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Political ecologies of infrastructural and intestinal decay

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Abstract

In March 2007, when *Cryptosporidium* contaminated water supplies in Galway City, Ireland, political authorities responded quickly to upgrade water treatments plants. This response framed the crisis as a solely technical problem of infrastructural decay, obscuring legacies of urban and agricultural (over)development. In this paper, we examine dominant responses to infrastructural contamination that depoliticize and re-inscribe divisions among bodies, nature, infrastructure, rural and urban. The temporality of the Galway outbreak and the speedy response by the state is not replicated throughout Ireland. In parts of rural Roscommon, the neighbouring county to Galway, microbiological risks to the drinking water supply have been left unattended for more than eight years. The interplay of social, political, economic, and ecological factors produces uneven exposures to health risks that are situated within and mediated through water infrastructure. Drawing on postcolonial insights, the unevenness of infrastructural provision across Ireland does not just tell a story of exclusion and othering, but also provides space for different infrastructural projects to unfold. While the response to contamination within the public water supply replayed well-known technical fixes, the work of the National Federation of Group Water Schemes, the representative body of community managed water systems in rural Ireland, illustrates a different form of infrastructural practice that negotiates legacies of institutional abandonment and acknowledges the wider hydro-social cycle as part of, rather than ancillary to, water infrastructure. By blending political ecologies of health and postcolonial approaches to infrastructure, we analyse the unevenness of responses to infrastructural contamination and trace its relationship to legacies of uneven development and imaginaries of urban and rural Ireland.

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History and politics were now a severe intestinal disorder. (McCormack, 2016)

Introduction

In *Solar Bones*, a 2016 novel by Irish author Mike McCormack, the narrator describes caring for his wife who has been struck by a sudden and severe vomiting bug. He recounts the shock of seeing her – a 'woman who never took to bed for anything' – wracked with a mysterious illness. Only after several days do official reports connect her ailing body with hundreds of others contaminated by the public water supply. In the immediate wake of the crisis, residents of Galway city organized protests and demonstrations: How had this been allowed to happen? Why were Irish citizens being made to queue for water like 'third world supplicants' (McCormack, 2016)? Contamination had violently ruptured the imaginary of Ireland as a modern and developed country, where clean water emerges from the tap without fail.

McCormack's fictionalized account is based on real events that took place in March 2007 when *Cryptosporidium*, a parasite that causes the acute intestinal disease, cryptosporidiosis, contaminated Galway's water supplies.[1] Authorities traced its source to a lake, Lough Corrib, the only source for Galway's public water. Initial reports suggested that *Cryptosporidium* had entered the water supply following heavy rains earlier in the year, washing agricultural slurry into the lake (Pelly et al., 2007). However, subsequent tests on those suffering from the illness revealed that the main source of the *Cryptosporidium* was from human faeces, not farm animals. The rapid growth of Galway during the construction boom of the mid-2000s had stressed existing wastewater infrastructures; the wastewater treatment plant, designed for 250 households, was receiving sewage from 800 (EPA, 2011a). Political authorities quickly responded by upgrading water treatment systems with UV filters to block further contamination and quell the public's growing anger. The response to the outbreak followed a predictable pattern: to address a pressing public health crisis, a technical solution was implemented to quickly solve it. This reconceived the crisis as a solely technical problem, diffusing its political nature and connections to legacies of urban and agricultural (over)development. In the years since Galway, the dominant response to threats from *Cryptosporidium* by the Irish state has been the same: to isolate and filter out *Cryptosporidium* at the point of water treatment. This 'infrastructural fix' aims to resolve systemic causes of contamination. It does not question the source of the pollution and need for further treatment and instead internalizes the problem within the infrastructural network itself.

Mike McCormack's novel captures how history and politics erupt in the form of an outbreak of intestinal disorder in Galway, Ireland's third largest city. However, this is not the only form that the history and politics of infrastructural contamination takes in Ireland. In parts of rural Roscommon, the neighbouring county to Galway, risks to the drinking water supply from *Cryptosporidium* and other microbiological contaminants have been left unattended to in some cases for more than eight years. Since EU-wide surveillance

of cryptosporidiosis began in 2008, Ireland has had the highest or second highest incidence rate across all member states. One explanation is the scale of industrial dairy farming that has developed in Ireland since the 1970s. While the Galway outbreak was traced to human waste, in human infections the most common species of *Cryptosporidium* in Ireland originates from cattle. Roscommon's experiences entangle legacies of rural abandonment, agricultural overdevelopment, and the struggle of community-owned and managed water infrastructures to negotiate these challenges. By blending postcolonial approaches to infrastructure with political ecologies of health, we analyse the unevenness of infrastructural contamination and trace its relationship to histories of development and imaginaries of rural Ireland. We use the focus of this special issue on infrastructural decay and repair to foreground the multiple ways that infrastructure reproduces powerful imaginaries of rural (non-modern) and urban (modern) Ireland, obscuring legacies of agricultural overdevelopment and the uneven exposure to health risks among some rural populations. We map responses to health risk on to expectations of how infrastructure should work to understand political responses to contamination. These responses, reinforce imaginaries of decay and disuse in rural contexts, and imaginaries of modernity and promise in urban environments, but also offer opportunities for alternatives.

We explore and elaborate on these processes by examining the state's response to *Cryptosporidium* in drinking water supplies, arguing that this represents the reinforcing of infrastructure as metabolic mediation of rural/urban flows and relations. Moving beyond an urban political ecology analysis, we go on to discuss how rural/urban distinctions are also constructed through the uneven distribution of infrastructure for treating contaminants like *Cryptosporidium*. We conceptualize the uneven experience of the modern infrastructural ideal within Ireland through the work of postcolonial urban geographies and political ecologies of health. We emphasize recent work in health geography and science and technology studies that foregrounds the uncertain and expanded spatial *and* temporal scales through which late industrial toxins circulate. Turning to the work of the National Federation of Group Water Schemes (NFGWS), the representative body of community managed water systems in rural Ireland, we discuss how these minor infrastructural projects, operating at a distance from the state, offer a different way of addressing the presence of *Cryptosporidium* in drinking water. Infrastructural upgrades on the public supply have been mirrored by 'modernization' efforts taken by the NFGWS since the 2000s. However, to a lesser degree the NFGWS has also pursued source water protection initiatives, drawing on the particular cultures, social relationships, and place-based knowledge that exist in community-owned schemes. The NFGWS's initiatives invite us to recognize and reflect on a different form of infrastructural politics, one that negotiates legacies of institutional abandonment and acknowledges the wider hydro-social cycle as part of, rather than ancillary to, water infrastructure.

