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# Geography $H_2O$: Compounding Water Studies

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## Abstract

This paper sets fire to watery debates, using fire to rethink studies of water. Water, as applied to fire, requires understanding the substance in its molecular form – as a compound. Thinking of water beyond a binary as $H_2O$ (rather than as salt or fresh) enables a further reframing of what water is, and hence what water can do, and its capacities for society and space. Focusing on the perhaps unusual example of fire extinguishment and the development and operation of automatic sprinkler systems, drawing from the Manchester Museum of Science and Industry archives and from developments of the Manchester-based firm Mather and Platt, this paper asks what water's formulation of two-parts hydrogen and one-part oxygen does or can do through its material compounded, tri-part form. In doing so the paper makes 3 core contributions: (1) to geographies of elements, urging for a focus on the capabilities of *compounds* as well as singular classical and periodic matter; (2) to geographies of fire, pitching for studies that move beyond environmental scholarship of fire's links to the climate crisis towards fire in other socio-cultural, economic and political contexts; and (3), to the development of water studies, arguing for a shift beyond the binarised thinking that often splits geography between bodies of water, creating separate bodies of scholarship on the topic. To do so, the paper demonstrates how $H_2O$ has been harnessed and applied – not as an either/or, but as a compound, where its elemental combination is crucial to its work. In sum, the paper works with fire to work with water, presenting further ontological inroads for thinking with/through/about water worlds.

*Keywords*

Water, Fire, Salt, Fresh, Sea, Compound.

## (Surprise) introductions?

This is a paper about fire. From the title you may be somewhat surprised. But fire and water have an intimate, intricate, interrelated connection. Water is the means, more often than not, to quell fire. To stop fire. To put out the flames. But whilst water can extinguish (some) fires, it can also feed them. Traditionally oil and water do not mix, for example, and water will, generally, not stop an oil blaze. Water and electricity are also a dangerous combination. Further combustion, more sparks, are likely to follow. But this paper draws from a particular 'spark': an interest in the ways geography and geographers have been, and currently are, dealing with water in their vast and varied work. It uses fire, perhaps unusually, as conduit for this discussion. Indeed, this paper works with fire in order to work with water, presenting further ontological inroads for thinking with/through/about water worlds. This is because, for some time, and in conversation with other colleagues, notably Australian geographer Leah Gibbs (see 2014), I was beginning to wonder if the seas and oceans we, and others, were studying were not the fluid, churning, mobile, voluminous masses we'd been positing them as (see Steinberg and Peters, 2015). Rather, I wondered if they were rather more bounded, fixed, stuck; separated, niche, disconnected. Like putting water near electrics, something sparked. Like tipping water on oil, ideas came spitting out, igniting.

The way geographers have dealt with 'water' is somewhat binarised and bordered. In over a decade of working with water, I have never once (until now) cited Erik Swyngedouw who has written prolifically about water (see, notably 2004). Only recently have I cited Farhana Sultana on water and its fluid properties in relation human life (2009) and its emotional connections (see 2011), in spite of plenty of marine and maritime work on feelings and affects of engaging seas and ocean. I hadn't cited her work in view of debates around resource justice (see 2018), even though justice at sea is a crucial topic, not least in respect of ocean grabbing (see Bennett *et al*. 2015; Franco *et al*. 2014 and Foley and Mather 2019). I knew Alex Loftus but hadn't used his work either (see Sultana and Loftus 2013, 2019) on rights to water, even as rights to the sea are currently at stake with the entry of a new legally binding agreement on oceans made in 2023, the BBNJ, or 'Biodiversity in Areas Beyond National Jurisdiction' treaty – the biggest addendum to the Law of the Sea in decades. I hadn't quoted Filippo Menga (with Swyngedouw, 2018) on fresh water, power and technology, in spite of the intersections and overlaps in ocean worlds where 'tech' is becoming crucial in modes of ocean use and abuse, extraction and exploitation (see for example, debates on deep sea mining, Zalik, 2018). I hadn't used his work on transboundary water governance issues (Menga, 2016), although the transboundary issues with ocean governance are stark (see recent work by Ansong *et al.* 2021 on governance challenges of Marine Spatial Planning, or longstanding research by Steinberg, starting in 1999, on political line drawing in the ocean). I hadn't cited Veronica Strang (2015) who has a book named *Water*. The list goes on. And on. Oil and water do not mix apparently. Neither do salt and fresh it seems. They weren't/aren't, citing 'us' ocean folks often either.

Fire, I argue in this paper, allows a potential reflection on the way we approach water in geography, and as geographers. It does so by thinking of water in its complex *molecular* make-up rather than water in its singular, constructed categorisations 'fresh' and 'salt', 'sea' or 'stream' (which are false binaries anyway, fresh water for example is rarely 'fresh' in that it contains varying degrees of minerals, and likewise 'salt' and 'fresh' coalesce in different spaces, such as the estuary). Indeed, 'fresh' water, as the literature in this area reveals, is far from singular. It is incredibly complex: it can be in short supply or abundance. Clean or dirty. It can be harnessed and deployed. It can wreck devastation through flooding or leaks. This results from the complicated composition of water in relation to society, space and politics (see again Sultana and Loftus, 2013 and 2019). Likewise the salty ocean is not singular. Some seas and the minerals that combine with them make it saltier still, or denser, or heavier, with ramifications for (more than) human engagement (Mentz, 2020). Accordingly, and rather strangely then, geographies of multiplious water worlds are already fairly complex, yet that complexity somewhat erodes through a disciplinary compartmentalisation that streamlines water types into often distinct fields. This may be because the topics linked to water may be different and by default pull bodies of water apart (i.e. studies of fresh water relate often to issues of development and drinking water availability – we do not drink ocean water, so a separation is made through the framing of interests brought to bear on water). Nonetheless, this siphoning of water results in a duplication of ideas where scholars are working with a similar substance, writing about similar concepts or themes, but remaining in separate streams.

Now of course, it would be possible to investigate the separation of salt and fresh water geographies without setting fire to them. But this paper is not simply about this binary in geographical thought. It also aims to make two further contributions. First is to consider whether a different modality of understanding, or different vocabulary of expression may help in unpacking water's capacities – that of $H_2O$ – which configures water not as either/or but as a particular physical *compound*. To this end the paper is also about thinking of compounds, rather than singularities and what compounding studies – combining and mixing them – might do. As such, the paper contributes to geographies of elements/elemental geographies (see Adey 2015, Englemann and McCormack 2021), urging for a focus on the capabilities of *compounds* as well as singular classical and periodic matter. Moreover, fire, as I will go on to show, offers a framework for thinking about the capacities of water, whether salt or fresh, to think instead about what that physical compound *does*, bringing salt and fresh together – in one discussion. The paper thus furthermore offers an extension to work under the remit of 'geographies of fire' (see Neale, 2018, Pyne, 2009) pitching for studies that move beyond environmental scholarship of fire's links to the climate crisis towards fire in other socio-cultural, economic and political contexts.

