoretical, methodological, empirical, and ethical questions within geography and interdisciplinary practice to evidence and address the substantial change to the materialities of water(s) occurring in response to environmental change, environmental pollution, and global climate change. These local to global changes are transforming the materialities of water(s), redefining our social understandings of the agency of water, altering how social life is constituted alongside changing waters, and shifting conceptualisations of water justice and (more-than-human) ethics.

In this introduction, we highlight three significant contributions of this collection of papers to debates on materiality of water and infrastructure. First, the papers in this Special Issue bring into focus novel and plural articulations of the materiality of water and the distributed human and non-human agencies that co-constitute hydro-social assemblages. Second, they examine the implications of pluralising materiality of water for theories of agency in hydro-social assemblages, as well as for understanding waterscapes and water justice as more-than-human. Third, they highlight the centrality of critical social science and interdisciplinary methods in bringing forth the importance of materiality for research, policy and practice. We conclude by identifying potential areas of interdisciplinary practice and future research on the material matters of water/s and infrastructures that engage with the interplay between ecological, hydrological, technical and social processes.

Water matters: Plural articulations of materiality and the agency of hydro-social assemblages

The papers in this collection highlight how the materiality of water is inherently plural and always evolving. One way in which they illuminate the plural articulations of the materiality of water is by examining how it is co-constituted through its entanglements with other living organisms (e.g. larvae and microbes), chemical compositions (e.g. corrosive salt), and changing physical properties (e.g. colour and taste). For instance, Tatiana Acevedo-Guerrero (2022) focuses on the material properties of water stored in open containers by low-income dwellers seeking to cope with everyday water shortages in informal settlements in Barranquilla, Colombia. She conceptualises stored water as ‘a place of fertility’ (2022: 1), in which *Aedes aegypti*, the vector for zika, dengue and chikungunya can breed. Here, the materiality of water is not intrinsic and is always more than just physical. *Water with larvae* is the outcome of structural processes that generate uneven water circulations in the city and the need for storage. The exposure of water tanks to organic materials, air, heat and sunlight, in turn, transforms the material properties of water in ways that foster the entanglement of water with dengue, zika and chikungunya pathogens and human bodies. In underserved urban areas, therefore, ‘home’ becomes a hydrological, hydro-social and socio-ecological assemblage of viral risk linked to stagnant water infrastructures in the proximity of the house. Everyday hydro-social risks at the household scale are also central to the work of Maria Christina Fragkou (2024). She draws on feminist political ecology and urban metabolism scholarship to explain how water supply solutions to cope with climate change are socially, materially and emotionally metabolised by residents in the Chilean city of Afagosta. The study combines a survey on water use practices and treatment at household scale, perceptions of quality and the analysis of the physical properties of drinking water, that brings to light volumes distributed, pressures, quality standards and organoleptic characteristics. The paper thereby demonstrates the importance of accounting for water’s material properties and flow attributes to understand household practices and foster water security in the face of intensifying climate change.

Similarly, Santiago Gorostiza et al. (2022), focus on substances in water by engaging with the changing chemical compositions of *water with salt* and the resulting corrosive flows and faulty materialities emerging from a brine collector assemblage in Spain. The collector is conceptualised as a technological fix to the increased salinity of rivers, caused by mining companies and affecting the textile industry and the drinking water supply of Barcelona. Operationally, ‘fixing the problem’ entails directing corrosive flows of water with brine from the mines to the sea through a large underground pipe. Attending to the organisational everyday of the brine collector failures and leakages, and the fragility of institutional arrangements, the authors engage with the ‘precarious materiality’ of the collector and the ‘corrosive agency of brine’, threatening non-living and living matter, over a period of 30 years (Gorostiza et al., 2022: 5). Although the brine collector was reassembled between

2008 and 2011 as a ‘technological fix to the technological fix’, the reconfiguration is conservative rather than transformative. The brine collector’s resilience and capacity are augmented, thereby increasing mining production and corrosive brine flows in an already fragile assemblage. The paper thereby reveals that the agency of brine extends beyond its material properties, as it is co-shaped by historical, socio-political, and economic processes that have continuously prioritised mining over environmental and social goals.

