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Making waves: Promoting municipal water reuse without a prevailing scarcity driver

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ABSTRACT

The wealth of water reuse research in scarcity and/or rapid urbanisation contexts has underpinned significant change in many relatively water scarce contexts. Less progress has been achieved in water rich contexts; a fact illustrated by the lack of change on the ground. The Climate Emergency demands that all municipalities urgently contribute to more efficient resource management of water. Consequently, to advance municipal scale reuse projects in locations where scarcity is not forcing the issue, for example Scotland, there is a need to predicate water reuse on different drivers, specifically climate change and the circular economy. Moreover, greater contextual sensitivity needs to be applied when exploring barriers to reuse to more critically exploit opportunities, for example avenues to reform complex regulatory frameworks, different contingencies around trust, and different potential degrees of the yuck factor. To achieve this, new initiatives need to be urgently undertaken to consider the barriers to reuse that will not be swept aside by the imperative of scarcity. The notion of a yum factor, whereby positive sentiments are nurtured to combat instinctive repugnance, coined as yuck by the bioethicist Arthur Caplan, is advanced as a strategic objective to promote more rapid expansion of municipal scale reuse.

1. Introduction

Water scarcity drives reuse projects around the world (Jimenez and Asano, 2008), however we argue that, in the context of the Climate Emergency, the necessity of reuse eclipses even this most compelling catalyst. The prism of scarcity is not universally fit for purpose, a fact resulting in a significant lack of empirical experience of water reuse in situations where there is no immediate scarcity, and more appropriate optics are required in order to urgently instate reuse projects where lack of a plentiful supply of water is not already pushing reuse to the top of the agenda. The evidence for this failing could not be clearer. Over 80 % of the world's wastewater is returned to the environment untreated. This is water that has been generated through the use of freshwater, raw water or saline water in domestic, agricultural, industrial or commercial processes, including municipal wastewater, this latter being a subset excluding industrial use (Tortajada and van Rensburg, 2020). Treated waste water is also largely unused, for example, the EU only reuses 2.4 % of treated wastewater (Georgiou et al., 2023). This latter comprises waste water that has been treated in sewage plants and discharged into freshwater or marine environments in a cycle whereby 'raw water' is then collected, treated again and used for domestic, industrial, agricultural, or landscape irrigation processes (Tortajada and van Rensburg, 2020).

Where there is no perceived, severe shortage there are few municipal reuse projects at any great scale. This paper proposes a step change for contexts where lack of water is not generating impetus, building upon research that predicates water reuse on global climate change, pivoting the rationale away from local or regional scarcity where necessary, and towards climate justice, water justice, and the circular economy.

Most global reuse projects have had the same fundamental driver underpinning their success, namely a water scarcity rationale (Jimenez and Asano, 2008). The essential need for water in human settlements, for industry and agricultural irrigation, moves mountains, literally in some cases. When it comes to galvanising public support, solving technical challenges and creating the appropriate governance structures to facilitate effective solutions, a discourse around scarcity is, more often than not, mobilised to overcome barriers (for example, Ferrier et al., 2022). Dwindling supply connected to climate change, rapid

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urbanization, and growing economic demands (Sarma et al., 2023; Ravikumar, 2022) are matters of urgency around the globe. However, scarcity is not the only imperative for municipal water reuse schemes. There are increasing demands for environmentally sustainable, circular economy solutions in relatively water rich regions lacking the unstoppable force of immediate need that have bulldozed obstacles aside elsewhere, notably in California, Western Australia and the Mediterranean region. This is not to belittle the considerable difficulties that continue to hamper development of municipal wastewater reuse everywhere. The peer reviewed literature on reuse is rich with analyses of political, economic, social and technical (PEST) challenges (Fielding et al., 2019), albeit this corpus is heavily weighted towards arid and semiarid contexts or rapid urbanisation, where scarcity is advanced as the primary driver.

