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# An interdisciplinary political ecology of drinking water quality. Exploring socio-ecological inequalities in Lilongwe's water supply network



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## ABSTRACT

Urban political ecology attempts to unravel and politicize the socio-ecological processes that produce uneven waterscapes. At the core of this analysis are the choreographies of power that influence how much water flows through urban infrastructure as well as where it flows, thereby shaping conditions and quality of access in cities. If these analyses have been prolific in demonstrating uneven distribution of *infrastructures* and water *quantity*, the political ecology of water *quality* remains largely overlooked. In this paper, we argue that there is a clear theoretical and practical need to address questions of quality in relation to water access in the South. We show that conceptual resources for considering differentiated drinking water quality are already present within urban political ecology. We then contend that an interdisciplinary approach, highlighting the interdependencies between politics, power, and physiochemical and microbiological contamination of drinking water, can further our understandings of both uneven distribution of water contamination and the conceptualisation of inequalities in the urban waterscape. We illustrate our argument through the case of water supply in Lilongwe, Malawi. Our political ecology analysis starts from an examination of the physicochemical and microbiological quality of water supplied by the formal water utility across urban spaces in Lilongwe. We then present the topography of water (quality) inequalities in Lilongwe and identify the political processes underlying the production of differentiated water quality within the centralised network. This paper thereby serves as a deepening of urban political ecology as well as a demonstration of how this approach might be taken forward in the analysis of urbanism and water supplies.

## 1. Introduction

Despite the implementation of large-scale programs like the Drinking Water Decade (1981–1990) and the Millennium Development Goals, urban dwellers in sub-Saharan Africa are increasingly exposed to health risks associated with inadequate access to clean water (Hunter et al., 2009; Wright et al., 2004; Ashbolt, 2004a,b). At the core of this failure are two fundamental causes. First, these programs have overwhelmingly focused on coverage, while other fundamental dimensions of access, such as quality and continuity of supply, have been largely overlooked (Boakye-Ansah et al., 2016; Bain et al., 2014;) Second, water service configurations continue to fail those most in need. In 2012 coverage in sub-Saharan urban centres had reached 64%, instead of the expected 77.5 % (WHO and UNICEF, 2014), while in-house

connections dropped from 43% in 1990 to 33% in 2015 (WHO/UNICEF, 2015). Such figures are often justified on the grounds of technical and financial limitations (Dagdeviren and Robertson, 2011), as well as patterns of urban growth (Muchadenyika, 2015). The UN-HABITAT world city report (2016), for instance, explains how the particularly rapid increase in people living in slum or informal settlements, grown from 790 to over 880 million between 1990 and 2014, is directly linked with poor access to basic services such as water supply.

Eschewing some of the more technocratic and apocalyptic explanations of water injustice, Urban Political Ecology (UPE) draws out the role of politics and power in shaping water flows and infrastructural developments in cities (Truelove, 2016; Domènech et al., 2013; Ioris, 2012; Swyngedouw, 2004, 1999, 1997; Bakker, 2003; Crow and Sultana, 2002). Nevertheless, there is a tendency to interpret

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inequalities in urban water supply as a split between those who are connected and those who are unconnected. Recent studies in Science Technology and Society (STS) and everyday urbanism have questioned such assumptions, arguing that understanding differentiated access and the full range of inequalities in urban water supply also implies questioning the homogeneity of the centralised water supply network (Alda-Vidal et al., 2017; Björkman, 2014; Misra, 2014; Lawhon et al., 2014; Anand, 2012). If these interpretations have been fruitful, the political ecology of water *quality* remains largely overlooked. Drinking water quality continues to be entrenched in disciplinary studies in microbiology focusing on physico-chemical and microbiological quality (Kosamu et al., 2013; Machdar et al., 2013; Castro-Hermida et al., 2008; Kimani-Murage and Ngindu, 2007; Betancourt and Rose, 2004) and in studies in public health focusing on risks associated with contaminated water (Bain et al., 2014; Fewtrell et al., 2005; WHO, 2000; Ashbolt, 2004a).

In this paper, we argue that there is a material need for UPE to engage with questions of *quality* in relation to water access. We contend that an interdisciplinary approach, highlighting the interdependencies between politics, power and microbiological contamination of drinking water, can further conceptualisations of socio-ecological inequalities in the urban waterscape. We illustrate our arguments in two ways. We first provide a brief review of debates around UPE and the dimensions of inequalities, demonstrating that important critiques of commodification have, perversely, led to a neglect of concerns over quality. By following the process of abstraction through which water is produced as a commodity, many urban political ecologists have failed to attend to the material properties of water. Conversely, while the re-materialisation of political ecology serves to rectify this imbalance somewhat it risks neglecting what urban political ecology has done so well – teasing out the socio-ecological relations through which inequalities are produced.

We therefore develop an interdisciplinary perspective that produces a more multifaceted understanding of water inequality. Such an interdisciplinary perspective is not without its difficulties and we reflect on the methodological implications of an interdisciplinary UPE of water quality drawing out the range of different perspectives from which we find inspiration. In the latter part of the paper we draw from research undertaken in Lilongwe, Malawi. Our political ecology analysis starts from an examination of the physicochemical and microbiological quality of water supplied by the formal water utility across urban spaces in Lilongwe. We then develop the topography of water (quality) inequalities in Lilongwe and identify the social and political relations through which differentiated water quality is produced within the water supply network. We conclude that approaching the materiality of water through this interdisciplinary analysis serves to articulate inequalities from multiple perspectives and provide wider breadth to examinations of urban water as a socio-natural question.