While these papers reflect water’s entanglement *with* other materialities, *lively waters* emphasise the dynamic processes where living beings, such as microbes, actively reshape the materiality of water itself. Elliot Hurst and colleagues (2022) engage with the agential properties of lively matter by attending to the intra-actions (Barad, 2007) of plants, microbes, and animals in two (waste)waterscapes in rural India. They examine and conceptualise constructed wetlands as lively infrastructures that rely on ‘processes involving other-than-human living beings’ for the production of knowledge on wastewater quality (Hurst et al., 2022: 1). Empirically, lively water is traced through *Escherichia coli* enrolled in hegemonic approaches of water quality testing, the intra-action of plants and wastewaters that reveals water quality and guides everyday farming practices, and human–snakes violent interactions engendered by the presence of wastewater. Here, materialities of water are characterised as simultaneously agentic forces and a form of knowledge produced by ‘material-semiotic actors’ that ‘transform matter and shape waterscape meanings’ (Hurst et al., 2022: 1). The authors thereby call for greater engagement with aquatic life in hydro-social scholarship as a way of extending critique from concerns of uneven waterscape to multispecies justice.

In other papers, the plural articulations of materiality are illuminated through the exploration of intra-actions with other more-than-human natures. Here, the materiality of water is *more-than-water* not only because it is socially produced, but also because it emerges from engagements with other materialities and their inherent properties. For instance, Elisa Savelli et al. (2022) trace the materiality of drought to historical and contemporary intra-action of multiple human–non-human agencies. They examine the historical legacies and biophysical processes that transformed the 2015–2019 drought in Ladismith (Western Cape, South Africa) into a severe socio-ecological crisis. To this aim, the paper places political ecology, material geographies and hydrology into engagement and conceptualises droughts as ‘socioecological phenomena coproduced by the recursive engagement of human and non-human transformations’ (Savelli et al., 2022: 1). Empirically, the work explores the intra-actions between colonial and post-colonial processes of water and land dispossession, the commercialisation of agriculture and the agential properties of soil, vegetation and microclimate. These intra-actions, the authors argue, ultimately rendered the region vulnerable to the recent drought, which affected more severely black landless workers. The authors thus conclude that conceptualisations of drought as socially produced water scarcity conceal the agential property of soil, vegetation and microclimate that co-produce drought and their uneven outcomes.

Another central question of this SI concerns the ethical and political implications of pluralising the materiality of water. Specifically, some papers explore the potential for political innovations and collective action, as well as for composing more just and carefull hydro-social assemblages. Drawing on Barad (2007) and Latour (2004), Judith Tsouvalis (2023) asks how departing from the ontological position of the inseparability of multiple agencies emerging from (rather than preceding) intra-actions can contribute to address matters of concern and foster better human–environment relations. Empirically, the paper examines the ‘intra-active collective politics’ of Loweswater Care Project (LCP), an inter- and trans-disciplinary group emerged to trace and address the formation of cyanobacteria in the Lake District (Tsouvalis, 2023: 1). Engaging with the interplay of land-use-water and of deep-time geomorphic and hydrological processes enabled group participants to pluralise materialities of cyanobacteria and intra-act with multiple human–non-human agents, including sediments and rock, rivers, sheep, phantom midges, policies and water management

practices. This, in turn, changed their approach to addressing the ‘problem’ with algae, demonstrating that composing better socio-natural worlds requires ‘humility on our part and a slow pace of proceeding, which will allow us to feel what is at stake and for whom, and to forge new connections that could have better outcomes for all’ (Tsouvalis, 2023: 17).

Attention to political innovations and collective action is also central in the work of Edwin Rap et al. (2022) on radical reassemblages. Radical reassemblages refers to the ‘agency of a pumping collective in renewing and reassembling itself’ and to the ontological inseparability of its constitutive elements: infrastructure, people and water flows (Rap et al., 2022: 1). Empirically, the paper examines the life history of a pumping collective located in an irrigation system in Egypt from colonial times to its most recent transformations. This, they propose, requires paying attention to the material properties of infrastructure ‘in use’, and how these are transformed in emerging assemblages. The most recent transformations of the pumping collective reveal its ‘remarkable agentive capacity to reassemble’ in response to increasing water scarcity and political unrest in the region (Rap et al., 2022: 18). The authors conclude that de-centring agency in irrigation management systems carries important epistemological and axiological implications. First, it reveals that the success of an irrigation system cannot be explained solely through design principles; rather, it is dependent on the transformational capacity of the pumping collective. Second, it highlights that transformational capacities are shared across human–non-human collectives. The authors thus conclude by emphasising the need to move beyond nature–society dichotomies both in research and policy processes.