So, this is a paper about fire. Sort of. If you were expecting a paper about water, it might be a let-down because really, it is about relations of fire *and* water and about *compounding* water studies. It is about setting fire to existing watery debates, watching if they burn, and seeing what is left in the ashes. And, like the science of understanding compounds, it about seeing what mixes and what results. It is a bit of an experiment. To begin this experiment, the paper is set out as follows. It starts with a further discussion of geographies of water, fresh and salt, drawing out their commonalities – *compounding* them. It then turns to geographies of fire, briefly, to set out its usefulness for thinking of water as compound. Next it switches to empirical material of fire extinguishment with water (notably the development of sprinkler systems) to illustrate the possibilities of thinking of water as $H_2O$ Here it draws from archival material held at the Manchester Museum of Science and Industry and a set of in-depth oral history interviews[1] of an employee of one of the firms at the centre of fire protection development, Mather and Platt (whose Manchester factory also features in the infamous 1943 L S Lowry painting 'Going to Work'). Using these materials, situated firmly in the UK's industrial heartlands of the North West, the paper uses watery histories of fire-quelling technologies to examine the potentials of a 'Geography $H_2O$'. Indeed, the paper concludes by speculating what thinking of water as $H_2O$ might offer as a frame of thinking, as well as positing that studies of fire might usefully move beyond current examinations (focused predominantly on harnessing fire for environmental and agricultural purposes, to studies of wild fires and biodiversity loss). It argues that *compounding* might be productive in thinking of society and space relations.

## Water studies

In 2014-5 two books were published with the same name. One titled *Waterworlds: Anthropology in Fluid Environments* (Hastrup and Hastrup, 2015) was most certainly a study of water but not the water of seas and oceans. Chapters covered the politics of groundwater in Kiribati (Robertson, 2015) and the Sahel (Reenberg, 2015), lagoon spaces (Rubow, 2015), rainwater cycles in the Andes (Stensrud, 2015) and water's spiritual and moral properties (Vium 2015). Only one chapter *edges* towards the ocean, an examination of the Arctic ice edge, where water is configured not as sea, however, but as 'land' (see also Steinberg and Krisstoffersen, 2015). The other book was also called *Waterworlds* but with a different subtitle: *Human Geographies of the Ocean* (Anderson and Peters, 2014). Here, the chapters could not have been more different, covering ocean knowledges (Laloë, 2014), and embodied experiences (Anderson, 2014), more-than-human ocean worlds (Peters, 2014) and fisheries governance (Bear, 2014) and links to livelihoods (Hallaire and McKay, 2014). The word 'water' and the kinds of 'worlds' these books spoke of, were quite separate.

These books exemplify a problem with the ways geographers have been – and arguably continue to – work with water. Water, as a topic of study for geographers (and indeed other social scientists) has been consistently afflicted with multiple layers of binary thinking. The marginalisation of the sea in geographical scholarship, for example, has often been accredited to the *centrality* of 'earthly', grounded thinking in Western scholarship (see Jackson, 1995; Lambert *et al.* 2006; Peters, 2010; Steinberg 2001; Mack 2013). Work tells us that the seas are the 'margins' of 'academic vision' (Lambert *et al.* 2006, 453). As Mack notes, "[t]he seas are either [seen] as the backdrop to the stage on which the real action is seen to take place – that is, the land – or they are portrayed simply as the means of connection between activities taking place at coasts and in their interiors" (Mack, 2013, 19). This echoes an earlier assertion by Steinberg that "[t]he ocean … [has been] idealized as an empty transportation surface, beyond the space of social relations … The ocean … became constructed as *outside* society and the terrestrial spaces of progress, civilization and development" (Steinberg 2001, 114, emphasis added). As such, the sea is held in a binary to 'land' and landed life. In freshwater studies too, a dominance on 'landed' processes has prevailed, positioning water as somehow 'different' or 'other' to the central concern – that of grounded realities. Indeed, the study of rivers has traditionally been characterised by a predominant focus on the dynamics erosion and deposition – those cuts the water makes in the 'solid' earth – over those of flow and fluidity. Scholarship has oftentimes focused on the cities that emerge on their landed banks, or the geopolitics of nation-states that run through them (see Smith 2021). Ironically, where water is now taking centre stage, binaries persist, as noted, with a significant lack of dialogue between the 'salt' and 'fresh' and a stark absence of conversation between the two.

1. The paper draws on a set of three oral history interviews conducted in 2018. Each interview was in excess of 2 hours. The interviewee was selected for their lifelong history in the industry, and with the major firm responsible for the technological development and rollout of fire protection devices such as sprinklers. Other oral history interviews are planned, snowballing from this initial contact. Like all interviews, the ones used offer not a representative view but a subjective, partial and situated perspective with the strength of the data laying in its depth and specificity rather than in any knowledge that is the basis for making generalizable claims (see Peters 2017). The particulars of this method are detailed in the section 'Compounding methods', to follow.

It is important to note that these binaries are built around western ontologies – ways of knowing that denigrate water as 'other' to land. The binaries that this paper refers to have been long dismantled by work that has refused to draw binaries in the same way that has been determined by much western philosophy (as noted by Descartes, with separations between states: body and mind etc.) Indigenous scholarship, for example, draws understandings from lived realities of entanglement and connectivity between land and sea, and differing water bodies: sky and sea (rain and ocean) (see Hau'ofa 2008, and more recently George and Wiebe 2020, and Lobo and Parsons 2023). These ontologies offer a vital reading to the ways water is understood. The Geography $H_2O$ proposed here is a rather different response to the persistence of dualities in water's disciplinary treatment.

As documented in the introduction, in spite of the 'fluid' concerns of both sets of scholars, there is still an apparent lack of work that transgresses water's saline boundaries. One prohibiting factor may be the very terminology used. Sea and ocean scholars rarely use the word 'water' (the book title above being an exception). 'Water' seems to be the domain of freshwater scholars, with those focused on the seas and oceans using this more specific terminology. Yet the two are talking about the *same* classical element, or elemental compound. But studies of water are not *compounded.* More often than not, despite reference to complex relations *with* the substance, the substance itself for scholars of fresh and salt water, is dealt with largely in the singular.

This is in spite of both 'camps' of scholars writing about water's material properties. Water is spoken of as solid, liquid and gas, of the substance as moving and motionful (see Steinberg and Peters, 2015). But it is not often spoken of in view of the physical processes whereby the constituent atoms that *compound* to form water can shift to make solids, liquids and gases based on their 'arrangement', forged by energies upon that compound structure. How multiple forms of water as $H_2O$ may act or react with other substances in a chemical, physical sense is under-examined, alongside a consideration of its densities or intensities, velocities or the range of water based on $H_2O$'s linkages to other elements. Indeed, water is hardly ever (indeed, never) pure. Pure water is virtually "non-existent in the natural environment. Natural water, whether in the atmosphere, on the ground surface, or under the ground, always contains dissolved minerals and gases as a result of its interaction with the atmosphere, minerals in rocks, organic matter, and living organisms" (Water Encyclopedia 2023). These edit water's capacity. This is why sea water is not like 'fresh' water, and fresh water is definitely not a singular category either, with likewise some seas having different chemical compositions than others.