Infrastructure and contamination

We draw on urban political ecology, postcolonial urban geography, and political ecologies of health, to consider how certain forms of infrastructural decay and repair reinforce dominant imaginaries of rural (non-modern) and urban (modern) Ireland. These literatures highlight the social, political, and ecological relationships that infrastructures mediate, albeit unevenly, across space and time. From this perspective, contamination of drinking water by *Cryptosporidium* is not just a technical glitch but a breach in the socio-ecological fabric and the complex imaginary of infrastructure as (urban) modernity. While acknowledging that the rural/urban relation has been elaborated on within urban political ecology

and related fields, this paper argues that postcolonial studies of infrastructure in the Global South offer a valuable lens for thinking through the uneven geographies of water infrastructure in Ireland and the different infrastructural politics this helps produce. As we outline below, urban political ecology has been central to conceptualizations of infrastructure as metabolic mediator of rural and urban bodies and environments. However, other aspects of infrastructural politics that pertain to our case, namely the uneven distribution of infrastructure and the health risks associated with this, have largely focussed on urban contexts in the Global South. By bringing together urban political ecology with postcolonial urban geography and political ecologies of health, we hope to amplify the traffic between these rich, interdisciplinary fields.

Infrastructures have long been a symbol and achievement of modernity, imposing order and a semblance of mastery over humans and nature (Kaika and Swyngedouw, 2000; Wakefield, 2018). They provide engineering and technological solutions to social, political, and environmental problems, and reconfigure the social and physical relationships within the landscapes in which they are built and in which they operate. When these infrastructures work, they are invisible, embedded into everyday life, laid underground, or naturalized as part of the landscape. Urban political ecology 'denaturalizes' these processes by examining the historical development of large-scale infrastructures that extract, produce, and distribute water under specific, power-laden relationships shaped by capitalist strategies of accumulation (Heynen et al., 2006; Swyngedouw et al., 2002). By focusing on how water is produced, this scholarship shows how ecologies, bodies, cities, and flows of capital are combined and constituted to ensure certain water services for the population. Of particular relevance are the critical perspectives developed within urban political ecology that dislodge neat spatial delimitation and distinction between the urban and the rural. The metabolic foundations of urban life are connected to hinterlands and landscapes far removed from the city (Cronon, 1991; Gandy, 2002). These accounts recognize that the political economic relationships that draw resources, energy, water, and labour from rural areas to urban centres are constituted through powerful ideological and discursive fields that reproduce the urban as modern, global, and progressive, and the rural as traditional, local, and backward (Hommes et al., 2019). While urban political ecology helps us to understand how infrastructure regulates a particular metabolic relationship between rural and urban, one that is inseparable from broader imaginaries or rural/urban, there are other questions relating to infrastructural decay and the rural/urban relation that we engage in this paper. Our point here is not to illustrate the subordination of the rural by the urban, but instead to explore alternative possibilities and relationships to infrastructure. We draw on insights from political ecologies of health to help us trace, in the absence of treatment infrastructures in rural contexts, other kinds of relationships around infrastructures.

Writing from and about the Irish context, it is important to understand that universal, public water services have never been realized. The history of rural group water schemes (GWSs) stands as clear evidence of this, although they are largely absent from public discourse on water and water infrastructures. The infrastructural fix to the risk of *Cryptosporidium* tells a story of rural/urban metabolism, while simultaneously revealing the uneven infrastructural provision that maps on to uneven rural/urban development. Postcolonial urban geography is a body of scholarship we draw upon to better understand the unevenness of infrastructural provision. While still focused on the uneven processes of urbanization, postcolonial urban scholars have challenged the United States and Eurocentric literature that situates infrastructure within a universal, Western story of progress and development (Anand, 2011). By switching empirical and analytic focus to the Global South, it becomes quickly apparent that stable, well-functioning, and 'invisible'

infrastructures are not the reality for the majority where chronic failures, outages, breakdowns, and absent public infrastructures are an everyday struggle (Silver, 2014; Simone, 2004). What this work makes clear is that infrastructures are for some and not others, and that the uneven distribution and access to functioning infrastructures maps on to and reproduces existing social inequalities concerning race, class, ethnicity, and gender.

These critical perspectives now find traction in Global North contexts where previously stable infrastructural systems, the backdrop of cultural, political, and economic everyday life since the end of the Second World War, are breaking down and prone to new risks (Larkin, 2013; Wakefield, 2018), evidenced most recently by the water contamination in Flint, Michigan (Ranganathan, 2016), and the urgency around 'day zero' in Cape Town in 2017 (Scheba and Millington, 2019). In focussing on Ireland, this paper is part of an effort to re-think assumptions about Global North/South geographies and the experiences of (infrastructural) modernity therein. Ireland is particularly interesting in this context, having been both a British colony and, as independent state, part of the post-War, liberal European project. Our focus in this paper is not, however, Ireland's conflicted relationship with (post)colonialism, but rather the rural/urban relation within Ireland, and how this might be productively thought through geographies of the Global South which emphasize the uneven experience of European modernity. This paper contributes but also expands on work cited above that seeks to examine gaps and failures in infrastructural provision in the Global North. Rather than only focussing on moments of failure, as with the outbreak in Galway in 2008, we also examine the chronic failure and absence of vital water infrastructures that occurs in certain places, to certain people, over time (Harvey, 2018). In the case of providing water safe from *Cryptosporidium* in Ireland, the failure is acute and urgent in the case of urban populations, but normalized and chronic for parts of rural Ireland. As well as reading postcolonial insights into our understanding of the biopolitics of rural/urban infrastructure provision, we draw on this literature's attention to difference and agency even in the context of abandonment and exclusion. In the absence of networked infrastructures in large parts of the Global South, geographers and anthropologists have drawn attention to the myriad ways that people craft their own forms of infrastructure, relying on social networks, shared labour, communal responsibility, and ongoing improvisation (Silver, 2014; Simone, 2004). These collective forms of urban infrastructure rely on and generate distinct forms of social cooperation and collective action that can in turn shape distinct forms of politics (Bresnihan, 2020). This paper contributes to postcolonial studies of infrastructure by drawing the geography and experience of rural infrastructural trajectories in the Global North into the frame.

Functioning water infrastructures are essential for human health. It is thus unsurprising that there are clear parallels and overlaps between the infrastructural focus of the work cited above and health geographies. Relationships between human health and water infrastructures are uneven (Gandy, 2006), contoured by their temporal and geographic contexts (urban/rural, Global North/Global South, postcolonial) (McFarlane, 2008; Sultana, 2010) and dominant ideas about the relationships between human health and environment (Murphy, 2006; Nash, 2006). Health geographers' attention to place and time highlights the politics that materialize health concerns and manage human health risks. Bodily health is never disentangled from the processes that shape places; places are active in the production of human health rather than passive spaces in which bodies exist as healthy or not (Kearns and Moon, 2002; Neely and Nading, 2017). Attention to the multiple processes flowing through places helps explain variations in experiences of health and has traced how uneven development and ideas about modernity shape and dictate disease management (Carter, 2012; Nash, 2006).