## 2. Urban Political Ecology and the question of *quality* in relation to water supply

### 2.1. Introduction: water quantity as key focus in UPE

At the heart of UPE is an attempt to unravel how power controls and redirects resources and flows, thereby producing urban configurations and outcomes that are unevenly experienced in environmental, social, and economic terms (Brand and Thomas, 2013; Castree, 2001; Gandy, 2003; Ekers and Loftus, 2008; Heynen et al., 2006; Kaika, 2005; Keil, 2003, 2005; Swyngedouw, 1996, 1999). Processes of urban metabolism are, therefore, never neutral; instead they are at the root of uneven geographical developments (Heynen et al., 2006; Gandy, 2005; Swyngedouw, 1999), which more strongly affect low-income and vulnerable groups, even in cases where pro-poor policies are explicitly adopted. In framing water injustice in this way, UPE has mainly focused on understanding the political ecology of cities through the way

infrastructural configurations and (water) circulation shape processes of urbanisation (Lawhon et al., 2014).

Swyngedouw's work on Guayaquil, Ecuador, was path-breaking in its analysis on how urban transformations and water distribution by the public water utility worked to marginalize the urban poor (Swyngedouw, 1997). Similar studies have subsequently shown the impact of neoliberal reforms on differentiated access to services (Bakker, 2010; Heynen and Robbins, 2005; Budds, 2004; Smith and Hanson, 2003; Bakker, 2003; Loftus and McDonald, 2001) as well as the role of gender, class and race as key variables in producing uneven water infrastructure development and differentiated access to water (Truelove, 2016, 2011; Ge et al., 2011; Sultana, 2011; Sultana and Loftus, 2013; Bakker, 2003, 2009). In a succinct summary, Bakker (2003: 333) writes that “for the urban elite, water supply is often relatively abundant, and relatively cheap. For the urban poor, the scarcity of potable water is a daily hardship”. Except for a few studies focusing on the relationship between modernity, scientific knowledge on waterborne diseases, hygiene and technologies (Kooy and Bakker, 2008; Gandy, 2006), urban political ecologists have been less attentive to questions of quality. In the section that follows we discuss why UPE scholarship has placed less attention to the material properties of water. We then turn to methodological considerations of an interdisciplinary perspective on urban water quality.

### 2.2. *Quality and quantity as different measures of inequality*

“Quality no longer matters. Quantity alone decides everything”

Marx [1847] 2008: 57

If Urban Political Ecology approaches have been particularly effective at critiquing the relations that produce uneven access to water, they have frequently been less effective at dealing with questions of quality. Paradoxically, this relative lack of attention to questions of water quality runs counter to the broader project of rematerializing nature within UPE (Demaria and Schindler, 2016; McClintock, 2015; Rice, 2014; Mee et al., 2014), which builds on the earlier turn to materialities in Political Ecology (Bakker and Bridge, 2006), the more recent focus on the agential properties of matter (Bennett, 2010) and the force-full characteristics of specific objects (Meehan, 2014). Addressing urban political ecology directly, Demaria and Schindler (2016) suggest that there is a need to broaden its scope through a conversation with industrial ecology and ecological economics. They suggest that a first wave of UPE has been overly focused on capital as a determinant of ecological processes, whereas a second wave has developed a more convincing analysis of the role of non-humans. They therefore seek to “balance critical urban theory [drawn from UPE] with attention to materiality [drawn from ecological economics and industrial ecology]” (2016: 308). This balancing act is, however, not as simple as they suggest and risks eliding areas of intellectual dissonance. Elsewhere, in a highly generative and richly suggestive paper, McClintock (2015) has shown how a conversation with Critical Physical Geography can enable new ways of interpreting (and transforming) lead contamination in West Oakland. In contrast to Demaria and Schindler (2016) McClintock's approach is to deepen the resources available within UPE, rather than simply supplementing. Similarly, Rice (2014) deepens existing UPE to demonstrate how climate change governance might be re-interpreted through paying particular attention to the materiality of carbon. We see much scope for conversations with such contributions; however, in contrast to Demaria and Schindler's (2016) approach, we consider whether it might not be possible to find resources *within* urban political ecologies of water and an approach that is attendant to a range of different determinants while remaining open to the question of nature's matter.

Part of the reason for the emphasis on water quantity over quality within some urban political ecologies of water is suggested in the quotation from Marx with which we began this section: the increasing

importance of the exchange abstraction has a tendency to flatten the distinctive qualities of ‘things’. A process of abstraction is necessary to ensure that people, resources and places are exchangeable through a universal equivalent – money. At the heart of this process is a struggle over the dominance of abstract social labour over the concrete practices of producing and reproducing. John Holloway illustrates this process through an example of cake-baking. While Holloway may have initially started baking out of the joy of producing for others, the process of abstraction fundamentally reconfigures his work to the extent that “my doing has become completely indifferent to its content; there has been a complete abstraction from its concrete characteristics. The object I produce is now so completely alienated from me that I do not care whether it is a cake or a rat poison, as long as it sells” (Holloway, 2010: 913).