Yet a singularity persists. In work which began to think seriously of water as an element and of the elements geographically (Peters, 2018) – this in addition to work already conducted on the geographies of earth, fire and wind/air (Adey, 2015; Engelmann and McCormack 2021) – water as a substance beyond binary categorisations began to emerge. But it was still treated as a singular planetary feature: the classical element of 'water'. Although now not scientifically sound, the classic 'elements' have fuelled the academic imagination (see Bachelard for example, 1988). But, whilst there is some merit in thinking of water as a worldly, classical element, it is not, of course, an *element* in the scientific sense. Water remains something of a classic element, a singular 'thing' in much work – salt and fresh. But thinking with elements – in this case the 118 'base' elements of the modern periodic table, may well be helpful (Romero *et al*. 2017). Water, is of course, a *compound* mixture of three, of two types of elements – hydrogen (two-parts), oxygen (one-part), and everything else that might gather from its surrounds, calcium, magnesium, sodium etc. Thinking of it in this way allows it to shift beyond the singular, and binaries, to an altogether more compounded understanding which may allow for different academic purchase in making sense of society space relations – in settings across saline divides.

## Fire studies

Fire may also be understood as a classical element. It is one of the so-called 'foundational' elements of earth and life (Peters, 2018). In recent years geographers have become increasingly interested in the dynamics of fire, its spatial qualities and its intersections with (more-than) human life, although work remains limited. Even though the subject of fire has cropped up in geographical work for some time (not least in some physical geography studies (i.e. on biomass fires or wildfires), the work of environmental historian Stephen Pyne (see 1997) was to develop it as an area of interest (coinciding ironically, with a growth in work on seas and oceans too, see Steinberg 1999 for example). Here, Pyne was to explore 'cultures of fire' and the anthropogenic harnessing of fire and controlling of fire across time and space (see Pyne, 1998, 2001 for general texts and 2011 and 2012 for those in the specific contexts of North America and Europe respectively).

In 2009, Pyne was to outline a manifesto for the importance of fire to the discipline (see 2009). As he notes, "the human geography of fire is little studied even by disciplines for which it would seem ideal" (2009, 443). Pyne's work especially, has centred on relations not just of societies through time, but the intimate relations between fire and the earth and earth histories, where ecologies have been shaped by the advent of fire – for which people are often singularly responsible (Pyne, 2009, 445). He has explored fire's use for reshaping planetary relations through agriculture, to the harnessing of fire for combustion and its associated industries, drawing lines to what this has wreaked for the planet (see 2009, and also 1997, 2001). For Pyne, the view of fire is an expansive, macro-scale perspective, teasing out its relations in and with the world and its various peoples.

From here, geographical work has built from Pyne, but remains still somewhat partial (not least compared with research focused on 'earth', 'water' and 'air' as the other classical elements, or other planetary processes – flooding, hurricanes, earthquakes and so on). Although Pyne demonstrates humanity has long harnessed fire, the discipline's own harnessing has been rather lacking. The most significant fiery developments have been those in environmental geographies and political ecology that have investigated wild fires and responses, as well as their intersections with climate change (see Gibbs, 2021; Neale 2018). Other work has explored the planetary relations of fire (Clark and Rickards, 2022), power of combustion (Clark and Yusoff, 2014), and also its geopolitics (Dalby, 2018).

On a different scale and through a different frame, some work has focused on specific modalities of fire-society relations through fire prevention. Notable here is O'Grady's critical work on the British Fire Service, using frames of spatial security and future governance as a lens for working with fire (see 2014, 2018). This is also a feature of work by Corcoran *et al*. (2016), which is focused on fire management. The paper here builds from, and departs from, earlier work. It focuses, likewise, on fire prevention and pre-emption and in doing so, compounds fire *with* water. It also homes in on a rather more micro-scale, yet arguably, expansive technology and technique of watery fire management – the sprinkler. Indeed, sprinklers are largely overlooked in the literature (with just one reference in the Corcoran *et al.* piece, for example, 2016, 182). This paper hence not only posits for a compounding water studies but also mixing them with fire.

## Compound methods

My interest in fire and its relation to water is a result of a particular familial compound. A bond of father and daughter. As a child I always thought my dad worked with fire. Now I am older, now time has passed, now I understand; I see things differently. My dad has always worked with water. He wasn't a firefighter, on the frontline, putting out the flames. He was someone careful, methodical, positioned in the background. He designed fire prevention devices. In 1964 my dad began an apprenticeship with one of the first fire engineering firms, Mather and Platt, originating in Manchester. He was to gain employment in their south London office as a trainee draughtsman at the age of just 16 (James Peters, Interview, 2018). To be a fire engineer you have to understand how fire works – but also, notably how water, or rather, the specificity of $H_2O$ – works. He had to understand what feeds fire and keeps it moving but also how fire can be stopped – how it may be halted in its tracks. He had to be trained to understand how other elements and compounds – gases, solids and liquids – can react with fire; stoking it or dulling it.

A fire engineer typically designs the interior of buildings to immobilise the movement of fire should it occur. They design sprinkler systems, the positioning of fire doors, the kinds and types of hand-held extinguishers and other devices which must be present. They integrate smoke alarm systems as warnings of danger. Here I want to focus on my father's specialism – one of $H_2O$ and the water sprinkler system. Sprinklers are intricate systems of pipes, of hidden infrastructures in the carcass of a building that move water to various points, to be released on the advent of a fire. These complex sprinkler systems anticipate where the movement of fire will lead and where it might be dampened. They release water – $H_2O$ – in various structures and forms – to attend to specific intensities and types of fire.

For my father, understanding the properties of water – the H, the 2, the O – its structure and application, was fundamental to the ability to extinguish flames. For my dad, water isn't water. It isn't singular. It isn't divided by categories of salt or fresh of sea or river. There isn't a divide been solid ground and liquid water. They mingle. They work in the same space. Water is a compound and understanding the structure of that compound was vital to a lifetime's work. My dad and I were, and still are, bonded – somewhat differently, but ever closely –through working with water. We were dealing with the same 'thing' – a thing called 'water' but we thought about that 'thing' differently. One 'materially', 'metaphorically' but ultimately singularly. The other materially, certainly, but never metaphorically, never singularly. He thought about things chemically. What could such an approach reveal? What if we compound and make more complex geography by speaking of water in its physical form of $H_2O$?

This took me to the archives of the Manchester Museum of Science and Industry, which holds records pertaining to Mather and Platt, the North West of England company that was at the forefront of fire engineering innovation. It took me to the beginnings of sprinkler design, to the beginnings of particular applications of water where water as $H_2O$ – its chemical properties – are vital. Between 2017-9 various materials were viewed and reviewed, alongside items such as sprinklers and sprinkler valves. These were bundled in a large catalogued set (A2009.28.2 and A2009.28.3) which consisted of a range of documents including news cuttings, firm newsletters, industry magazines, centenary records, operational handbooks, personal correspondence, photographs and pamphlets. They were analysed using a variety of tools to unpack the meanings of the texts: from content to discourse analysis (see Peters, 2017).