Political ecologies of health foreground places in their historical contexts, particularly as relates to the interplay between natural resources, ecosystems, political economic processes, and health effects (Brisbois et al., 2018; King, 2010). Many draw upon the theoretical and methodological robustness and pluralism of political ecology to examine the spatial unevenness of socio-political processes across scales (Jackson and Neely, 2015; King, 2010; Tedesco et al., 2010). These are explored through irregular or uneven spatial patterns, such as access to health care services and exposures to toxic chemicals, and variable ideas and perceptions about bodies and places that shape investment, public health interventions, and siting of polluting facilities and activities (Guthman, 2015; Hanchette, 2008; Sultana, 2010), disrupting distinctions between humans and environment, bodies and nature. *Cryptosporidium* transgresses familiar divisions between landscape and infrastructure, rural and urban, animal excreta and drinking water as it passes from the intestinal gut of grazing cows, to fields and watercourses, to drinking water supplies, and ultimately into pipes and taps of the networked water infrastructure. *Cryptosporidium* also reveals public expectations regarding well-functioning, state-provided infrastructures. When water treatment systems work, they make vital metabolic functions invisible; when they fail, these relationships surface in sickened bodies. Water treatment infrastructure thus operates to obscure the relationship between 'raw water' and 'potable water', in effect separating impure 'rural' water bodies from purified urban water systems.

While interest in the relationships between health and place has developed rich understandings of uneven spatialities of health and health risk, recently health geographers have theorized time more complexly, turning to the interplay between uneven spatial patterns of health risk and multiple temporalities of health exposure (Davies, 2018; Guthman and Mansfield, 2013). Here, we draw upon this literature to elaborate on the entanglements of urban/rural imaginaries and the spatial and temporal scales through which toxins of late industrialism circulate. Uneven spatial patterns can be produced through layered and nonlinear histories of exposure and its effects. Exposure effects may be latent and accumulate, may not follow predictable cause and effect, may trouble distinctions between past and present, and as such are often uncertain. Within this work on temporalities, uncertainty suffuses efforts to draw causal pathways between exposure and response and is experienced in spatially uneven ways (Murphy, 2006; Senanayake and King, 2019). These temporal relationships are captured in notions of chemical infrastructures (Murphy, 2013), toxic landscapes (Lerner, 2010), and toxic infrastructures (Fortun, 2001), notions that explore the spatial and temporal extents and multi-scalar relationships between chemicals, bodies, and capital, where acute events and the slow erosion of industrial pollution force environments, communities, and bodies to live and weather its consequences across extended durations, sometimes permanently (Davies, 2018; Nixon, 2011). This paper contributes to the already rich traffic between infrastructure studies and political ecologies of health. Rather than focus on the slow violence of chemical pathways, however, we highlight the acute and chronic experiences of *Cryptosporidium*, linking temporalities of infrastructure with imaginaries of rural and urban places to understand the unevenness of disease risk and the responses to it. We are particularly interested in the politics that surrounds the uncertainty and scale of contemporary toxins and the difficulties of rendering these perceptible in ways that may mobilize meaningful action. This is both a representational and political challenge. In the final part of the paper, we turn to the activism of rural GWSs to discern how the dominant distributions of landscape and infrastructure, 'raw' water and drinking water, are being challenged.

In the sections that follow, we build a more complex picture of why these three interrelated scholarly fields offer different but complementary perspectives for better

understanding infrastructural repair and decay. We draw attention to dominant responses to infrastructural contamination – ways that depoliticize and re-inscribe divisions among bodies, nature, urban/rural, and infrastructure. Following this, we interrogate the uneven experiences of *Cryptosporidium* and its relationship to longer legacies of infrastructural provision in Ireland. Finally, while the response to microbiological contamination within the water supply has replayed well-known technical fixes within the public and community managed water sectors, GWSs pursue a different, if minor, politics of infrastructural contamination, one that complicates histories and legacies of the rural/urban divide.

The elusiveness of *Cryptosporidium* and its infrastructural 'fix'

Piped water is supplied in Ireland by the public water supply (83%), private wells and small supplies (11%), and GWSs (6%) (EPA, 2018). Compared to other EU countries, Ireland has many public supplies (973 supplies, Irish Water, 2016) for a relatively small population of 4.79 million people (CSO, 2018). Urban areas first received piped water and many Victorian-era mains and pipes remain in the public network (Nelson, 2018). Rural areas lacked piped water until the mid- to late-20th century but were supplied by GWSs rather than the public network.

Until recently, public water supplies were the responsibility of each of the 34 local authorities. This changed incrementally under the Water Services Acts of 2007 and 2013. In 2007, the Irish Environmental Protection Agency (EPA) expanded on its advisory role and gained the authority to enforce drinking water standards in addition to providing guidance on how to improve the quality of drinking water. Local authorities retained responsibility for the delivery of public water until 2014 and were funded through general taxation. In 2014, the public water sector reorganized. To meet conditions of Ireland's bailout during the global financial crisis, operation and management of public water were consolidated under a new semi-state utility, Irish Water. Funding for Irish Water's capital and operating costs was to come from domestic water charges based on metered usage, although these would be later reversed (Bresnihan, 2016). EPA gained oversight of Irish Water (Brady and Gray, 2016) and can issue directives to upgrade facilities to protect water quality. Public and Group Water Supplies are regulated water suppliers and can be held accountable for the quality of the water they provide. Roughly 10% of drinking water that is supplied by household wells are not subject to water quality regulation by the state.

The public water supply faces many challenges of which *Cryptosporidium* is one. There are concerns about lead and leakage, new microbiological and chemical agents, and recent severe storms and drought highlight vulnerabilities in assuring consistent quantities of clean water (Fitzgerald, 2018; Murtagh, 2018; Nelson, 2018). These challenges are met with frequent calls for more investment, upgrades, and improved monitoring to repair old decaying water systems. However, *Cryptosporidium* has qualities that make it difficult to manage.