In his critique of the production of abstract space, Lefebvre, similarly, dissects a process through which specific geographical qualities come to be eviscerated. Thus, abstract space appears homogenous and serves the purposes of those opposed to difference (Lefebvre, 1991). Nevertheless, this homogeneity is only an appearance and it serves the purpose of trying to rid space of difference. Through this lens, the violence of abstraction (ibid) is a real process but one that remains open to struggle and contestation. When analysing water, many urban political ecologists have tended to follow not Lefebvre but Neil Smith (2008) in order to understand the production of nature in an abstract form. Smith’s arguments around the production of nature have therefore influenced a particularly powerful critique of the commodification of water. Following Smith, the development of capitalist relations of production can be seen to have transformed a simple act of production for need (expressed in nature as a use value) into one focused more directly on production for profit. The implications for water provision, to borrow Swyngedouw’s (2003: 10) felicitous phrase, are that “local waters are transformed into global money”.

It is in Smith’s distinction between first and second nature – one of the most misunderstood aspects of his overall thesis (Loftus, 2012) – that this shift from the production of nature as a use value to the production of nature as an exchange value is considered most deeply. As a historical materialist, changes in production have deep ontological (and, indeed, epistemological) implications for Smith. The best description of this ontological shift, Smith claims, is found in Alfred Sohn-Rethel’s (1978) work. For Sohn-Rethel “[First nature is] concrete and material, comprising commodities as objects of use and our own activities as material, inter-exchange with nature; [second nature is] abstract and purely social, concerning commodities as objects of exchange and quantities of value” (Sohn Rethel 1978 quoted in Smith, 2008: 79). Recognising that such a distinction might imply the very dualistic framing against which the production of nature thesis is targeted, Smith qualifies the statement, writing “The same piece of matter exists simultaneously in both natures” (ibid). Nevertheless, the focus of Smith’s critique – and much of the work that has followed – has tended to be on one moment in this differentiated unity: the production of nature as an abstract commodity. The apparent evisceration of ‘quality’ in the production of this abstract (second) nature (cf. Lefebvre, 1991) has tended to mean that the myriad qualities comprising different resources are ignored. Thus, while deeply critical of such abstractions, some urban political ecologists still tend to treat water as a “modern abstraction” (for a critique, see Linton, 2010). Indeed, in making a methodological choice to focus primarily on second nature, scholars reproduce the very process of inversion (the supplanting of quality by quantity) that is the subject of their critique (Ekers and Loftus, 2013). Nature thereby tends to be considered only in its abstract form, rather than as encompassing the myriad qualities that remain in spite of the violence of geographical abstraction (Loftus, 2015). An approach is needed that recognises how water “exists simultaneously in both natures” (Smith, 2008: 79) and on both the sets of social relations that produce water as a commodity (thereby shaping uneven access to that commodity) but also on the socio-ecological relations that give rise to wide variations in water

quality and to the exposure of certain groups to poor quality water.

### 2.3. Urban Political Ecology as interdisciplinary understanding of socio-natural inequalities in urban water supply

While on a theoretical level the interweaving of socio-environmental processes is convincingly argued, methodological questions about how one might *do* a genuinely interdisciplinary UPE that crosses the natural and the social sciences remain. Scholarship calling for the re-materialisation of Political Ecology (Müller, 2015; Gabriel, 2014; Meehan et al., 2013; Bakker and Bridge, 2006) is concerned with such questions. Central to socio-materiality is the idea that the non-human is not just a set of objects that humans mobilise, “but actors that mediate urban relations and can change their trajectory” (Gabriel, 2014: 45). Political ecologies of health, have been particularly active in examining how the non-human – bacteria, medicine, technologies, and (water-borne) diseases – figures in the production of health, diseases, and care (Hausermann, 2015; Jackson and Neely, 2014; Sultana, 2013; Mansfield, 2008). UPE scholars have also engaged with geospatial scholarship seeking to problematize and historicise depoliticised and technical notions of the environment through questions around how power works to produce an uneven distribution of costs and benefits of environmental configurations (Cousins and Newell, 2015; Turner, 2003; Warren et al., 2001). A study modelling the urban carbon footprint of the water supply network in Los Angeles, for instance, uses a political ecology analysis “to open up the black box of the carbon modelling” (Cousins and Newell, 2015: 42).

In UPE of water the engagement with materiality has opened new spaces of discussion on infrastructures as “power brokers” and “objects as force-ful” (Meehan, 2014: 215; see also Birkenholtz, 2013; Bakker, 2003). Sultana’s work, for instance, shows how different waters, technologies and social relations interact to coproduce uneven contamination, water qualities and (in)securities in the Bengal Delta (Sultana, 2013; Sultana, 2006). This scholarship, however, has yet to work out how to bring in the complex question of nature and materiality of water in interdisciplinary examinations. In what follows we draw on our own research experience in Lilongwe, where we seek to investigate the production of uneven water quality across the city. We thereby attempted to develop a conversation between natural and social scientists, between the biophysical processes enabling life and the socio-political processes with which these are interwoven. Working across these different registers, we seek to make a broader argument for the necessity of understanding water quality within UPE.