A wealth of critical knowledge has been accumulated. Included within this debate, the very notion of scarcity is often contested. The allocation of finite water resources potentially transgresses the rights of many, and scarcity is, for some critics, instrumentally constructed, acting as a mask for water injustice (Mehta, 2003). Correspondingly, water justice forms another strand of contemporary study. Scarcity constructs can be rooted, it is argued, in historical contingencies, reinforced with intransigent legal frameworks (Langridge et al., 2006), and socio-political interactions biasing water management agendas (Kellner, 2021). However, scarcity, whether posited as a construct or otherwise, is not always and everywhere an effective driver of municipal reuse. The absence of perceived scarcity, particularly in localities where there is abundant rainfall, for example Scotland, has frustrated attempts to prioritise municipal reuse with both publics and policy makers failing to appreciate the urgency of reform when setting priorities (Troldborg et al., 2017b).

2. Revisiting barriers to public acceptance

After decades of scholarly research, there is a large body of evidence indicating key factors representing obstacles to reuse projects (Fielding et al., 2019). Fig. 1 illustrates these known challenges and outlines the solution pathways.

Our summarised barriers and opportunities (Fig. 1.) overlay a large body of literature addressing diverse factors considered to significantly impact the development of reuse schemes. In the centre of the figure, a risk assessment acts to characterise the domain through which barriers (right hand column) and enablers (left hand column) can be tackled.

The so-called yuck factor, a phrase introduced into this context by the bio-ethicist Arthur Caplan, describes a repugnance to the very thought of consuming or even coming into contact with water associated with human waste (George, 2012; O'Callaghan, 2012; Smith et al., 2018). When questioned, people describe their disgust at the prospect of having to accept recycled water (Smith et al., 2018). Studies have attempted to gauge the degree to which this negative, instinctive or pre-cognitive affective reaction has posed a barrier (Rozin et al., 2015). Trust is also evidenced as a critical dimension when public authorities and private enterprises attempt to provide recycled water to consumers (Ross et al., 2014).

A further obstacle to any change in this area is the policy and regulatory context (Hendry and Benedickson, 2017). In many countries the collection, treatment and disposal of wastewater, if treatment exists at all, is inadequate, (WWAP, 2017); in the UK, systems designed in the 19th century are spilling their overflows onto beaches and into rivers. At the same time, wastewater management involves complex technical rules to ensure protection of the water environment, and manage 21st century problems of emerging pollutants and micro plastics. The EU's Green Deal is proposing a recast Directive on Urban Wastewater (European Commission, 2022) which is intended to enlarge the scope of the

Fig. 1. Yuck to Yum (Y2Y) summarised barriers and opportunities for extending reuse.

current rules (still in force in all the UK jurisdictions) to make the sector energy-neutral by 2040, as well as significantly improving the quality of treated wastewater. Additionally, it will cover rainwater and surface drainage, currently a significant omission. Although wastewater reuse is usually considered in relation to scarcity, proper management of surface water is highly relevant in countries prone to flood risk, opening up another set of factors that may incentivise reuse of some streams of wastewater.

Water efficiency is a complimentary area where much could be done. Waterwise produced a UK Strategy to 2030 (Waterwise, 2022), whilst all the UK governments have been consulting jointly on mandatory water efficiency labelling (DEFRA, 2022). Water efficiency does not always relate to reuse, although businesses utilising best practices will often be reusing water within their processes and premises.

Doubtless, these and other factors will continue to play a role where scarcity appears less instrumental. A question that remains unanswered however, is how these associated barriers interact in specific contexts and whether certain combinations, are likely to be more pronounced where the rationale of scarcity is not crushing public reservations and steering political action. In other words, the dynamics of the system of barriers and drivers is not fully understood. This reservation does in practice seem to be evidenced. In Australia's Western Corridor Project, where a projected need for additional supply of water failed to materialise after the completion of a water recycling facility, the plant was effectively mothballed (Meehan et al., 2013; Smith et al., 2018). More typically, without effective demonstration of demand outstripping supply, municipal scale projects rarely get off the ground. Scotland, where the current authors have been working to build a foundation for water reuse, is a case in point (Troldborg et al., 2017b). We present a conceptual model of the system dynamics in Fig. 2 showing interactions between barriers as a series of feedback loops.