First identified in humans in 1976, *Cryptosporidium* is a protozoan parasite that can cause cryptosporidiosis, a disease marked by gastrointestinal distress and diarrhoea lasting for several days or weeks (Leitch and He, 2011; Thompson et al., 2016). While it can infect healthy individuals, cryptosporidiosis can cause severe and life-threatening illness in the immunocompromised (Bouzid et al., 2013; Checkley et al., 2015). It must be diagnosed with laboratory confirmation of stool samples; however, not all symptomatic individuals seek medical attention, nor do all policies mandate testing (Leitch and He, 2011; Pelly et al., 2007).[2] Still, cryptosporidiosis in Ireland has not measurably declined since it became a notifiable disease (Figure 1). Ireland's first documented case occurred in 2002 and Ireland

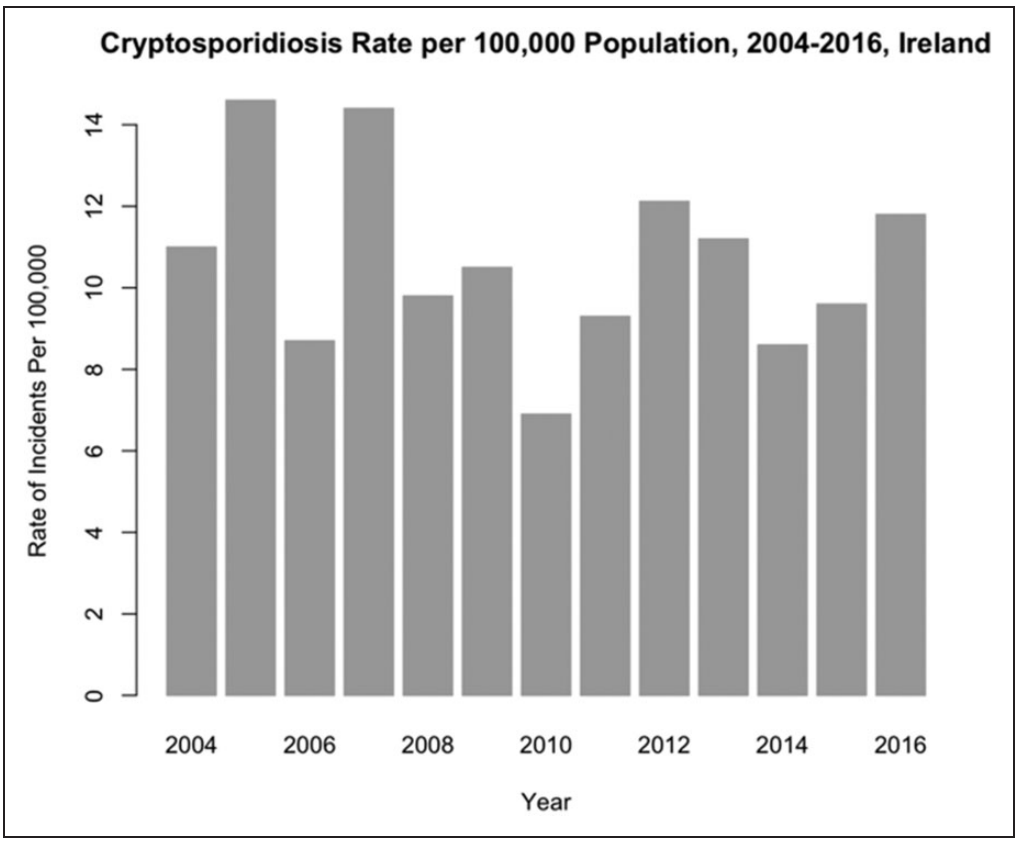

Figure 1. Cryptosporidiosis incidents per 100,000 population, 2004–2016 (Garvey and McKeown, 2005, 2007, 2008; HPSC (Health Protection Surveillance Centre) 2006, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017).

began surveillance for cryptosporidiosis in 2004. Since EU-wide reporting began in 2008, Ireland has had the highest (2008–2011, 2013, 2015–2016) and second highest (2012, 2014) incidence rate in Europe (HPSC, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017); Efstratiou et al., 2017).

In addition to being difficult to track in humans, *Cryptosporidium* is challenging to detect, remove, and treat in water due to its small size and hard outer shell that resists many treatments including chlorination (Austin et al., 2012; Guerrant, 1997). It can also survive within inhospitable environmental conditions outside of a host for extended periods and can grow and multiply within aquatic biofilms (Betancourt and Rose, 2004; Cacciò and Chalmers, 2016; Thompson et al., 2016). Technologies that can inactivate *Cryptosporidium* include UV disinfection, the dominant response to protect water supplies in Ireland, despite its costs and required expertise for its upkeep and maintenance.

Species type provides clues to *Cryptosporidium*'s origins. In Europe, *C. hominis* and *C. parvum* are the two species of greatest concern and incidence in human cases (Ryan et al., 2014). *C. hominis* is of primate, often human origin, while *C. parvum* originates from cattle (Garvey and McKeown, 2007; Pelly et al., 2007). *C. parvum* is more commonly found in humans in Ireland and has seasonality (Garvey and McKeown, 2007). Instances peak in late

spring, coinciding with lambing and calving seasons and increased human–animal contact (EPA, 2011a). Outbreaks of both species may follow heavy rainfall which can transfer agricultural products and human waste into waterways (Cacciò and Chalmers, 2016). While species type may suggest where the pathogen originated from, it is not definitive of its source, meaning from which farm or animal the pathogen travelled remains unknown.

These uncertainties shape how *Cryptosporidium* materializes for scientists, doctors, and water suppliers. Rather than attributing *Cryptosporidium* to an overdeveloped animal-based agriculture or construction industry, the dominant response has been to attribute it to under-developed physical infrastructures that treat 'raw' water. Although *Cryptosporidium* is a relatively new concern for water service providers, and thus not part of former treatment systems, this does not fundamentally change how the failure of water infrastructure (in providing constant, safe flows of drinking water) is perceived and responded to. In this case, the expectations that surround infrastructure and (ab)normality of infrastructural decay and disuse are situated within imaginaries of rural and urban. These framings can only be understood through the imaginaries afforded infrastructure, where expectations are connected to divisions between nature and infrastructure and spatial and temporal imaginaries of modernity and progress. The state's response to implementing its fix for *Cryptosporidium* not only reifies imaginaries of urban/rural infrastructure, but it also reinforces the uneven experience of uncertainty and risk that surround it. As we detail below, the dominant response to *Cryptosporidium*, and in what places it occurs, internalizes these wider contradictions and restores the imaginaries of water infrastructures within their rural and urban contexts. This is infrastructure as metabolic mediator, regulating the distribution of rural and urban environments, and the movement and relation of rural and urban bodies.