### 3. Interdisciplinary UPE of drinking water quality: understanding the interweaving human and non-human transformations

Understanding the interweaving of human and non-human transformations requires an approach that accounts for both the social and material dimensions of politics. For drinking water quality inequalities in the urban metabolism, this entails identifying social relations that produce water as a commodity and unravelling how these contribute to changing physico-chemical properties of the water and, ultimately, to the uneven distribution of bacteriological contamination across urban spaces. Methodologically this involves combining qualitative approaches with methods that map and quantify material water flows and assess microbiological contamination.

In the sections that follow we discuss the uneven distribution of water contamination in Lilongwe, the capital of Malawi. The city has a population of approximately 1 million inhabitants that live in 58 administrative areas. Of these 26 are classified as low-income (LIAs) and house about 76% of the city’s population (UN-HABITAT, 2011). The Lilongwe Water Board (LWB) serves approximately 78% of the population through in-house connections in higher-income areas and water kiosks and few yard taps in low income areas. We combine the analysis historical processes and political transformations that have shaped

water service configurations with the assessment of chemical and micro-biological transformations of drinking water quality flowing through the centralised water supply network.

First, to ground the research in a geographical understanding of the uneven production of space, we look at the relation between production of urban and sub-urban spaces and uneven condition of access to water. Our understanding of the uneven geographies of Lilongwe is based on a review of policies and urban development plans of the past four decades, and eighty interviews conducted with urban planners, water utility managers, kiosks attendants, water users and other actors concerned with the distribution and use of drinking water. Additionally, a survey was undertaken ( $n = 497$ ) in six administrative areas of the city.<sup>1</sup> Second, we analyse non-human transformations through a water quality assessment of the drinking water distributed by the Lilongwe Water Board. Laboratory work included the microbiological and physicochemical analysis of 170 samples collected both at the kiosks and at the consumption point (i.e. household storage) in two low-income areas (Area 56 and Area 7), and at yard taps and in-house connections in two higher-income areas (Area 47 and Area 2) (see also Boakye-Ansah et al., 2016). While collecting samples, observations of everyday practices of supplying water at the kiosks and strategies to access and store water in low-income areas were carried out. The research for developing the case study was undertaken between November 2014 – February 2015, and February – April 2016.

#### 4. Producing socio-natural inequalities in drinking water quality in the centralised water supply network of Lilongwe, Malawi

##### 4.1. The production of uneven urban spaces: modernity, sub-urbanism and sub-standards service levels

Socio-natural inequalities in water supply originate from socio-spatial differentiations rooted in Lilongwe's urban landscape since its establishment as the post-colonial capital. The first president of Malawi, Banda, promoted the "garden city" project, which envisioned a modern, clean and green urban space. As the former Commissioner for Town and Country Planning (1984) explains, "Lilongwe New Capital City is a national symbol and image of Malawi, the seat of Government, and meeting place of international visitors. Therefore, it must be aesthetically appealing, pleasant and delightful to perceive, live in, work and play".<sup>2</sup> Part of the 'landscaping' of this national symbol entailed the segregation of high density low-income areas, contrasting with the garden city imaginary projected by the city centre. This was achieved by relocating low-income residents at the margin of the city and creating physical barriers such as vacant land, swampy low lands, tree belts, and streets (Potts, 1985). Urban planners also recognised that "in real life there is nothing that is absolutely perfect" and that working towards the new city imaginary also entailed problems of "technical nature",<sup>3</sup> such as the elevated costs to provide infrastructure and basic services for all. In-house connections were, thus, only planned for key areas of the city (i.e. Capital Hill and Parliament Building, planned residential areas for senior government officials and middle-level government officials, industrial areas, army, hotel and banks), while the traditional housing areas, urban spaces developed for lower income residents, were to be served through water kiosks within 1000 feet of the plots (Englund, 2002). Post-colonial Lilongwe, therefore, ended up reproducing much of the race-based and Apartheid inspired class organization, with Asian, white and wealthier black people inhabiting

low-density areas in the city centre, where modern public buildings, basic services and infrastructures were concentrated, and the working class marginalised in high-density areas, characterised by the highest infrastructure and basic services deficits (Myers, 2003).

Lilongwe rapidly grew from fewer than 20,000 inhabitants in 1966 to over 100,000 in 1977 (Gitec Consult GmbH, 1980 in Matope, 1984) and is expected to have reached a million residents in 2015 (UN-Habitat, 2011). The planning policies and the selective development of urban spaces combined with the informal urban growth of the 90s worked to produce a fragmented waterscape, characterised by different service modalities and uneven service levels. Although the Lilongwe Water Board reports relatively high levels of coverage, fragmentation occurs also within the centralised water supply network. Of the 78% of the urban population served by the Lilongwe Water Board, 56% are served through in-house connections and 44% through water kiosks. The remaining 22% of the population accesses water through shallow wells and boreholes (NSO, 2008).