Alongside the historical documents, I also conducted a series of oral history interviews with my dad, capturing the unique insight of an employee of the Manchester-based, world-leading fire protection firm, Mather and Platt and then Wormald, (who took over the company). There is a positional politics to working with family members. On the one hand, we should not discard those closest to us if they offer a window to respond to research enquiries shaping our work. On the other, it is important to acknowledge how familial relations (like any relationship between an interviewee and interviewer) shape the knowledge outcomes (Rose, 1996). My dad loved his job. He spoke often and openly about it. After the devastating fire at Grenfell Tower, he featured on a BBC 'Inside Out' documentary, detailing the issues with the building's fire protection. His phone was stacked with photos that to most people would have been nothing more than pipework, but to him, were a life-saving infrastructure, vital to 'get right'.

I had expected him to speak freely about his career and work but the setting of formal dates to discuss it, and the presence of a recording device, made for a stifled start. I learned quickly that my dad did not like to look back but to focus forwards: what difference could he still make, not what difference had he made already. Yet gently prompted over three sessions, he reflected helpfully on the relations of fire and water integral to his work, and to mine. His answers, to his daughter, were surprisingly (and a little uncharacteristically) modest for a man who liked to otherwise showcase his achievements in the pub. As such, what was provided was a richly detailed account of a changing industry over 40+ years, coded around themes of water, elements, compounds (and for an aligned paper, civil contingencies and securities). As Blunt notes "life stories in text and in person provide vivid and compelling accounts of everyday life, experiences and emotions on subjects as wide-ranging as human life itself" (2003, 86). And as Levine-Hampton notes, "[o]ral history interviews bring important perspectives to established historical and geographical narratives", enriching what may be learned in the 'official' records of archives (2022, 469). At the time of conducting the interviews my dad was still working full time in the industry. The interviews have since, themselves, become part of an archive of his life. My use of them is most likely now sentimental as well as practical to the concerns of this paper. Yet family histories should not be discarded because,

> [w]hile academicians can certainly belittle plebeian entertainments such as tracking great-grandpa's birth certificate or displaying great-grandma's quilt (perhaps under the label of naïve "heritage", (sensu Lowenthal, 1996) scholars must guard against assuming that … (this is) intellectually unassailable, and thereby dismiss the scholarly research potential of examining family history (Guelke and Timothy, 2016, 15).

Having discussed my approach, I next turn to the histories of fire protection, before shifting back to the empirical material noted here, to illustrate how it helps us think water differently.

## Situating fire protection: Towards Geography $H_2O$

The story of fire prevention using water – or rather the capacities of $H_2O$ – dates back hundreds of thousands of years (Pyne, 1997). The story of *automatic* fire protection dates back to the aftermath of the Fire of London, 1666, but the details of the device, patented by John Green in 1673, are sadly lost (see the Manchester Science and Industry Museum Archives A2009.28/2/34, Mather and Platt Fire Protection Handbook (n.d.) page 4). There are many twists and turns in the history of the development of fire prevention technologies, and a geography that spans from the UK, US to India, Australia, and back again. It is a story underscored by a politics of pre-emption (see Anderson 2010) and a debate over necessity. It is a story about cost, risk, insurance, life. It is a story just as poignant today with the recent fires in UK, notably Grenfell, which were centred not just on material failures in building design but fire extinguishing technologies, notably sprinklers (Kelly, 2020).

Sprinklers would become a revelation in automated fire extinguishing in the $19^{th}$ century, perhaps unsurprisingly coinciding with the Industrial Revolution and the 'other' revelation – the power of internal combustion engines as a means of fuelling other news means of automated production (see Clark and Yusoff, 2014). The growth of mass production in newly built factories, often mixing highly flammable components – cottons, wood, coal – meant that fire risks increased exponentially during this period, creating demand for other novel industries that could dampen the flames. Indeed, factory fires could result in huge losses for proprietors, of expensive overhead items: premises, equipment, pre- and post-production goods, as well as impacting the livelihoods of those working in such factories, reliant on the work.

Sprinklers were (and are), in essence, a simple idea. Water, distributed in pipes, could be released by the heat of fire by a temperature-sensitive valve, where the application of two-parts hydrogen, one part oxygen, could then cool and smother the flames. In 1806, inventor John Carey created what was one of the first sprinklers – effectively "a perforated … pipe system and controlled by weighted valves held closed by a cord; the burning of the cord automatically opened the valve" (Manchester Science and Industry Museum Archives A2009.28/2/34, Mather and Platt Fire Protection Handbook (n.d.) page 4). There was no record of commercial application of this system or "the forerunner to the present-day sprinkler system", attributed to a Major A. Stuart Harrison of the First Engineer London Volunteers' (ibid, n.d., 4). Rather, it was Henry Parmelee who "produced in 1874 the first automatic sprinkler to be commercially developed. It found rapid favour in the USA and in 1882 the first English installation of the Parmelee system was made in the cotton spinning mills of John Stones & Co. Astley Bridge, Bolton" (ibid, n.d., 4). One year later, in 1883, Frederick Grinnell of Providence, Rhode Island, USA, building from the Parmelee system "finally produced a sprinkler which achieved outstanding success". This was to be known as the Grinnell system (ibid., n.d., 4). The basis of sprinkler systems today, is the same system Grinnell invented in the late $19^{th}$ Century (Inspect Point, 2023, n.p).

It was later, in 1883, William Mather, a Manchester industrialist "visited Grinnell and acquired rights to the new sprinkler for the entire Eastern Hemisphere. Soon after the new firm of Mather and Platt Ltd introduced the new sprinkler to Europe, Australia and India" (Manchester Science and Industry Museum Archives A2009.28/2/34, Mather and Platt Fire Protection Handbook (n.d.) page 4). "Developments to the sprinkler design by Grinnell continued throughout the late 1800s and early 1900s" (see Manchester Science and Industry Museum Archives, A2009.28.2.12 The Early History of Grinnell Corporation and the Fire Sprinkler Industry by Jerome Pepi, Vice President of Fire Protection Products, 1996). Later in the $20^{th}$ Century, the firm Mather and Platt was acquired by Wormald.

> John Wormald would work for Mather and Platt Ltd as a fire insurance expert. He appointed his younger brother Joseph, as an agent in Australia for the Grinnell sprinkler, underwriting insurance. In 1900 he took on his other brother Harry and they continued in business … After some financial turmoil by 1950 the company expanded by acquiring smaller sprinkler companies. In 1976 they acquired Mather and Platt. The latter was a global company working in Europe, South Africa, India and the Middle East as well as Australia. In 1989 the company was the world's largest international fire protection company, covering all aspects of fire protection and operating profitability in all major geographic locations. (Manchester Science and Industry Museum Archives, A2009.28/2/15, An abbreviated history of Wormald on the occasion of its centenary (1889-1989)).