The importance of the technical fix is evident in regulatory actions that flowed from the 2007 Galway event. The EPA subsequently undertook a review of all public water supplies and in 2008, began publishing a quarterly list of public water treatment plants in need of upgrading, replacement, or improved operational control. The Remedial Action List (RAL) identifies the public water supplies with serious deficiencies based on poor water quality tests and the lack of treatment for *Escherichia coli* and *Cryptosporidium*. To be delisted, a facility must implement engineering and/or operational controls. Since it was first published in 2008, 87% (292) of supplies have been removed from the RAL. Seventy-seven supplies were listed at the end of 2017, 11 of which were added in the preceding year, and which together supply water to 686,109 consumers (EPA, 2018). This approach was reinforced in 2016. At the behest of a legally binding direction from EPA, Irish Water implemented the National Disinfection Program (NDP) to target public water supplies that lacked disinfection technology (EPA, 2018). The NDP signals an intensification and extension of EPA's focus on water treatment, now pursued by Irish Water, by focusing on disinfection or what EPA calls the 'most important step in the water treatment process'. Clear financial implications result when the problem of *Cryptosporidium* is internalized within the water infrastructure itself. Irish Water (2018b) has committed to invest €2 billion to improve drinking water quality between 2014 and 2021, with the goal of reducing the number of treatment plants on the RAL to zero by 2021.

EPA's guidelines for *Cryptosporidium* and its description of the water supply identify water treatment as the solution to contamination. EPA's visualization of the drinking water supply process (Figure 2) stresses various chemical and physical treatments given to water at the water treatment plant. It does not include practices that would protect source water and ultimately re-inscribes familiar boundaries around what it considers part of the water supply and how it is made safe.

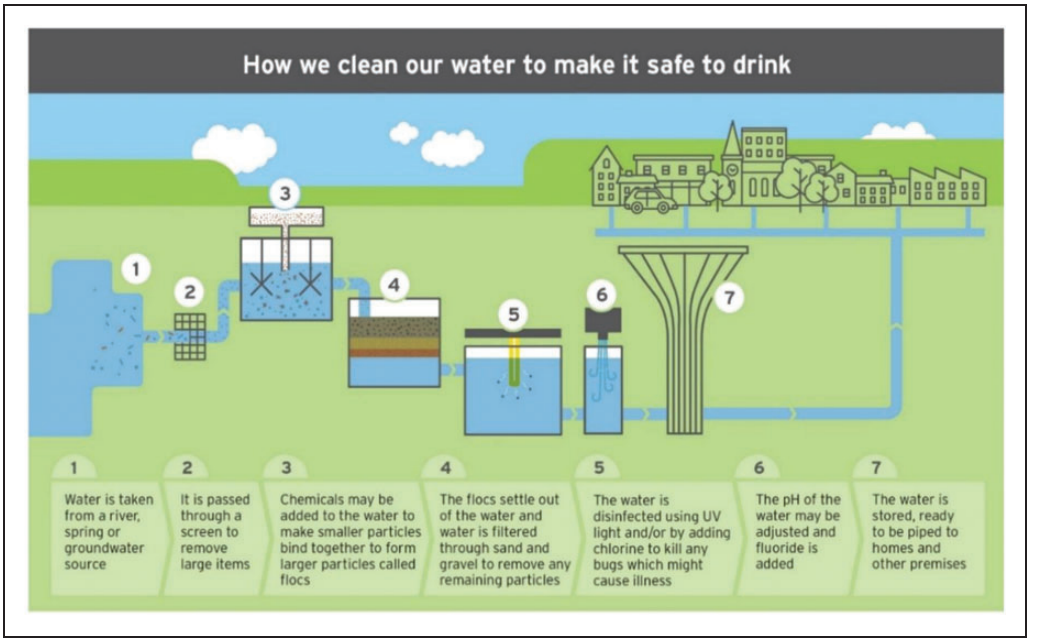

Figure 2. 'Steps in the drinking water supply process'. Source: EPA (2018: 14).

The response to *Cryptosporidium* is also circumscribed by acute and pressing human health needs and its sometimes-elusive pathways. EPA's (2011a: 23) risk management for *Cryptosporidium* describes the constraints of the pathogen's uncertainty during outbreaks. Given the likelihood that the causes of an outbreak are uncertain, and that officials will be working with limited information, EPA suggests that outbreaks are best managed first through methods that treat the water at points just prior to its consumption. This may include consumers boiling their water before its use and the installation of UV filtration at water treatment facilities. Thus, much of the state-led response to containing *Cryptosporidium* has involved filtering it out of the water supply. As will be discussed later, these forms of repair work have spatialities and temporalities that shape exposures to health risks, but which also reinforce imaginaries of rural and urban, and unmodern and modern.

Yet, importantly there is also dissonance between the knowledge of where *Cryptosporidium* most commonly originates – animals – and the government's agricultural policies. The focus on water treatment as the source of the problem and the site of the solution reinforces this disconnect. According to EPA, Ireland's agricultural sector, dominated by beef and dairy, was responsible for 39% of moderate surface water pollution between 2007 and 2009. Since 2005, total herd size has increased by 4.4% and dairy cow herd size is projected to increase by 7% on 2015 levels by 2025 if expansionist goals set by the government's Food Wise 2025 agricultural policy are met. Expanding cattle herds excreting greater quantities of faeces on land maximized for grass production, which reduces environmental barriers to run-off and has a soil substrate compacted by machinery and decades of over-use, furnishes conditions for microbiological contaminants to circulate (Agriland, 2019). Urban waste poses further challenges. In 2017, the EPA reported that 50 large urban areas had failed standards in the EU urban wastewater directive (1991), including Ireland's two largest cities, Dublin and Cork. Even in Galway, an upgraded

water sewage facility is only being completed in 2018, some 11 years after the outbreak (Irish Water, 2018a).

While other water related policy, such as the EU Water Framework Directive (WFD), takes a more expansive view of the hydro-social cycle by protecting water quality within catchments (2000/60/EC; Kaika, 2003), it does not include drinking water. Further, in 2007, the EPA advocated for the Drinking Water Safety Plan approach from the World Health Organization to implement a multi-barrier approach to risk management and includes attention to the selection of water sources, proper training and awareness of operators, implementation of water treatment technologies, and regular monitoring for indicators (EPA, 2011a). These measures, however, are not required by law, and ultimately it is the technological fix that offers the assurances that the risk has been appropriately neutralized.

Acute events such as the Galway outbreak rupture ideas about Ireland's modernity and progress. In Galway, these events engendered outrage and shock, and shaped responses by politicians, then and now, which seek to ensure that drinking water supplies are not contaminated. This way of framing infrastructural decay focuses more on technical repair work to upgrade the capacity of treatment plants to filter *Cryptosporidium* out of drinking water supplies and less on the wider, socio-environmental causes. In drawing this contrast, we are not advocating abandoning water treatment as an important element of providing clean drinking water. Instead, we highlight how the state's response to *Cryptosporidium* reinforces urban and rural spatial imaginaries of modernity and backwardness, maintenance and decay, and overshadows alternative politics of infrastructural contamination, where source water is a part of, rather than separate from, water infrastructure.