##### 4.2. The discursive construction of good drinking water quality in the centralised network

While uneven distribution of water infrastructures in Lilongwe is relatively well documented and acknowledged (NSO, 2008; JMP, 2015), other inequalities in access have been largely overlooked. Although many studies suggest that the quality of piped water may be compromised by intermittent supply (Brocklehurst and Slaymaker, 2015; Kumpel and Nelson, 2013, 2014, 2016), the discursive construction around it in Lilongwe is that water has gone through treatment and, thus, is of good quality. A higher-level staff member from the Malawi Bureau of Standards (MBS) explained that "water from the LWB is treated and, therefore, it is of good quality"<sup>4</sup>; a view which was also shared by officials from the Ministry of Irrigation Agriculture and Water Development (MoIAWD). A Lilongwe Water Board high level manager doubts that water quality within the system might differ: "as far as I am aware, water from kiosks is of the same quality as what I collect from the taps in my house, so it can be collected and consumed on the spot without any quality issues".<sup>5</sup> This discursive construction also influences monitoring practices as the "quality of piped water is generally good, further monitoring is not a requirement". Similarly, users accessing water from water kiosks do not perceive quality as a risk. For kiosk users, the major water related risk is *quantity*, rather than *quality*. Discontinuity of the service, which forces them to revert to water from shallow wells and to store large quantities of water in their home, is the main concern.<sup>6</sup>

In contrast with this discursive construction, laboratory analysis shows that water quality – both microbiological (*E. coli* and total coliforms) and physico-chemical (turbidity, free and total chlorine) – differs from area to area. Free chlorine is a chemical disinfectant used to preserve water quality from pathogenic microorganisms that might enter during transport and distribution because of pipe breakages. The disinfectant concentration is usually inversely proportional to the presence of microbial contaminants, meaning that higher concentration ensures better protection from contaminants (i.e. lower concentration of microorganisms susceptible to this treatment). Laboratory analyses show that free chlorine concentration is higher in higher income areas, hence providing more protection against microbial contamination. Consequently, faecal contamination, measured as *E. coli*, is higher in water from kiosks, which often do not meet WHO guidelines ( $< 1$  CFU/100 mL of *E. coli*) and even local standards (Fig. 1).

In the following section, we show how the transformations in water

<sup>1</sup> Risk assessment and access to WASH services in urban Lilongwe, UNHIDE-INHABIT Survey, March-April 2016.

<sup>2</sup> Joseph J. Matope, Commissioner for Town and Country Planning, Office of the President and Cabinet Town and Country Planning Department, "Lilongwe: New Capital City of Malawi", Workshop on New Capital Cities in the Developing Countries: a Critical Examination of Experiences, Abuja, Nigeria 4–9 March 1984.

<sup>3</sup> Ibid.

<sup>4</sup> Interview, staff MBS, Lilongwe, 21st January 2015

<sup>5</sup> Interview, Lilongwe Water Board management, Lilongwe, 29th January 2015.

<sup>6</sup> Risk assessment and access to WASH services in urban Lilongwe, UNHIDE-INHABIT Survey, Area 56, Lilongwe, March-April 2016.

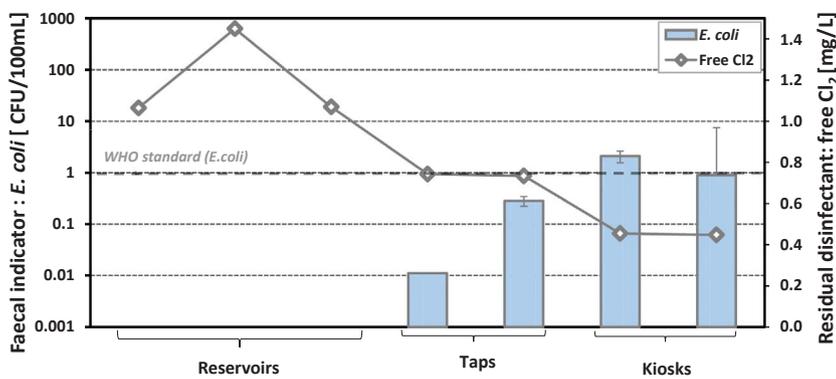


Fig. 1. Faecal indicators and residual disinfectant concentration in different points.

quality are produced by decisions on how and for whom the network should be developed, operated and maintained, and how water quality monitoring is carried out and enforced. By unravelling the power geometries that determine differentiated water quality across the centralised network we attempt to show how discursive and material constructions of water quality, and non-human transformations are intertwined.

#### 4.3. The material practices of water provisioning: developing, operating and monitoring a heterogeneous water supply network

##### 4.3.1. Structural decisions on the water supply network

Inequalities in water quality are embedded in the infrastructural configuration of the network. Although consisting of a single unit, the network in Lilongwe is not monolithic and uniform, but rather fragmented in different service modalities. The decision to develop a ‘dual’ network consisting of in-house connections and water kiosks was part of the first urban plan of the city and represents the first dimension of inequality. The duality of the centralised water supply network is then reproduced by decisions around the selection of pipes, taps, valves and kiosk. It was, for instance, observed that smaller pipes, of lesser quality, were used to connect water kiosks to the transport mains (see Boakye-Ansah et al., 2016). Further, the recent upgrading of the water supply network has mainly targeted planned areas. The water board is replacing old and corroded galvanized iron (GI) pipes with new high density polyethylene (HDPE) ones. However, as a Lilongwe Water Board staff member explains, “this being done on merit in the zone [...], merit here meaning in-house connections. We will be targeting the kiosks in the later parts of the year because the HDPE pipes are not enough.”<sup>7</sup> Similarly, there are differences in the construction techniques adopted in higher and lower income areas. While pipes in planned neighbourhoods are lowered at the depth recommended by the LWB, (100 cm for transmission pipes and 45 cm to 50 cm for connecting pipes) in the LIAs, pipes are often exposed on roads and walkways. Equally relevant are the decisions over which parts of the network are provided with valves and which ones are not. As indicated by a higher-level manager of the LWB, “the non-functioning air valve on the transmission line to the LIAs and specifically Area 56 is another factor contributing to the high frequency of bursts and breaks of pipes [...] after long hours of cut-off [...] the absence of wash-out valves on the same line also prevents flushing”<sup>8</sup>.