The material properties of infrastructure ‘in use’ are also central to the work of Alejandro De Coss-Corzo (2022) on everyday future imaginaries of water supply in Mexico city. Here, the material properties of the water network, illuminated by the mediating role of infrastructural labour, ‘enable the emergence of specific futures’ of hope and collapse (De Coss-Corzo, 2022: 4). Ethnographic work conducted by Alejandro De Coss-Corzo (2022) in Mexico city reveals how the organisational everyday of infrastructural failure, management and repair has material consequences on the way the future is imagined and experienced. Infrastructural futures are engendered in the different ways engineers and workers relate to the material conditions of the water supply network and the distinct forms of labour they perform to sustain the system. Workers that routinely engage with the network at the moment of breakdown increasingly perceive their everyday practices of maintenance and repair as insufficient and ineffective. For them, the future of collapse is materialising and irreversible. In contrast, engineers focusing on collapse avoidance enact a future of hope grounded on continued hydraulic expansion.

The last subgroup of papers brings questions on socio-technical and techno-legal assemblages (Barnes and Alatout, 2012) into engagement with Indigenous ontologies of water and the implications for water management in settler colonial contexts (cf. Laborde and Jackson, 2022; Yates et al., 2017), examining California’s groundwater governance as vertical frontier-making (Underhill et al., 2022) and the scalar politics of Indigenous waterscapes in Navajo Nation and Nepal (Mustafa et al., 2021). Vivian Underhill et al. (2022) draw on feminist Indigenous scholarship on the persistence of settler colonialism and frontier-making processes to situate and critique contemporary policy responses to groundwater depletion in California. By tracing water flows materially and discursively from the end of the nineteenth century, the paper illustrates the central role of the making of water as a productive resource for settler agricultural practices in the colonial project of Indigenous dispossession. The authors propose that water and hydraulic infrastructures continue to be mobilised to push the vertical groundwater frontier in California. While acknowledging groundwater depletion, the notion of sustainability promoted by California’s Sustainable Groundwater Management Act fails to challenge the frontier-making processes and the racialised, exploitative division of labour on which it depends. Therefore, sustainability, remains ‘predicated on entangled technologies of frontier-making, racial capitalism, and settler colonialism’

(Underhill et al., 2022: 3). They conclude that dismantling settler sustainability requires centring Indigenous self-determination, sovereignty and ontologies of water.

Relatedly, Daanish Mustafa et al. (2021: 3) conceptualise enactment of indigeneity for the Diné and the Musahar Peoples as the ‘constant process of reclaiming ontological space’ in response to the techno-legal assemblages of US and Nepali states that frame water as a ‘resource’ to foster Western visions of development and conservation. In the United States, the techno-legal assemblage of dams and the Prior Appropriation doctrine is contested by the Dine Nation through competition with and ‘reluctant co-option’ in the European tourist economy, as well as by ‘staking out an alternate ontological claim’ to the developmental waterscape of the American State (Mustafa et al., 2021: 14). In Nepal, techno-legal assemblage of the Chitwan National Park (CNP) and the related conservation policies, informed by the global conservation development agenda, foreclose access to the Narayani River for the Musahar. This conservationist waterscape is contested by the Musahar through rule-breaking and performing alternate ontologies of water. The paper thereby shows how across different geographical and historical contexts, indigeneity is never erased and is re-enacted through symbolic and material practices that story and assert Indigenous sovereignty over land and waters.