Understanding infrastructure as metabolic mediator between rural and urban environments is helpful for explaining the Irish state's response to *Cryptosporidium*: investing in technologies to filter out contaminants as they attempt to pass from rural bodies into urban bodies. This intervention protects the spatial distinction and dominant imaginaries of rural (unmodern) and urban (modern) in two ways. First, it obscures the industrial (agricultural) origins of *Cryptosporidium*, maintaining the idea of an under-developed (benign) countryside. Second, it allows for the continuation of modern (urban) life, resting as it does on the uninterrupted flow of clean water. Thus, the metabolic function of modern infrastructure is not simply about extending the reach of the city, enrolling new resources and labour. It is also about mediating the flows between the city and the countryside.

Chronic exposures and rural infrastructure

The state response to the risks posed by *Cryptosporidium* illustrates how infrastructures are used to mediate the rural and urban. However, by only focussing on this aspect of infrastructural decay and repair, other aspects of the rural/urban relation and how this relates to infrastructure can be missed. Who benefits from treatment upgrades in response to the risk of *Cryptosporidium*? Even though *Cryptosporidium* circulates largely in rural areas, priority is given to larger, public treatment plants that serve urban populations. In this section, we describe how the uneven exposure to *Cryptosporidium* maps on to the uneven distribution of infrastructure across rural and urban Ireland. While the last section discussed how infrastructures mediate nature/society as rural/urban, this section is about how infrastructures as mediators of risk are unevenly distributed. This perspective is informed by postcolonial urban geography with its attention to how the infrastructural ideal of European modernity is experienced unevenly.

Expectations of water infrastructures are tied to imaginaries that weave notions of rural/community and urban/public with backwardness and progress, and decay and maintenance.

Table 1. Highest incident rates by region, per 100,000 population, 2005–2016 (Garvey and McKeown, 2005, 2007, 2008; HPSC, 2006, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017).

Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Region	W	W	W	W	W	W	W	MW	W	NW & S	W	SE
Rate	34.3	17.4	74.4	21.2	26.0	16.6	23.1	22.4	23.4	15.5	18.2	22.9

When the water infrastructure failed in Galway, it ruptured *urban* expectations placed on water infrastructure. However, efforts to suture the problem contrast with how *Cryptosporidium* lingers in rural Ireland. Thus, *Cryptosporidium* risk is experienced unevenly spatially and temporally between urban and rural places. Reports from Ireland's HPSC demonstrate the spatial unevenness of cryptosporidiosis. Rural areas routinely have the highest incidence rates of cryptosporidiosis and are often classified as 'sporadic' cases, meaning they are not associated with an outbreak. Since reporting began in 2004, the rural Western region has had one of the highest incidence rates in Ireland (Garvey and McKeown, 2005; HPSC, 2011, 2013, 2014; see Table 1). For example, in 2013 the West had a rate of 23.4 cases per 100,000 individuals while the East (which includes Ireland's capital and largest city, Dublin) had a rate of 1.5 (HPSC, 2013). While higher rates in rural areas may be associated with greater direct animal–human contact, the HPSC (2011, 2012, 2013, 2014) characterizes rural locations and those serviced by private water supplies as being greater risk. Many rural areas depend on agriculture, where farm animals and their manure are plentiful and can move into water sources, and where boil water notices (BWNs), an indicator of contamination, can last for years. Incidence rates of cryptosporidiosis are also higher for individuals supplied by GWSs or private wells than those serviced by public water (HPSC, 2011, 2012, 2013, 2014).

BWNs also document the unevenness of the experience of health risk and infrastructure (Figure 3). BWNs direct users to boil water prior to any consumptive use following detection of *Cryptosporidium* and other pathogens in water supplies. BWNs occur more frequently in rural areas, lasting for several months, or in the case of Roscommon, as long as eight years. BWNs cannot be lifted until proper UV treatment is implemented and clean water samples are obtained. Thus, they are indicative of the uneven experience of health risk, infrastructure, and state investment. In Roscommon, while karst limestone sits just beneath a thin layer of soil, making it impossible to eliminate *Cryptosporidium* from the environment, there has been inadequate water infrastructure to treat raw water, and a lack of urgency to address this health risk.

The attention to difference and agency even in the context of abandonment and exclusion offered within postcolonial readings of infrastructural provision deepens our understandings of these urban/rural imaginaries. Some postcolonial urban scholars have sought to describe and understand the myriad of self-provisioning strategies developed by communities in, predominantly, urban settings in the Global South (Amin, 2014; McFarlane, 2008; Simone, 2004). In contrast to large-scale, state-led infrastructure projects, these localized alternatives demonstrate forms of infrastructure-making that are 'lively' (Amin, 2014), 'social' (Silver, 2014), and 'peopled' (Simone, 2004), relying on social networks, shared labour, communal responsibility, and ongoing improvisation. These collective forms of urban infrastructure rely on and generate distinct forms of social cooperation and collective action that can in turn shape distinct forms of politics (Bresnihan, 2020).

Translating this idea of minor infrastructures into the context of rural Ireland means attending to how communities in these places respond not only to the risk of

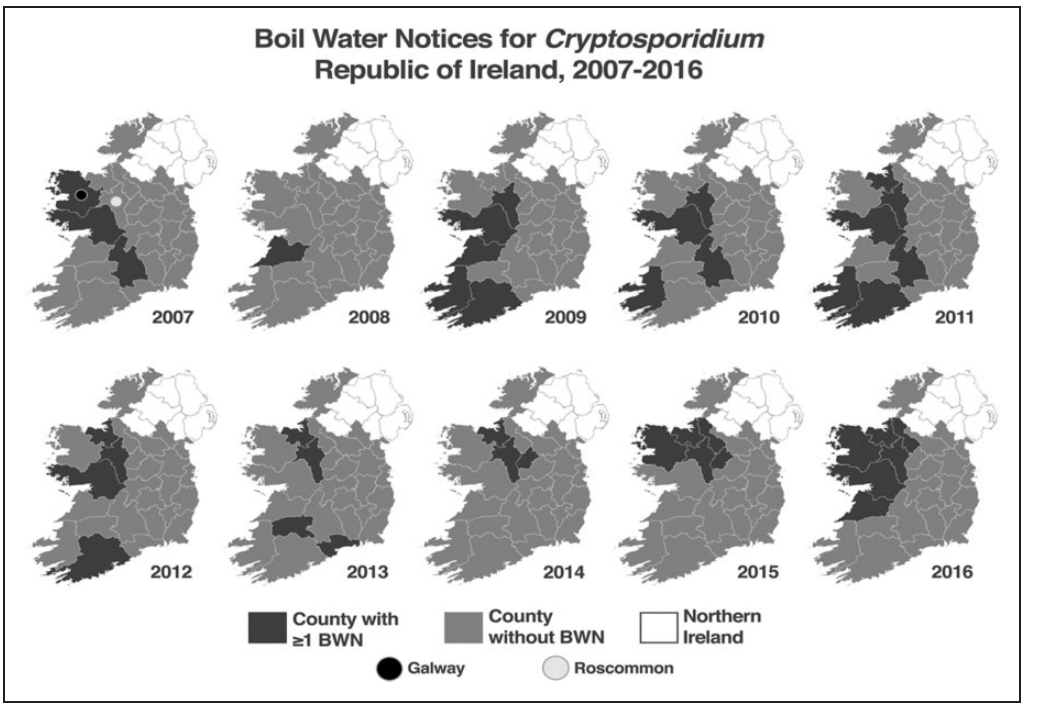

Figure 3. BWNs for *Cryptosporidium*, Republic of Ireland, 2007–2016 (EPA, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016a, 2017). BWN: boil water notice.