In the centralised water supply network in Lilongwe, therefore, water is distributed through different infrastructures and materials that unevenly protect water from contamination. As other studies have shown, these infrastructural inequalities lead to higher risks of pipe breakage, corrosion, low pressure, intermittent supply and, ultimately, water contamination (Basualdo et al., 2000; Ohwo, 2014; Sadiq et al., 1997; Sander et al., 1996).

##### 4.3.2. Producing uneven water flows in the city

As indicated by a foreign consultant with the LWB, “there is enough water at the source [dams] but the treatment plants are not able to produce enough water for all the users in the system, especially during the dry season when demand of water grows”<sup>9</sup>. The *Waterworks Act (1995)* of Malawi (section 12.16a) mandates the water boards “to disconnect the supply of water to any premises or to diminish, withhold or suspend, stop, turn off or divert the supply of water to any premises whenever the available supply of water from the water works shall in the opinion of the Board be insufficient” (GoM, 1995). The Act, however, is enforced by systematically disadvantaging low-income areas. The unequal distribution of water across the city is inherent to the structure of the network, designed to divert and store larger quantities of water in higher-income areas. The systematic prioritisation of higher-income areas is exacerbated through everyday operations, discursive constructions and rationalizations of the staff dealing with everyday shortages, water rationing and different user groups across the city (Alda-Vidal et al., 2017).

An operational staff member of the Lilongwe Water Board explains that shortages are more of a burden for people living in high-income areas, as “water is the least of problems confronting residents in the LIAs, in contrast to residents in the planned [higher-income] areas who use several devices which require the constant flow of water”<sup>10</sup>. Similarly, operational staff differentiate between groups of users and who is to be protected or not from water shortages: “honestly the priority goes to the North, which houses the industries, diplomats and the political area”<sup>11</sup>. At the core of the selective discontinuity are powerful actors who are better placed and able to negotiate access: “none wants an ambassador calling you to tell that there is no water, while in the Southern Zone people have many other problems besides water”<sup>12</sup>. Other rationalisations include financial arguments: “residents from these rich areas pay the bills so if the water is not enough I have no option than to send it to them”<sup>13</sup>. Because of these practices, residents suffer water shortages for up to 4–5 days. As a resident explains, “we get water only when the rich people are asleep”<sup>14</sup>. The high rates of discontinuity increase the likelihood of pipe breakages due to the constant alternation between water and air in the network. This, in turn, may cause ingress of contaminants into the water in transmission, increased turbidity, reduction in free chlorine concentration and an increased risk of faecal contamination.

##### 4.3.3. Selective maintenance and monitoring of the network

The dichotomisation of the network is reinforced through everyday practices of operation and monitoring of the system. Despite the significantly higher rates of leakages and pipe bursts in low-income areas,

<sup>9</sup> Interview, consultant, LWB, Lilongwe, 16th September 2014.

<sup>10</sup> Interview, Lilongwe Water Board operational staff, Lilongwe, 6th October 2014

<sup>11</sup> Interview, staff, LWB, Lilongwe, 23rd September 2014.

<sup>12</sup> Interview, Lilongwe Water Board staff member, Lilongwe, 6th October 2014.

<sup>13</sup> Interview, Lilongwe Water Board staff member, Lilongwe, 16th January 2015.

<sup>14</sup> Interview, Kiosk Attendant, Area 56, Lilongwe, 16th January 2015.

<sup>7</sup> Interview, Lilongwe Water Board, Plumber Area 7, Lilongwe, 16th January 2015.

<sup>8</sup> Interview, LWB, Lilongwe, 1st December 2014.

the latter are hardly targeted for maintenance. Observations in the field and maintenance data from the LWB showed that, whilst it takes a maximum of three days for maintenance to be carried out in planned areas, it takes up to three months in LIAs, where – as a kiosk attendant explains – “[this] pipe here has been leaking for the past three months and I don’t know when it will be repaired”.<sup>15</sup> In stark contrast, a resident in the planned neighbourhood explained that “there are hardly any breakages or leakages of pipes because you don’t see pipes lying on the surface they are buried well in the ground [...] if they occur a call is placed to the Water Board and they are fixed immediately”.<sup>16</sup>

Water sector organisations rationalise these practices by arguing they have not been given a clear mandate for the maintenance of the water kiosks. While the system is relatively straightforward in the case of in-house connections, where maintenance is carried out directly by the LWB staff, the responsibility of the water utility is contested when it comes to the kiosks. Zone managers of the LWB are of the view that kiosks fall under the Kiosk Management Unit (KMU) a department of the LWB, entirely dedicated to kiosk management: “kiosks are under the KMU therefore repairs after the meter is up to them”.<sup>17</sup> On the other hand, according to the KMU manager, “LIAs fall under the zones so maintenance of connection pipes should be left to them”.<sup>18</sup> Further, in instances where the zones authorize maintenance of pipes in LIAs, it is to prevent loss of water to satisfy set performance indicators for non-revenue (NRW) water, rather than driven by concerns of water quality and availability in low-income areas.<sup>19</sup>

Prioritization of higher-income neighbourhoods in the maintenance of the system further exacerbates the differences in the quality of drinking water supplied to different neighbourhoods in the city. The safety of treated drinking water in transport largely depends on the robustness of the distribution system. Long response times to maintenance increase pipes’ exposure and may provide pathways for ingress of contaminants under “transient pressure conditions”<sup>20</sup> (Fox et al., 2014; Mansour-Rezaei and Naser, 2012; Percival et al., 2000). Delays result in the contamination of water with particles, which in turn may result in increased turbidity, reduction in residual chlorine as well as high counts of microorganisms (see Fig. 1).