Sprinklers – a development pioneered and spread from a North West of England company – would become a global technology, but one largely hidden from view. They were (and are) invisible infrastructures (see Graham and MacFarlane on infrastructural worlds, 2014). In an ideal world, they are never needed, and if needed, their benefit is that they can often contain fires quickly through the application of water to specific sites, preventing spread. But what was crucial, in the hundred years of sprinkler development, and what remains critical to sprinklers today, is that they are a fundamental, pre-emptive technology in fire safety, protection and prevention that rely purely on $H_2O$. They rely on the *compound capacities* of hydrogen and oxygen combined, and surpass water's other categorisations, such as salt or fresh. Indeed, sprinkler systems are a commonplace safety feature at sea, on ships. SOLAS – the Safety of Life at Sea Convention (which came into place in 1914 after the sinking of the Titanic) – contained new provisions in the 1974 iteration, requiring all passenger vessels to have sprinkler systems (IMO, n.d.), with further provisions across ship types made in 1981, 1990, 1996 and 2000 (ibid, n.d.). Inlet valves mean that many ship-based systems rely on surrounding *seawater* for fire protection (Sethuraman, 2021). Sprinklers in factories of the 1800s, to the present day, on land, will deploy 'fresh' water. It is not the either/or, which matters, but the application of $H_2O$ – water as compound. This seemingly rather niche example of fire protections helps us to think water beyond binaries, to rather the capacities of its elemental mixture, for society and space.

### Water beyond binaries: Compounds with fire

Fire is a reaction that emerges from a tri-part compounding of heat, fuel and the chemical element of oxygen. Studies of fire compound with water – almost always – as water is the means to quell fire. As interviewee James Peters was to simply state: "water is absolutely marvellous when it comes to … putting fire out" (Interview, 2018). And it is the very compound of water which makes it effective against fire. The unique combination of two parts hydrogen, locked together with one part oxygen creates the substance 'water' which, when applied to fire, reduces heat and then lowers it to below ignition temperature. It does this through water as a liquid, but also as the water as air, when water is condensing. Indeed, when water is applied to the fire it evaporates in the heat of that very fire, with the vapour then creating an overall cooling effect prevent further burning. Moreover, water smothers fire – its composition, $H_2O$ – cuts off oxygen to the fire, preventing it from burning further. It does this *even as* the compound contains oxygen and hydrogen two separate elements that fuel fires. Why is this? When hydrogen and oxygen combine – as a *compound* – they behave differently to the way they would as individual parts. Put more simply:

> When two elements combine to form a compound, the properties of the compound formed are different from the properties of 'parent' elements. Therefore, although hydrogen is combustible and oxygen helps combustion, the water helps to extinguish the fire. Here, hydrogen and oxygen help combustion but their compound reduces combustion. (Toppr, 2023, n.p)

Or as 'Firefighter Insider' note,

> Water is not flammable and can't catch on fire. This is because it is made of hydrogen, which has been fully oxidized and can't react with oxygen any further. However, the hydrogen and oxygen can fuel and increase a fire when they are separated. (Firefighter Insider, 2023, n.p)

However, as Firefighter Insider' magazine also notes,

> "[t]hat doesn't mean, however, that there are no fire risks from water and it's very important to understand how water reacts, with other substances and fire itself, to keep those risks to a minimum" (2023, n.p).

Water often times reacts poorly with oil based fires (but not always, see discussion to follow). The Grinnell Automatic Sprinkler is, as noted, a simple technology. As the Manchester Mather and Platt Fire Protection Handbook (n.d.) notes, it simply uses $H_2O$ to:

> … extinguish or control fire in its early stages before it has time to develop. Pipework fitted with sprinklers is spaced at regular intervals, is installed throughout the protected building, and is connected to a reliable water supply. When fire occurs, only the sprinklers in the immediate vicinity of a fire automatically operate and discharge water to control the fire … The ringing of the alarm gong is caused by the action of water flowing through the pipes leading to the opened sprinklers. Usually the discharge of water from sprinklers is sufficient to extinguish a fire completely, but if any obstruction prevents the water falling on any burning materials, the fire will be held in check until the arrival of the Fire Brigade. (Manchester Science and Industry Museum Archives A2009.28/2/34 Mather and Platt Fire Protection Handbook (n.d.) page 4)

In spite of many technological developments, sprinklers today function on the same basis as their original design and they rely purely on the capacities of $H_2O$ – water as a special compound. Demonstrating the potentials of $H_2O$ application via sprinklers, a report of fires where sprinklers were installed showed the particular benefits of a system where $H_2O$ could be applied to specific sites of fire, holding it in its tracks. Indeed,

> [a]n examination of the reports up to 1930 of fires in buildings protected by Grinnell Sprinklers show the following:
>
> Over 33,000 fires have been extinguished or held in check. Of these fires: 35% were extinguished by one sprinkler only, 50% by two sprinklers only, and 75% by six or less sprinklers.
>
> (Manchester Science and Industry Museum Archives, A2009.28/2/35 Portable Appliances and Automatic Systems or Extinguishing Fires (Pamphlet by H Hoyle of Mather & Platt, Ltd, n.d.) page 5.

The picture of sprinkler success remains positive. The British Automatic Fire Sprinkler Association (BAFSA) reported 53 'sprinkler saves' in 2021-2, representing instances where sprinklers were activated (BAFSA report 2021-2). Indeed, it is the *absence* of sprinklers that reveal their value, as exemplified by the horrific tragedy of the Grenfell Tower fire (Kelly, 2020). As James Peters, fire engineer, stated: the work of the sprinkler is both in its *automatic* working, and its *application* of $H_2O$. As he recalled,

> …and of course, it's as I keep harping on, sprinklers are the silent sentinels … a sprinkler system, providing it has a viable water supply, will operate, and it will contain a fire. It is just water doing the work. (James Peters, Interview, 2018)

The water 'does its work' through the very *application* of the compound. Fire engineers have to think carefully about the use of $H_2O$ in how it is applied through sprinkler systems. This may depend on the design of the building to be protected, the size of rooms, height or number of storeys, the way the building may circulate oxygen (one of the tri-part fuels of fire), as well as the amount of water coverage that may be needed in respect of the space concerned – the pressure, or intensity of $H_2O$, the speed of flow (velocity) and its range or spread throughout the area.

Indeed, the benefit of sprinklers is that they actually use relatively little $H_2O$. The misting effect that makes them so productive in fighting fires comes from the way the water spreads, like a film, over a specific area as it is filtered through the sprinkler valve. Fire engineers assess whether water has 'adequate pressure and capacity' to do its work based on the design in which the $H_2O$ sprinkler is set (Manchester Science and Industry Museum Archives

A2009.28/2/35 Portable Appliances and Automatic Systems or Extinguishing Fires (Pamphlet by H. Hoyle of Mather and Platt Ltd, n.d.). As James Peters described,

> [a]ll the systems are hydraulically calculated to ensure that the system works properly, even getting water up to the highest levels in a building, where the pressure drops … your atmospheric pressure loss as we call it, where you literally lose 100 millibars of pressure for every metre that you try and push it up the building, that's before it actually does anything. So you have to calculate the size of the pumps you need, the size of the pipework that you need, and sprinklers actually, or most modern sprinklers now, actually work at a minimum pressure of .5 of a bar actually at the, at the sprinkler head. This is where they're most effective. (James Peters, Interview, 2018)

And they work in a variety of settings, crossing land and sea, salt and fresh. As James Peters also noted, they can work in transport infrastructures (including tunnels housing underground rail lines) to ships at sea. As he noted, "It's not just run out into the street, its dive into the ocean, so you've got to be able to contain these fires. And again … they (cruise ships) use exactly the same principles, fire pumps, drawing water directly from the sea and distributing it through sprinkler systems" (Interview James Peters, 2018).