Cryptosporidium, but also to longer histories of infrastructural abandonment. A predominantly urban public in Ireland may not perceive *Cryptosporidium* within rural landscapes or see it as a pressing problem when it occurs in rural areas. Yet abandonment and the unevenness of development can overshadow other infrastructural politics that have unfolded in rural Ireland. Parts of rural Ireland, left to develop water infrastructures themselves, have developed different relationships that stem from decades of social and agricultural policies, (dis)investment, and abandonment.

Rural GWSs developed in the 1960s and 1970s in Ireland due to the absence of state-provided, networked infrastructure. While small government grants helped them establish (Brady and Gray, 2010), voluntary labour dug the original water networks and has maintained GWSs in the years since. Schemes in the 1960s supported efforts to expand rural tourism. By the 1970s, incentives to develop schemes responded to the growth of the agricultural sector following Ireland's inclusion in the European Economic Community in 1972. Piped water had immediate benefits for new industrial agriculture by increasing yields, particularly from dairy cows (McDonald, 2018, personal communication). Despite their initial hesitancies, farmers donated water sources to GWSs and contributed to their upkeep. Although the state invested through capital grants, it did not significantly contribute to GWSs in these early decades. Still, by the 1990s GWSs supplied water to 29% of rural areas (Deane, 2003) for domestic and commercial use, connecting to as few as 2 households to over 1000 (Brady and Gray, 2010). GWSs have used a variety of methods to fund the treatment and distribution of water, including standing charges and meter-based fees.

Events in the 1990s precipitated a shift in GWSs' relationship to the state and their water systems. The government abolished domestic water charges on the public water network in

1996, following pressure from the anti-water charges movement. Many GWSs saw this decision as unfair: general taxation would now fund the public water network, while GWSs would continue to provide for their own water services through fees and voluntary labour. In 1997, the NFGWS organized to advocate on behalf of the sector and support GWSs to meet regulatory compliance for water quality. Since 1997, it has negotiated state funding for upgrades to rural water infrastructure, operational subsidies, and research on source water protection strategies.

The NFGWS tapped into funding made available in light of new regulatory responsibilities imposed on the Irish State following alarming reports about Irish drinking water quality. The 1998 EU Drinking Water Directive set new parameters for drinking water quality, and rulings that were anticipated from the EU Court of Justice were set to make the Irish state responsible not only for the quality of the public water sector, but also GWSs. This was a problem, as in 1998 42% of GWSs failed to meet standards for human consumption (*The Irish Times*, 2000), did not have adequate treatment or funding for upgrades, and faced strains from decades of agricultural stressors on source waters.

Ireland sought to fix non-compliance by upgrading the water supplies and moved to increase investment in rural water services through the Rural Water Program, established in 1998. Rather than incorporate non-compliant GWSs into the public water supply, the state allowed GWSs to rationalize and upgrade through 'Design Build Operate' (DBO) schemes. DBOs formalized new relationships between GWSs and private water service firms to design, build, and operate water treatment facilities over 20-year contracts. To make DBOs more economical, GWSs were encouraged to 'bundle', allowing multiple schemes to utilize one water treatment facility but continue to manage their own water distribution networks and water sources. As part of DBO service contracts, water treatment companies were only held responsible for the quality of water their plants treated when source water entered at an initially agreed upon standard. Many contracts were signed based on a few, often insufficient samples. In the years since, source water quality has become more of an issue for GWSs. Connections between the catchment areas, agricultural pollution, and drinking water quality were magnified by financial arrangements and responsibilities created by DBOs. Thus, the NGFWS engaged in research to manage the link between intensive forms of animal-based agriculture and the costs of water treatment.

Since the 2000s, several GWSs have partaken in source protection pilot projects and have had drinking water safety plans developed for their supplies. In 2005, the NFGWS entered into a multi-year research project with the Dundalk Institute for Technology. This project, the National Source Protection Pilot Project (NSPP), focused on identifying and remediating points of source water pollution. The NSPP shifted from drinking water treatment to managing the hydro-social cycle, a turn they described as '[m]oving from a treatment philosophy to a protection philosophy' (Lianne et al., 2011). The project worked with specific understandings of the hydrological cycle drawn from the WFD, using catchment as a way of conceptualizing and addressing drinking water quality, even as the WFD does not include drinking water. The NSPP also reflected different relationships among water systems, communities, and landscapes. It found that the agricultural sector's contribution to water pollution was unequivocal as the sources of both diffuse and point source pollution. Microbiological contaminants were one component of the broader concerns that the project focused on, such as the impacts of agriculture on soil compaction and nutrient loss. By seeing source water quality as a part of the water infrastructure, the NSPP entangled agricultural practices, agricultural policy, and water quality.

This led to recommendations from the NSPP and efforts by the NFGWS to encourage farmers to fence in animals away from waterways, to create alternatives drinking water

sources for livestock (i.e. water troughs), and to educate farmers on better practices to protect water supplies from agricultural slurry. The NSPP has helped identify areas where the NFGWS has continued to do research to protect source water. This includes research to protect groundwater sources rather than focusing on surface water more commonly considered to be at risk from poor agricultural and land-use practices, to study septic tank pollution, and to delineate zones of contribution through catchment mapping for GWSs. These relationships have grown out of legacies of state (dis)investment but offer the possibility for a different kind of infrastructural politics to manage contamination. The example set by the NFGWS is not *the* answer, but an alternative way of navigating the material politics that contamination gives rise to. However, the expediency and success of installing UV filters and the reliance on these same rural areas on the agricultural sectors ultimately pose challenges to source water protection efforts, particularly when the focus of attention and energy is limited to the local scale.