The model we propose indicates the lack of incentives to reuse projects lying within a dynamic system of interlocking barriers (Fig. 2.) Overlapping domains of 'risk assessment' and 'economic assessment' are proposed to explore the specificities that are necessary for further research, policy development, and interventions to be designed. An example of the domain interactions is the regulatory framework which intersects with 'technical challenges' as part of an economic assessment; an exemplar being the need to enforce quality standards with a technical solution that is affordable. Equally, the regulatory framework must take account of environmental risk assessments in most jurisdictions including Scotland. Public acceptance is conceptualised as a prerequisite for both domains to succeed in expanding the reuse praxis.

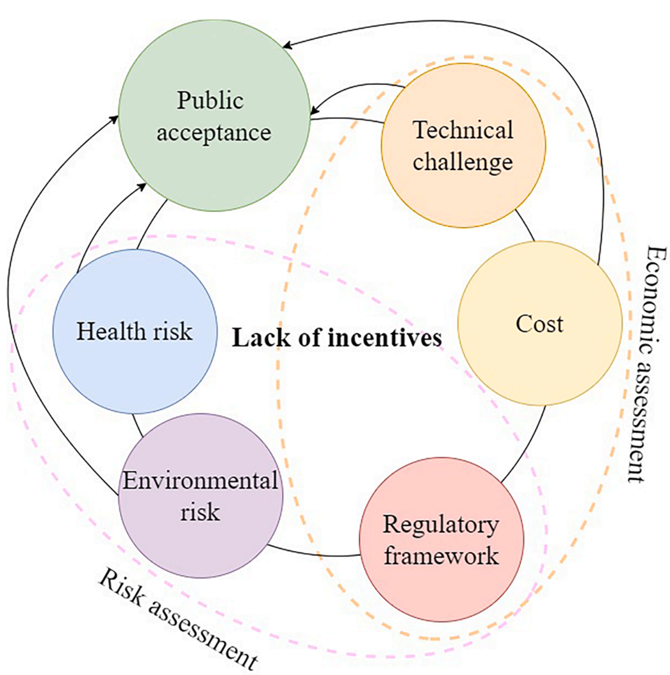

Fig. 2. Schematic representation of interlocking barriers to municipal water reuse beyond the scarcity driver.

Affordability must also be addressed, a factor posing tough questions relating to public acceptance or willingness to pay in democratic contexts (Fielding et al., 2019; Fig. 1). An appropriate valuation framework, looking beyond direct cost and resource consumption is essential if implementation is to broaden. Scholarly work has begun to define the basis for new economic models, particularly in the context of the European Water Framework Directive (for example, Tsagarakis, 2005). Assigning economic value to recycled water can be pursued through non-market valuation which can promote fairness and equity (or water justice) and societal benefits in terms of environmental justice, while acting as a bulwark against special interests (Loomis, 1997). Quantitative valuation of intangible benefits is challenging, and non-market valuation methods have many well described limitations, however, such methods do offer a framework able to capture hard to reach values (Gunawardena et al., 2020). For example, non-market environmental benefits of reuse adoption can be estimated through contingent valuation methods (CVM), whereby households' willingness to pay (WTP) for the treatment of waste water to different environmental standards can be estimated (Alcon et al., 2012).

3. An abundantly clear case for climate change mitigation to underpin water reuse

Scarcity is unsurprisingly and rightly a powerful driver of wastewater reuse, particularly in arid and semiarid areas of the world (Salgot and Folch 2018), although we acknowledge its potential appropriation as a political construct (Mehta, 2003). Correspondingly, many studies have highlighted scarcity as a driver of change and much of the research has been concentrated among populations where the scarcity discourse was centre stage (for example, Carnie, 2022; Po et al., 2003; Mesa-Jurado et al., 2012), notable exceptions being Goodwin et al. (2018), Troldborg et al. (2017b). Controlling within analyses for the effects of a scarcity narrative, on other factors, whether contested or otherwise, in other words assessing interactions between drivers, has been largely non-existent. The absence of feedback loops assumes that drivers are independent variables. In practice, consumers may more readily accept recycled water where there is little or no alternative, i.e., scarcity contexts, irrespective of other considerations. We argue that the relative significance of yuck, trust, price, governance, or other factors in contexts of relative abundance will be higher, on the basis that a scarcity argument has the potential to be overriding. In short, the majority of existing studies focused on arid, semiarid or otherwise shortage affected localities is potentially misaligned with contextual sensitivities in relatively water rich contexts where factors may be weighted differently. A new conceptual model is outlined in Fig. 2.