Similarly, monitoring practices focus on higher-income areas, where the risks of water contamination are lower. Monitoring reports from the LWB, between the periods of May to December 2014 for the study areas showed that the number of samples routinely collected in LIAs (40) is much lower than the ones collected in higher-income areas (85). Yet, because the population in LIAs is seven times higher than in the higher-income areas, according to WHO guidelines,<sup>21</sup> more samples should be collected from these areas. Selective monitoring of the network is rationalised by the Lilongwe Water Board staff by explaining that “water supply to kiosks is usually cut-off and kiosks closed during the times of monitoring leading to the collection of fewer samples from the kiosks” (Staff Water Quality department). The unequal distribution of discontinuity of water through the network thus becomes a justification for the inequalities in monitoring and in water quality protection.

#### 4.4. Coping with unequal distribution of water cut-offs: bodies, pails and soil

Lilongwe Water Board’s responsibility to provide drinking water ends at the kiosk, where residents buy water. Water quality at the kiosk, however, does not reflect realities of water consumption in low-income areas. Unlike customers served through in-house connections, who use water at the distribution point, residents accessing water through kiosk use pails to collect, transport, store and consume water at their household. These pails become an ‘integrative infrastructure’ for water distribution and storage, together with the labour of the household member, mostly women, who are responsible for providing water for the household. As shown in Fig. 2, residents own practices of collecting and transporting water into pails and homes have a strong impact on water quality, which deteriorates exponentially from the kiosk to the household.

Those in charge of collecting water, walk with uncovered containers to the kiosk, where they usually must wait in a long queue. Often, they do not wash the pails before filling them, because “you have to pay for whatever the meter reads and so if they cannot be pay for washing buckets, they should wash from their homes before coming” (Kiosks Attendant, Mtandere-Area 56). To wash their pails at home, where they do not have running water, residents use a mix of water and soil, which risks contaminating their transport and storage infrastructures. Whilst residents’ practices contribute to the incremental contamination of their drinking water source, these practices are forced on them by the level of services provided, including distance from the water source and discontinuity of supply. As a resident explains, “the bucket is not something cultural, it is everyday life [...] if we would have water the whole day we would not need to have buckets, then we could go straight to the source” (in Rusca et al., 2017). Water services for consumers accessing water through in-house connections is entirely supply driven. On the contrary, in the case of water kiosks, the cost of purchasing and maintaining the ‘mobile infrastructures’ used to transport and store water at household level are passed on to the household. As a result, the responsibility and the costs of ensuring that water is not contaminated at this stage are passed on to the residents. Once the containers are filled, they are carried uncovered to the homes, where they are exposed to environmental contamination. These practices contribute to a drastic decrease of the water quality mainly due to recontamination in absence of residual chlorine.

Access and storage practices are exacerbated by the high rate of water discontinuity, which forces residents to develop and implement everyday coping strategies to ensure a certain degree of continuity in their access to water. First, they often need to revert untreated water sources. Water discontinuities force residents to access water from untreated water sources. Where possible residents will use treated water for drinking purposes and the other sources for personal and household hygiene. This practice allows them to save money and cope with discontinuity but, as many residents, explain, practicing hygiene with untreated water causes rashes and other skin infections (Rusca et al., 2017). Another strategy to cope with discontinuity is to store larger quantities of water at home. This has two consequences. First, risks of water contamination increase. Second, this also entails that residents are to own multiple pails for different purposes. The pails then become constraining object within the house: “you have cases where a human being has to compete for space in the house with a storage facility”.<sup>22</sup>

## 5. Conclusion: re-materialising uneven geographies of water

In this study, we have examined inequalities in water quality in Lilongwe as an articulation of socio-political processes, differentiated technologies and microbiological and physico-chemical

<sup>15</sup> Interview, Kiosk Attendant, Area 56, Lilongwe, 19th November 2014.

<sup>16</sup> Interview, resident, Area 47, Lilongwe, 11th November 2014.

<sup>17</sup> Interview, staff, LWB, Lilongwe, 14th January 2015.

<sup>18</sup> Interview, staff, LWB, Lilongwe, 23rd January 2015.

<sup>19</sup> Interview, staff, LWB, Lilongwe, 1st December 2014.

<sup>20</sup> Refers to fluctuations in pressure; this fluctuation in pressure emanating from frequent intermittent supply favours the ingress of contaminants from surrounding areas due to the pressure of the surroundings being higher than that in the distribution system.

<sup>21</sup> WHO recommended minimum number of samples collected per year from piped water supply system: < 5000:12; 5000 to 100,000: 12 per 5000 population; > 100,000–500,000: 12 per 10,000population plus additional 120 samples; > 500,000: 12 per 50, 000 population plus additional 600 samples (WHO, 2011).