Whilst sprinklers see $H_2O$ cross land and sea, salt and fresh, and demonstrates the capacities of the compound, there is a particular sprinkler development that shows the potential of shifting from a geography of water – or watery geographies, to Geography $H_2O$; a compounded, complex take on the physicality of water's properties. That is the 'mulsifyer' system. One of the most significant challenges in fire protection has been dealing with chemical fires – fires involving highly flammable materials such as oils. At the end of the 1800s and start of the 1900s, with an industrial boom, there were keen efforts to work out how to best extinguish such fires. After all, water and oil do not mix.

Mather and Platt, the North-West of England firm my father first worked for, developed a system for extinguishing oil fires with sprinklers. They did so using *only water*. They did so by understanding the chemical properties of water and its form in application. They came to understand that a particular 'spray' of water, where the density of $H_2O$ was precisely 'right' could form an 'emulsion over the surface of oil', 'cooling' and 'smothering' it. (Mather and Platt Fire Protection Handbook 1964, A2009.28/2/34). It is this compound application that was 'game changing' in firefighting. As the Mather and Platt Fire Protection Handbook notes,

> …some of the world's worst fires which have occurred in the history of firefighting have been those involving oils and similar flammable liquids…Mather & Platt discovered that fires involving medium and heavy oils, and similar substances could be rapidly extinguished by the use of water only… The Mulsifyre system applies water in the form of a conical spray consisting of droplets of water travelling at high velocity … it works via e*mulsification* (droplets of water form an emulsion over the surface of oil, that will not support combustion … (it is)… often used in power stations, steel mills, paint works, oil mills, boiler rooms etc). (Manchester Science Museum and Industry Archives A2009.28/2/34 Mather and Platt Fire Protection Handbook (n.d.) page 27)

Here, water as a binary was irrespective. As the developmental handbook noted, to prevent an oil chemical fire, surprisingly,

> water only is used – *either sea water or fresh water*…. When oil and water are brought together in the ordinary way they do not mix… (but) $H_2O$ sprayed in a velocity and density on to the oil, spirit etc. in such a manner as to cause the two to form what the chemist calls an emulsion …the oil is broken up in to an immense number of tiny globules – too small to be seen by the naked eye – which are separated from each other by a film of water … Thus an emulsion composed of two-thirds of petrol and one-third of water refuses to burn … the petrol is unable to take fire. (Manchester Science and Industry Museum Archives, Fire Engineering Division Mather and Platt, Fire Appliances Folder, n.d A2009.28.3.1, emphasis added)

Here it is $H_2O$ – where water molecules are loosely and illogically arranged and directed with a particular velocity – that can quell some of the most dangerous, and tricky to extinguish fires. In this instance, water isn't ever just water. It isn't singular. It isn't salt, it isn't fresh. It isn't in the margins, or centre. It is a substance constituted of its parts – two hydrogen, one oxygen, applied in a spray of particular velocity, intensity and reach.

I'd been thinking about water for some time. But not like this. I've learned a lot from my dad. I guess they do say you never stop learning from your parents.

## (Obvious) conclusions?

This paper has been concerned with fire, and water. It has compounded the classical elements with a particular focus in mind: to think of water beyond the singular (classical) substance, to instead be cognisant of its compound structure as $H_2O$ and the work it does in this capacity. Indeed, as the previous section has revealed, when understanding the relations between the classical elements of fire and water, it is impossible to only think of water as singular, simple. One must think of its chemical composition in the work it does – as fire and water combine. To understand how water quells fire, an understanding of its compound structure is needed and then in turn the application of that compound structure, through regimes that shape its speed, pressure and spread.

The purpose of the experiment this paper tests – a compounding of fire and water – has been to demonstrate a relationship between the two and to offer an insight to an under-examined case study, that of the automated sprinkler, to contribute to scholarship about fire. But it has also been, more ambitiously, to posit that studies of water are currently beholden to separations (that non-western scholarship has long identified) that might limit the ability of scholars to talk to one another, to see connections and to do productive work. As this paper has showed, studies of water are stifled by binaries that fix in place bodies and 'types' of water, which restrict the very fluid capacities of the material. It has been my contention that thinking of water materially – not in terms of its character as voluminous, churning, mobile and so on – but as a chemical composite, may be a useful way to overcome siphoned thinking. What is more, thinking of $H_2O$ alerts us to another useful conceptual frame: that of the compound – of mixing, merging and amalgamating which also may be beneficial in extending how we make sense of water (and related, fiery, earthy and atmospheric) worlds. This aligns, clearly, with the longstanding work on entangled water worlds (Bremner, 2014, Hau'ofa, 2008, Sultana, 2009).

What might our geographies look like if we think of water as compound rather than noun? What might a geography $H_2O$ look like, rather than a geography of water that is fresh or salt, sea or river, wild or tamed – these unhelpful binaries that afflict watery thinking? Moreover what might *compounded geographies* look like, alongside those elemental ones that have been all the rage in recent years? (Adey, 2015; Engelmann and McCormack, 2021) But where also does this leave us? There is still work to do, of course. It is, as yet, unclear what the merits of a Geography $H_2O$ might be. How could this framing change how we think of themes such as water justice, technologies and hydro-worlds, ocean exploitation? Will it add to, and make visible, a realm of connections between waters that were previously unseen? Only future work will tell.

On the other hand, a Geography $H_2O$ might be a 'dead duck'. Aren't our geographies of water already fairly nuanced and multifaceted? Isn't it right to think of the socially constructed meanings of water *beyond* stark chemical composition? All that said, in configuring water by its symbol, it *is* possible to once again reframe the question of what water is – to think about water differently (as my dad did) to ask what water's physical formulation of two-parts hydrogen and one-part oxygen does or can do through its chemical material form. In this way we might 'compound' or make (even) more multiple and complex our understandings of water or even ask different questions of water and water's social, cultural and also environmental, economic and political geographies. This paper then, argues for Geography $H_2O$ – water not as an *either, or*, but as a compound with unique capacities for society and space. It argues we might see where such a stream may lead.

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This work is dedicated, with love, to my dad, James Edward Peters, 'Jim', 1949-2023.

## Sources

Manchester Science and Industry Museum Archives files A2009.28.2 and A2009.28.3

## References


Adey, P., 2015. Accounting for the elemental. *Dialogues in Human Geography*, 51, 98-101.

Anderson, B., 2010. Preemption, precaution, preparedness: Anticipatory action and future geographies. *Progress in Human Geography*, 346, 777-798.