Conclusion: Minor infrastructures

The paper began with McCormack's novel *Solar Bones* because it captures the dissonance between the acute outbreak of cryptosporidiosis in Galway and the chronic, widely distributed processes of urban development, expanding animal-based agriculture, and imaginaries of decaying infrastructure that provide the conditions for *Cryptosporidium* to circulate. The dominant state response to the risks posed by *Cryptosporidium*, both in the immediate aftermath of the Galway outbreak as well as through subsequent institutional and regulatory reforms, has obscured these wider political ecological relations, in effect separating impure 'rural' water bodies from purified urban water systems. Understood through the urban political ecology literature, infrastructure plays a vital metabolic role not only in drawing resources and labour into the city, but also in mediating and filtering those flows. This is not just a material function but also a powerful symbolic one that regulates the relation of rural (non-modern) to urban (modern). This metabolic mediation simultaneously protects the promise of modern, urban infrastructure: the uninterrupted flow of clean water, and the image of a non-modern, rural landscape: by separating *Cryptosporidium* from its relation to broader and longer histories of agricultural intensification, the industrial origins of this microorganism are obscured and rural Ireland remains under-developed.

As well as following *Cryptosporidium* as it becomes perceptible and manageable through urban bodies and protest, institutional expertise, regulation, and governance, this paper has also described how *Cryptosporidium* is rendered less perceptible in certain rural environments, bodies, and infrastructures. The focus is not so much on the metabolic functions of infrastructure in mediating rural/urban relations, but the uneven distribution of such functions and what this illustrates about longer legacies of uneven (infrastructural) development. We draw on postcolonial urban geography to surface the uneven experiences of (infrastructural) modernity and the ways that excluded or marginalized (largely urban) populations have devised alternative means of self-provisioning, including access to water. Our paper contributes to this work by translating this analytic to the rural/urban relation in Ireland. Here, the spatial distribution of infrastructure is indexed to distinct temporalities of contamination. In the case of providing water safe from *Cryptosporidium* in Ireland, the failure is acute and urgent in the case of urban populations, but normalized and chronic for parts of rural Ireland, manifest in mundane routines of boiled water rather than public protest.

To paraphrase Michelle Murphy, how as critical and engaged scholars can we help to make *Cryptosporidium* perceptible *otherwise*? One way we have sought to respond to this

question is to situate our research in contexts and projects that are, in minor ways, doing this through practical engagement. The way that *Cryptosporidium* is rendered perceptible and imperceptible reinforces longstanding imaginaries of rural (non-modern) and urban (modern) in Ireland, an analysis that is itself a political one. GWSs are the outcome of state policies that neglected certain rural areas, excluding them from the modern infrastructural ideal. Since the 1960s and 1970s, these schemes have developed along different trajectories, organizing water services according to different logics and values. Recognizing this difference is not about idealizing community-based projects, particularly not when they are dependent on state funding and thus subject to state regulatory standards and requirements. That these rural infrastructural projects are non-networked does, however, provide space for infrastructural arrangements that are part of distinct histories, economic development, and social forms that exist within these rural localities. Developing questions, knowledge, technologies, and organizational practices from the perspective of these rural water schemes, and rural communities more generally, can dislodge an urban bias that tends to animate critical scholarship and activism concerned with infrastructural development. In concluding, we want to consider how the different imaginaries and concerns articulated in relation to urban-based, public infrastructures and rural-based, community-based infrastructures may give rise to alternative infrastructural politics.

As recently as 2016, Ireland witnessed an unprecedented popular mobilization around the proposed introduction of domestic water charges and a re-structuring of public water services. Largely urban-based, this movement was supported by trade unions, left wing activists, parties, and non-governmental organizations. The Irish anti-water charges protest was explicitly connected to a global wave of anti-privatization water movements and struggles (Clark, 2018). While the state presented the water reforms as necessary for an ageing and inadequate water system, the opposition framed it as an unjust austerity measure that had little to do with water services or environmental concerns. This anti-austerity focus was effective in mobilizing a mass movement, but it also displaced any meaningful engagement with Ireland's decaying water system and its complex connections to entrenched models of water-intensive and polluting models of development. Akin to the outbreak in Galway, there was an assumption that safe, secure supplies of drinking water should be provided by the state, and that a failure to do so was rooted in political ineptitude or neoliberal ideology (Bresnihan, 2018).

This perspective betrays the fact that many people in rural Ireland have not had access to public water infrastructures for decades. GWSs were largely invisible in national debates about the future of Ireland's water sector, even as many GWSs had introduced domestic water charges and metering in the early 2000s as part of the infrastructural upgrades. For GWSs, these reforms precipitated new concerns for source water protection because of the costs associated with treating water, effectively transferring money from water users to the private water companies tasked with providing treatment services. Concretely, this heightened awareness of the relationships between land use and agriculture on water quality, the treatment process, water chemistry, the piped network, including leakage, and general water use on the scheme. This situated knowledge is inseparable from the shared ownership and community ethos that underlies the functioning of the water schemes.

By coupling postcolonial insights with those from urban political ecology and political ecologies of health, the paper traces urban/rural imaginaries, infrastructural decay and repair, and exposure to health risk through histories of abandonment and exclusion in Ireland. While GWSs focus on the role of physical infrastructures in addressing the uncertain and complex causes of water contamination, they also recognize the embeddedness of infrastructures in the wider political ecologies of catchment, even if this is largely at a local

scale. This localism undoubtedly limits the scope of the GWSs; coupled with the reliance of these rural areas on agricultural activity, the potential to challenge the systemic drivers of water contamination is weak. Localizing water services is not the answer to problems of contamination, or any other of the water-related challenges Ireland faces. However, the experiences of the GWSs and some of the responses they have elicited do provide an invitation to scholars and activists involved in water justice to re-think the sites and forms of water politics, expanding debates and struggles beyond public/private ownership of large-scale infrastructure by taking into account the practices and politics afforded by minor infrastructures in the making. The challenge is how to translate between these different infrastructural trajectories and experiences, how to forge alliances that rupture entrenched urban/rural differences that might be capable of politicizing *otherwise* the complex entanglements of water, infrastructure, and the environment.

Highlights

- Infrastructural contamination and its repair are experienced unevenly across urban and rural context in Ireland
- Repair of infrastructural decay reinforces expectations of infrastructure connected to imaginaries of urban/rural
- Politics of infrastructural decay and repair can be reimagined through everyday responses to contamination that surface, rather than obscure, the connections between infrastructure, landscape, human and non-human bodies

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Notes

1. The crisis lasted 158 days, resulting in more than 240 confirmed cases of cryptosporidiosis and an estimated 496 unreported ones. This would be the largest outbreak in Ireland since cryptosporidiosis surveillance began in 2004 (EPA, 2016a).
2. Human treatment and preventive methods are limited. Only the US has approved Nitazoxanide to treat cryptosporidiosis, and its efficacy is not as clear (Checkley et al., 2015; Thompson et al., 2016)

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