<sup>22</sup> Interview, CCODE Project Manager, Lilongwe 13 April 2016.

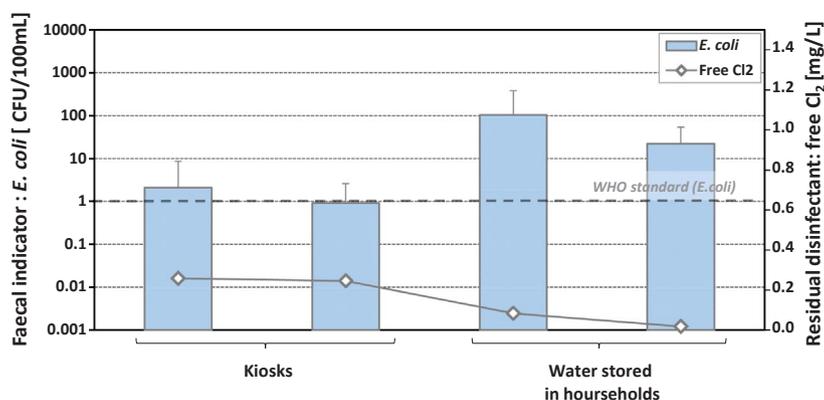


Fig. 2. Faecal indicators and residual disinfectant concentration at the kiosks and households in low-income areas.

transformations of water. Our microbiological and physicochemical analysis demonstrates that networked water supplies, discursively constructed as ‘reliable’, ‘good’ and ‘safe’, are contaminated. This contamination is dialectically produced by suburbanisation and the standardization of water services. At the core of this process are decisions on how the city should develop and who is entitled to premium services. Planning policies produce urban spaces for the poor, traditional housing areas in which lower quality infrastructures are developed. Everyday decisions on water distribution, prioritising planned areas of the city, exacerbate conditions of access in low-income areas, causing the water that the urban poor drink to be of a significantly worse quality than the water that the rest of the population drinks, despite it coming from the same source.

Pipes themselves play an active role in producing uneven water quality and distribution of risks across urban spaces. The force of pipes is both discursive and physical: on the one hand, they co-produce the ‘piped water-clean water’ narrative, grounded on ideas that equate networked infrastructures to clean water, progress, and health; on the other they co-determine physical transformation of water during transport and distribution. The pipes interact with the surrounding environment in the form of heat, soil, animals, pathogens, air, groundwater, and waste (water). In the process of transporting water, pipes may break, leak, or heat up and, thus, contribute to water contamination. Our microbiological analysis also shows that pipes are key infrastructures in the production of water contamination, thereby revealing the importance for UPE to broaden its focus from the more obvious manifestations of power and socio-technical processes to situated understanding of the workings of (water) infrastructures and to account for the practices and coping strategies of marginalised urban dwellers at the kiosk and their homes.

Approaching the materiality of water through this interdisciplinary analysis serves to broaden and deepen UPE. While critical UPE has tended to focus its critique on the forms of abstraction that produce differentiated access, the natural sciences and, in the case of this piece of research, water (quality) engineering studies have tended to be more attentive to questions of quality as well as to the non-human and its transformations. Engaging with such scholarship, and developing an interdisciplinary UPE, can, thus, serve to further our understanding of socio-natural inequalities. As a fluid and material resource, water cannot conceal inequalities: a physicochemical and bacteriological analysis that reveals pathogens and contamination render these inequalities more tangible, and physically located. Taken together, water quality and UPE analyses allow for articulating inequalities from multiple perspectives and provide greater breadth to examinations of urban water as a socio-natural question. As this study shows, water quality is co-produced with processes of urbanization and the production and reproduction of first and second natures. Water quality is not simply a direct product of different infrastructural designs, overburdened treatment plants, or operational/maintenance decisions related to the

system. Our analysis, thus, enable a focus on different moments within a broader socio-ecological totality.

An interdisciplinary UPE of water, we argue, requires innovative methods and lines of inquiry, new collaborations and a broadening of the sub-discipline’s original focus. Our case addresses a specific dimension of water quality inequalities – those produced within the centralised water supply network. Urban water supplies in cities in the global South are, however, characterised by multiple and sometimes overlapping delivery configurations, which are highly differentiated in terms of service delivery models, water sources and technologies. As our study shows, everyday strategies to cope with water discontinuity force residents to use alternate sources, such as wells, boreholes or streams. We propose that further developing a quality-centered UPE also entails extending the analysis to alternate service modalities and examining how these interact in the production of uneven water qualities. Further, despite the progress towards safer management of water treatment and distribution systems, drinking water has caused disease outbreaks also in the North (WHO, 2014). While intermittent supply coupled with on-site sanitation is typical of water supplies in the global South, other causes of contamination, such as pipe burst, leakages, poor maintenance practices and contamination during storage occur globally. An interdisciplinary UPE of water quality is, therefore, not limited to the global South. Last, the deepening of this framework also requires further examinations of how water quality is tied to other dimensions of inequality. This means considering and incorporating analyses of both who is most adversely affected by poor water quality and the role of gender, race, sexuality, age, informality, and income in producing the unequal distribution of water-related diseases, health and care.

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