Anderson, J., 2014. 'What I talk about when I talk about kayaking'. In: Anderson, J. & Peters, K. (eds.) *Water Worlds: Human Geographies of the Ocean*. Farnham, Ashgate, pp. 103-118.

Anderson, J. & Peters, K., 2014 (eds.) *Water Worlds: Human Geographies of the Ocean*. Farnham, Ashgate.

Ansong, J. O., McElduff, L. & Ritchie, H., 2021. Institutional integration in transboundary marine spatial planning: A theory-based evaluative framework for practice. *Ocean & Coastal Management*, *202*, 105430.

Bachelard, G., 1988. *Air and Dreams: An Essay on the Imagination of Movement*. Dallas: Dallas Institute Publications.

Bear, C., 2014. 'Governance of the seas: A more-than-human perspective on the Cardigan Bay Scallop fishery'. In: Anderson, J. & Peters, K. (eds.) *Water Worlds: Human Geographies of the Ocean*. Farnham, Ashgate, pp. 147-162.

Bennett, N. J., Govan, H. & Satterfield, T., 2015. Ocean grabbing. *Marine Policy*, *57*, 61-68.

Blunt, A., 2003. 'Home and identity: life stories in text and in person'. In: Ogborn M., Blunt, A., Grufford, P., Pinder, D., and May, J. (eds.) *Cultural Geography in Practice*. New York and London: Routledge, pp. 71-90

Bremner, L., 2014. Folded ocean: The spatial transformation of the Indian Ocean world. *Journal of the Indian Ocean Region*, 10(1), 18-45.

British Automatic Fire Sprinkler Association. BAFSA. 2022. 'Sprinkler Saves UK Annual Review 2021/2022'. Available at: https://www.bafsa.org.uk/wp-content/uploads/bsk-pdf-manager/2022/05/SS_AnnualReview.pdf Available at: Accessed 13/03/2023

Clark, N. & Yusoff, K., 2014. Combustion and society: A fire-centred history of energy use. *Theory, Culture & Society*, 315, 203-226.

Clark, N. & Rickards, L., 2022. An Anthropocene species of trouble? Negative synergies between earth system change and geological destratification. *The Anthropocene Review*, 93, 425-442.

Corcoran, J., Zahnow, R. & Higgs, G., 2016. Using routine activity theory to inform a conceptual understanding of the geography of fire events. *Geoforum*, *75*, 180-185.

Dalby, S., 2018. Firepower: Geopolitical cultures in the Anthropocene. *Geopolitics*, *23*3, 718-742.

Engelmann, S. & McCormack, D., 2021. Elemental worlds: Specificities, exposures, alchemies. *Progress in Human Geography*, 456, 1419-1439.

Firefighter Insider, 2023. 'Is Water Flammable? You May be Surprised…' Available at: https://firefighterinsider.com/water-flammable/ Accessed 10/03/2023

Foley, P. & Mather, C., 2019. Ocean grabbing, terraqueous territoriality and social development. *Territory, Politics, Governance*, 73, 297-315.

Franco, J., Buxton, N., Vervest, P., Feodoroff, T., Pedersen, C., Reuter, R. & Barbesgaard, M. C., 2014. The Global Ocean Grab: A Primer. online Available at: https://www.tni.org/files/download/the_global_ocean_grab.pdf, accessed 17/03/2020

George, R. Y., & Wiebe, S. M. (2020). Fluid decolonial futures: Water as a life, ocean citizenship and seascape relationality. New Political Science, 42(4), 498-520.

Gibbs, L., 2014. Freshwater geographies? Place, matter, practice, hope. *New Zealand Geographer*, 701, 56-60.

Gibbs, L., 2021. Animal geographies II: Killing and caring in times of crisis. *Progress in Human Geography*, 452, 371-381.

Graham, S. & McFarlane, C., 2014 (eds.) *Infrastructural Lives: Urban Infrastructure in Context*. New York and London: Routledge.

Hallaire, J. & McKay, D., 2014. 'Sustaining livelihoods: Mobility and governance in the Senegalese Atlantic' In: Anderson, J. & Peters, K., (eds.) *Water Worlds: Human Geographies of the Ocean*. Farnham: Ashgate, pp. 39-50.

Hastrup, F., 2015. 'The North Water: Life on the Ice Edge in the High Arctic'. In: Hastrup, K. & Hastrup, F., (eds.) *Waterworlds: Anthropology in Fluid Environments*, Vol. 3. Oxford: Berghahn Books.

Hastrup, K. & Hastrup, F., 2015 (eds.) *Waterworlds: Anthropology in Fluid Environments* Vol. 3. Oxford: Berghahn Books.

Hau'ofa, E., 2008. *We are the Ocean: Selected Works*. Honolulu, HI: University of Hawaii Press.

International Maritime Organization (IMO), 2023. History of SOLAS fire protection requirements online Available at: https://www.imo.org/es/OurWork/Safety/Paginas/History-of-fire-protection-requirements.aspx Accessed 12/03/2023

Inspect Point, 2023. 'Frederick Grinnell – Forefather of Fire Protection' Available at: https://www.inspectpoint.com/frederick-grinnell-forefather-of-fire-protection/ Accessed 12/03/2023.

Jackson, S. E., 1995. The water is not empty: cross-cultural issues in conceptualising sea space. *The Australian Geographer*, 261, 87-96.

Kelly, M., 2020. 'Grenfell client didn't install sprinklers as it was not a requirement', in Construction News, Available at: https://www.constructionnews.co.uk/health-and-safety/grenfell-client-didnt-install-sprinklers-as-it-was-not-a-requirement-22-10-2020/ Accessed 12/03/2023.

Laloë, A. F., 2014. 'Plenty of Weeds & Penguins': Charting Oceanic Knowledge. In: Anderson, J & Peters, K., (eds.) *Water Worlds: Human Geographies of the Ocean*. Farnham, Ashgate, pp. 39-50.

Lambert, D., Martins, L. & Ogborn, M., 2006. Currents, visions and voyages: historical geographies of the sea. *Journal of Historical Geography*, 323, 479-493.

Levine Hampton, R., 2022. Towards an agenda for oral history and geography:(Re) locating emotion in family narratives of domestic abuse in 1970s East Kilbride. *Area,* 54(3), 468-475.

Lobo, M. & Parsons, M., 2023. Decolonizing ocean spaces: Saltwater co-belonging and responsibilities. *Progress in Environmental Geography*, 27539687231179231.

Lowenthal, D., (1996). Possessed by the Past: The Heritage Crusade and the Spoils of History. USA: The Free Press.

Mack, J., 2013. *The Sea: A Cultural History.* London: Reaktion Books.

Menga, F., 2016. Domestic and international dimensions of transboundary water politics. *Water Alternatives*, 93, 704-723.

Menga, F. & Swyngedouw, E., 2018 (eds.) *Water, Technology and the Nation-State*. Abingdon: Routledge.

Mentz, S., 2020. *Ocean*. Bloomsbury Publishing: USA.