All together these papers show that pluralising water’s and infrastructure’s matter/properties can advance geographical scholarship in several areas, including the historical and geographical processes of knowledge production (Hurst et al. 2022; Tsouvalis, 2023), hydro-social risk in the face of climate change (Acevedo-Guerrero, 2022; Fragkou, 2024; Savelli et al., 2022), the transformative potential of socio-technical assemblages (Rap et al., 2022; Gorostiza et al., 2022), the production of water and infrastructural futures (De Coss-Corzo, 2022) and the ontological politics of water, development and sustainability for Indigenous peoples enacting their sovereignty over land-and-waters, within water management systems that persistently uphold coloniality (Mustafa et al., 2021; Underhill et al., 2022). The papers also show that a focus on the materialities of water is neither myopic nor narrow. Collectively, the papers reveal how the plural materialities of water are always shaped by, and shape, structural processes and everyday practices that co-constitute both the materiality of water and the infrastructures through which it flows. Concurrently, a focus on water’s and infrastructure’s matter/properties raises important questions about the kinds of methodological innovations needed and the alliances that might be forged to meaningfully engage with materiality. Below, we discuss how the papers in this collection address these questions.

Methods matter: Working with plural materialities and temporalities

The third thread emerging from this collection of papers is that methods matter for interdisciplinary, community and more-than-human knowledges. The papers demonstrate a range of diverse methodological resources that can be used to account for the materiality of watery ecologies and hydraulic infrastructures, and to story and reveal how humans and more-than-humans adapt to or alter hydrological flows and other material matters of water, including excess waters, contaminated and polluted waters, water-with-viral-vectors, water-as-property, water-as-life, water as decaying, absent or as unevenly distributed.

One way in which the papers in this collection are innovating in their research is by developing methodological approaches that extend interdisciplinary collaborations, bridging natural and social sciences. Despite being increasingly invoked as way to apprehend ‘the power concealed in hydrological flows’ and develop a ‘more explicitly relational study of water in society’ (Krause and Strang, 2016: 663; Krueger and Alba, 2022; Rusca and Di Baldassarre, 2019: 10; Wesselink et al., 2017), interdisciplinary water research that crosses natural and social sciences remains relatively limited, particularly in terms of effectively engaging qualitative critical social sciences alongside natural sciences. These fields are often presented and experienced by researchers as

ontologically, epistemologically, axiologically and methodologically incompatible (Sharp et al., 2011). Yet, several papers in this collection are developed by interdisciplinary teams and scholars, demonstrating that interdisciplinary collaboration can advance waterscape research in new and innovative directions. For instance, interdisciplinary engagement to advance understandings of socio-ecological complexities of current water systems is central to the work of Savelli et al. (2022). Recognising the politics of the social construction of water scarcity (Mehta, 2007), whilst also drawing on hydrology scholarship that traces the agential properties of complex, multifaceted processes of droughts (Loon et al., 2016), the author team, composed by hydrologists and political ecologists, generated ‘hydrological accounts of droughts [that are] less politically naive and socially blind’ and a political ecology of droughts that is attuned to the multiple materialities of water, soil, vegetation and microclimate (Savelli et al., 2022: 1). Similarly, Rap et al. (2022) draw on critical water scholarship and in-depth technical-engineering knowledge of technology to trace the transformations of a socio-technical pump assemblage. This methodological approach allows for a more nuanced account of the distributed agency within the assemblage, capturing how social processes and the technical components of the pump co-shape the ways this infrastructure is used and reassembled over time, reconfiguring water flows within the irrigation system.

A second area of methodological innovation in this collection involves placing interdisciplinary water research into engagement with community knowledges, fostering new forms of co-produced knowledge on the materiality of water. The papers thereby illuminate the relevance and richness of different forms of knowledge without establishing a hierarchy between them. For instance, Hurst et al. (2022: 1) place hydro-social scholarship into engagement with more-than-human geographies and ecology as a way to examine the role of ‘other-than-human living beings’ in transforming water quality. Through this approach, the researchers are well placed to engage with scientific and community knowledges of the human and more-than-human lives entangled with water quality and to critically examine established, and all too often taken for granted, Western-centric water quality assessments, which overlook other ways of knowing contamination and healthy waters. Different forms of community and scientific knowledge are also central to the work of Tsouvalis (2023). Here multiple forms of knowledge and methods from a range of actors—including residents, non-governmental organisations (NGOs), government, farmers, business owners and natural and social scientists—are mobilised to explore intra-acting agencies of cyanobacteria. Drawing on Barad (2007), the author argues that the phenomenon of cyanobacteria does not exist prior to, but rather emerges from, the intra-action of these agencies, which are thus ontologically inseparable. In this context, scientific modelling on land use and water quality is used as a heuristic device to perform what Barad (2007) has termed agential cuts to separate and examine components of the assemblage. Concurrently, a close engagement between critical geographies of water and the scientific field of hydrogeology revealed how ‘deep-time and Loweswater’s ancient fabric [...] matter in Loweswater to this day’ (Tsouvalis, 2023: 11)—not only as a conceptual leitmotif but as a material force that actively shapes the contemporary social and material landscape of the area.