What is needed is for a new wave of research to be urgently undertaken starting from the plausible assumption that, where there is no current water deprivation or perceived shortage, populations are likely to be subject to differently weighted influences when responding to radical change proposals for the municipal provision of their water. Social science and humanities is often under-appreciated in this context but can play a key role in developing new decision-making and governance roles for wastewater, exploring variations in context and delivering solutions equitably and sustainably (Martin-Ortega, 2023) .

Opportunity Mapping is a technique that can help to facilitate the development of economic cases for new municipal reuses schemes. Optimization of waste water resources may spur public and private providers particularly as existing infrastructures require renewal (Zhao et al., 2015). Stakeholders need to be mobilised through participatory engagement. Existing legalities, governance arrangements, and associated water reuse frameworks (WRF) will also act to shape reuse evolution (Reynaert et al., 2021) including eagerly anticipated changes to the European Urban Wastewater Treatment Directive which is seen as an opportunity for the wastewater treatment sector to overcome societal and environmental challenges. Novel approaches to risk assessment (e.g., Troldborg et al., 2017a) can also play a role in alleviating concerns. But with progress painfully slow where scarcity is not the catalyst, all barriers and all alternative drivers need to be reassessed.

Research can also draw upon other socio-technical challenges where public acceptance has been problematised, including genetically modified food (Horlick-Jones et al., 2007), nuclear power generation (Slovic et al., 1991), and wicked environmental challenges (Duckett et al., 2016), in order to reimagine how public acceptance might be promoted. Many more people need to be persuaded that anthropocentric climate change necessitates rethinking water provision in their municipality just as profoundly as immediate supply issues might do elsewhere. Reclaimed wastewater must be taken into account in formulating a sustainable water policy where reuse is not currently a priority (Angelakis and Bontoux, 2001). This is not to say that the twin drivers of supply constraints and environmental protection are not intertwined. Climate change is already radically altering water availability with temperature and precipitation patterns leading to unprecedented shortages, even in historically water rich countries (Pokhrel et al., 2021; Uhl et al., 2022; Visser-Quinn et al., 2021). But this is not the central argument for more efficient use of water resources in a great many municipalities at the current time and a compelling argument is needed if as a planet we are to avert the existential crisis that faces us all. Achieving net zero requires colossal efforts to use resources sustainably and with the maximum energy efficiency. A water-food-energy nexus is theorised (Allan et al., 2015; Smajgl et al., 2016) whereby interactions across domains demand huge restructuring. At a mundane level, wastefully purifying water to potable standards for a whole range of uses beyond drinking water, as is unnecessarily done across water rich countries, is an obvious area for transformation and for more enlightened thinking (e.g., Capodaglio, 2021). Related applications, including irrigation of parks and private gardens, vehicle washing, toilet flushing, and a range of industrial processes, may be easier to sell given that there is generally more public resistance to the prospect of drinking reused water than to other uses (Fielding et al., 2019).

4. Putting climate change first in water reuse research

Research can lead this process of rethinking water reuse by challenging preconceptions drawn from 'scarcity' contexts that do not necessarily hold everywhere. There is a need to renew the task to explore how reuse can be promoted where water is more plentiful and where wasteful, old habits are likely to die hard.