Neale, T., 2018. 'Are we wasting our time?': bushfire practitioners and flammable futures in northern Australia. *Social & Cultural Geography*, 194, 473-495.

O'Grady, N., 2014. Securing circulation through mobility: Milieu and emergency response in the British fire and rescue service. *Mobilities*, 94, 512-527.

O'Grady, N., 2018. *Governing Future Emergencies: Lived Relations to Risk in the UK Fire and Rescue Service.* Basingstoke: Palgrave Macmillan.

Peters, K., 2010. Future promises for contemporary social and cultural geographies of the sea. *Geography Compass*, 49, 1260-1272.

Peters, K., 2014. 'Taking more-than-human geographies to sea: Ocean natures and offshore radio piracy': In: Anderson, J & Peters, K. (eds.) *Water Worlds: Human Geographies of the Ocean*. Farnham, Ashgate, pp. 39-50.

Peters, K., 2018. 'Elements'. In: Peters, K., Steinberg, P., & Stratford E. 2018 (eds.) *Territory beyond Terra.* London: Rowman and Littlefield International, pp. 15-18.

Peters, K., 2017. *Your Human Geography Dissertation: Designing, Doing, Delivering.* London: SAGE.

Peters, K., Steinberg, P. & Stratford E. 2018 eds. *Territory beyond Terra.* London: Rowman and Littlefield International.

Pyne, S. J., 1997. *World Fire: The Culture of Fire on Earth*. Seattle and London: University of Washington Press.

Pyne, S. J., 1998. Forged in fire: history, land, and anthropogenic fire. *Advances in historical ecology*, 64-103.

Pyne, S. J., 2001. *Fire: A Brief History*. USA: University of Washington Press.

Pyne, S. J., 2009. The human geography of fire: a research agenda. *Progress in Human Geography,* 334, 443-446.

Pyne, S. J., 2011. *Awful Splendour: A fire History of Canada*. Vancouver: UBC Press.

Pyne, S. J., 2012. *Vestal Fire: An Environmental History, Told through Fire, of Europe and Europe's Encounter with the World.* USA: University of Washington Press.

Reenburg, A., 2015. 'Water Literacy in the Sahel:Understanding Rain and Groundwater. In: Hastrup, K. & Hastrup, F., (eds.) *Waterworlds: Anthropology in Fluid Environments* Vol. 3. Oxford: Berghahn Books, pp. 184-202.

Robertson, M.L.B., 2015. 'Enacting Groundwaters in Tawara, Kiribati: Search for Facts and Articulating Concerns'. In: Hastrup, K. & Hastrup, F. (eds.) *Waterworlds: Anthropology in Fluid Environments* Vol. 3. Oxford: Berghahn Books, pp. 141-161.

Romero, A. M., Guthman, J., Galt, R. E., Huber, M., Mansfield, B. & Sawyer, S., 2017. Chemical geographies. *GeoHumanities*, 31, 158-177.

Rose, G., 1997. Situating knowledges: positionality, reflexivities and other tactics. *Progress in Human Geography*, 21(3), 305-320.

Rubow C., 2015. 'Respect and Passion in a Lagoon in the South Pacific'. In: Hastrup, K. & Hastrup, F., (eds.) *Waterworlds: Anthropology in Fluid Environments* Vol. 3. Oxford: Berghahn Books, pp. 93-109.

Sethuraman, R., 2021. 'Water-Mist And Sprinkler Systems On Passenger Ships'. In *Marine* Insight. Available at: https://www.marineinsight.com/tech/water-mist-and-sprinkler-systems-on-passenger-ships/ Accessed 12/03/2023.

Smith, L.C., 2021. *Rivers of Power: How a Natural Force Raised Kingdoms, Destroyed Civilizations, and Shapes Our World.* London: Penguin Books.

Steinberg, P. E., 1999. Lines of division, lines of connection: Stewardship in the world ocean. *Geographical review*, 892, 254-264.

Steinberg, P. E., 2001. *The Social Construction of the Ocean* Vol. 78. Cambridge: Cambridge University Press.

Steinberg, P E. & Kristoffersen, B., 2017. 'The ice edge is lost… nature moved it': mapping ice as state practice in the Canadian and Norwegian North. *Transactions of the Institute of British Geographers*, 424, 625-641.

Steinberg, P. & Peters, K., 2015. Wet ontologies, fluid spaces: Giving depth to volume through oceanic thinking. *Environment and Planning D: Society and Space*, 332, 247-264.

Stensrud, A.B., 2015. 'Raining in the Andes: Disrupted Seasonal and Hydrological Cycles'. In: Hastrup, K. & Hastrup, F. (eds.) *Waterworlds: Anthropology in Fluid Environments* Vol. 3. Oxford: Berghahn Books, pp. 75-92

Strang, V., 2015. *Water: Nature and Culture*. London: Reaktion Books.

Sultana, F., 2009. Fluid lives: subjectivities, gender and water in rural Bangladesh. *Gender, Place and Culture*, 164, 427-444.

Sultana, F., 2011. Suffering for water, suffering from water: Emotional geographies of resource access, control and conflict. *Geoforum*, 422, 163-172.

Sultana, F., 2018. Water justice: why it matters and how to achieve it. *Water International*, 434, 483-493.

Sultana, F. & Loftus, A., 2013 (eds.) *The Right to Water: Politics, Governance and Social Struggles*. New York and London: Routledge.

Sultana, F. & Loftus, A., 2019 (eds.) *Water Politics: Governance, Justice and the Right to Water*. New York & London: Routledge.

Swyngedouw, E., 2004. *Social Power and the Urbanization of Water: Flows of Power*. OUP: Oxford.

Guelke, J. K and Timothy, D.J., 2016. 'Locating Personal Pasts: An introduction'. In: Timothy, D. J. & Guelke, J. K. (eds.) *Geography and Genealogy: Locating Personal Pasts*. Abingdon: Routledge, pp. 1-19.

Toppr, 2023. 'Hydrogen is combustible, oxygen helps combustion, but water helps to extinguish fire' Available at: https://www.toppr.com/ask/question/write-scientific-reasonhydrogen-is-combustible-oxygen-helps-combustion-but-water-helps-to-extinguish-fire/ Accessed 11/03/2023

Vium, C., 2015. 'Moral Valves and Fluid Properties: Water Regulations Mechanisms in the Bâdia of South Eastern Mauritana. In, Hastrup, K. & Hastrup, F. (eds.) *Waterworlds: Anthropology in Fluid Environments* Vol. 3. Oxford: Berghahn Books, pp. 219-246.

Water Encyclopedia, 2023. Natural Composition of Fresh Water. Available at: http://www.waterencyclopedia.com/En-Ge/Fresh-Water-Natural-Composition-of.html#:~:text=%22Pure%22%20water%20essentially%20is%20nonexistent,organic%20matter%2C%20and%20living%20organisms Accessed 12/03/2023.

Zalik, A., 2018. Mining the seabed, enclosing the Area: ocean grabbing, proprietary knowledge and the geopolitics of the extractive frontier beyond national jurisdiction. *International Social Science Journal*, 68(229-230), 343-359.