This brings us to the last methodological contribution of this collection, which emphasises the importance of apprehending multiple temporalities when engaging with the agentic properties of different more-than-human beings and materialities. In material geographies, longitudinal analyses are essential to capture multiple and heterogenous human and non-human agencies that may work on different temporal scales. Whether to link current climate-related phenomena like droughts to complex colonial socio-ecological histories (Savelli et al., 2022), to illuminate life histories of infrastructures and capture transformations of socio-technical assemblages (Rap et al., 2022) or to explore the corrosive agency of matter and capture historical evolution of assemblages (Gorostiza et al., 2022), or to illuminate settler colonial legacies inscribed in contemporary definitions of groundwater sustainability in California (Underhill et al., 2022), (deep) time matters (Tsouvalis, 2023). The methodological innovations presented in this collection—hydrological

modelling, walking landscapes/hydrogeomorphology, life histories of infrastructures, historical analyses, remote sensing, drawing on or developing longitudinal datasets on vegetation, precipitation and other non-human natures—thereby also become a strategy to decentre human agency in human–water temporalities.

Critical water studies at a critical juncture

This special issue is published at a pivotal moment for critical water studies and wider scientific research. In the face of intensifying climate change and complex, intersecting water-related challenges, critical questions arise about the forms of knowledge needed not only to advance scientific understanding of these processes but also to foster more inclusive and just futures.

We, the editors, are particularly inspired by two research directions emerged from this collection of papers, which we believe can innovate future research in critical and interdisciplinary water studies and generate knowledge that can foster transformative change. First, the Special Issue speaks to a broader water scholarship, extending beyond critical geographical perspectives. It offers novel insights to natural and engineering scientists examining the interplay between human and environmental systems, particularly within the frameworks like social-ecological systems and socio-hydrology (Baldassarre, 2024; Folke, 2006; Sivapalan et al., 2012). The collection of papers demonstrates how human–environment systems are shaped by a multitude of interconnected forces, including infrastructure, living organisms, and socio-political processes. Interdisciplinary fields of social-ecological systems and socio-hydrology can learn from and be inspired by the approaches in this Special Issue, where analytical methods explicitly incorporate water as part of a broader assemblage—one in which human decisions, infrastructure, ecological processes and physical properties co-evolve. This conceptualisation can enhance the explanatory power of descriptive models, by capturing more fully the complexity of human–water systems. Moreover, this Special Issue brings attention to critical issues of justice, ethics, and the co-production of knowledge. While socio-hydrology and socio-ecological systems traditionally focus on the interactions between human and hydrological/environmental processes, the papers in this collection highlight the need to expand these frameworks to address the socio-political dimensions of water management, particularly the importance of marginalised voices and diverse (more-than-human) perspectives and experiences.

This brings us to an important second research direction emerging from these papers. While one aim of critical research is to understand how the world functions—and, perhaps more crucially, why it sometimes fails to function as it should—another equally important aim is to envision and propose alternative ways of living together that foster more just and sustainable relationships with the planet and its ecosystems. The papers in this collection demonstrate the transformative potential of locating agency across human and more-than-human natures. Collectively, they show that focusing on plural materialities can generate deeper insights into how to compose more equitable and just human–environment relations and socio-natural worlds. The Special Issue brings to light concepts such as humility and care-full hydro-social assemblages, calling for a deeper engagement with multispecies justice and advocating for a deliberately slower, more reflective approach to shaping human–environment relations—one that can generate better outcomes for all. It is our hope that this Special Issue will inspire others to engage with and expand these new research directions for critical and interdisciplinary water research.

Highlights

- The papers in this collection highlight that the materiality of water is inherently plural.
- Pluralising materiality of water and infrastructure extends conceptualisations of agency, justice and care in hydro-social assemblages.

- Methods matter for interdisciplinary, community and more-than-human knowledges.
- The collection offers novel insights to natural and engineering scientists examining the interplay between human and hydrological systems.


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