In almost all of these *contexts of plenty*, the concerns of the consumers, or the general public, will be influential. Whatever changes are being proposed must have the agreement, or at least the tacit consent, of the public (Friedler et al., 2006). Related policy areas provide opportunities to engage with the public, to enhance their understanding of different parts of the water value chain and the benefits of managing the resource in a more holistic way. Positive associations between water reuse and environmental stewardship need to be instilled in the collective consciousness whereby a popular feel-good sentiment or a yum factor is nurtured across society. A novel framing of yuck to yum is carefully considered in our proposal. Since Arthur Caplan, a bioethicist at the University of Pennsylvania coined the term, his original formulation of the yuck factor has become deeply embedded in the corpus of reuse studies and has come to signify a plethora of negative sentiments far beyond narrower associations of disgust around water reuse for drinking water, spilling over into bodily contact of any form and even close proximity to perceived pollution (George, 2012; O'Callaghan, 2012; Smith et al., 2018). It is this wider set of associations, described as a catchall for technophobic related repugnance (Schmidt, 2008), and even wider generalised, conservative opposition to new developments (Fethe, 2000) that we aim to juxtapose through the antonym of 'yum'. Caplan's deployment of the term 'yuck' is bold and arresting, belonging to a philosophical tradition including Jeremy Bentham and Immanuel Kant, both of whom drew on lexicographical innovation to popularise new ideas; an underused linguistic approach in current academic discourse (Fethe, 2000). Our goal, in mirroring Caplan's terminology via 'yum', is not limited to neutralising repugnance or dispelling disgust, but strives to establish visceral, feel-good associations around the environmental benefits or water reuse for all kinds of applications across daily lives, for example garden irrigation and vehicle washing. People can feel good (attach moral value) about being environmentally responsible and their emotional support can galvanise action (Wang et al., 2018).

Creating a popular mind shift requires concerted action. New assessments of the yuck factor need to consider whether this driver is more influential in local contexts where the immediate supply shortages of communities are less pressing (Nkhoma et al., 2021). Particular sensitivities are likely to include pricing. Expensive retrofits for non-potable supply, as opposed to new installations, are likely to result in financially unattractive tariffs (Adewumi et al., 2010), therefore price needs to be factored into a context where water at any cost is not the dominant economic motivation. Additionally, issues of trust need to be considered (Ross et al., 2014; Domènech and Saurí, 2010) where community distrust makes it is easier for opponents of reuse to defend the status quo.

A water justice lens which emphasises that water crises are simultaneously ecological, political and social issues can serve to promote principles of fairness and equity and help build trust. Water Justice recognises that better water governance can be furthered through democratic, overarching principles, but is, at the same time, often highly context specific, requiring approaches embracing participation.

Too often, analyses based on situations of scarcity seem to be the source of expert consensus on how to build foundations for reuse in all contexts. This approach seems to ignore the fact that on the ground, scarcity discourses appear to be the prime mover in the vast majority of successful, municipal scale water reuse projects and that comparatively little success is apparent elsewhere. Put simply scarcity constructs empower reuse initiatives leading to *de facto* reuse whereas climate change is currently not having the same leverage. There are lessons to learn from scarcity driven success stories and the studies that are predicated upon them (Meehan et al., 2013). Furthermore, the alleviation of scarcity remains a real concern in many parts of the world (Liu et al., 2019) and this must continue unabated: there should be no diminution of efforts to alleviate scarcity and we applaud the successes therein and the associated research underpinning much progress. However, drawing universal conclusions about the socio-economic barriers to water reuse from cases where those obstacles have been or are being swept aside by the imperative of scarcity, seems fundamentally flawed from a scientific perspective. Rather, fresh approaches that build on more appropriate weighting of factors likely to shape reuse in contexts of relative plenty, and that draw on interdisciplinary research including around other controversial socio-technical developments, are urgently required.

5. Conclusions

- Scarcity and rapid urban expansion scenarios dominate the reuse space and are not effectively driving reuse in more water abundant contexts. This is evidenced by the lack of de facto, municipal reuse schemes in these 'wetter' contexts.
- The existing literature is correspondingly dominated by scarcity and rapid urban expansion contexts and does not provide the necessary underpinning for reuse in all scenarios.
- Circular economy and environmental sustainability arguments to tackle the climate emergency are central if municipal reuse projects, where scarcity drivers are weaker, are to flourish.

- Barriers to reuse are reasonably well characterised but their relative importance and their interactions in different contexts need to be analysed and better addressed for greater progress to occur.
- Social science can help to build a better foundation for reuse in more water abundant contexts by drawing on other problematic socio technical developments and helping to build participatory approaches to engender and galvanise stakeholder action.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

No primary data was used for the research described in the article.

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