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From pea soup to water factories: wastewater paradigms in India and the Netherlands

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ABSTRACT

Freshwater scarcity has increased in the cities of the global South due to rapid urban agglomeration and changing climate. Alternative water resources such as treated wastewater can play a significant role to reduce the water supply-demand gap. In the recent past, wastewater has been used solely for irrigation and other allied agriculture purposes, with limited focus on reuse for other purposes within the cities. Despite the progress in wastewater treatment technology and various policy frameworks, in low income and lower-middle-income countries, limited progress has been made. Through this article, we compare three aspects, representing the wastewater paradigms in India and the Netherlands. The three elements are 1) framing, 2) policy goals, and 3) technical and financial instruments. Using policy document analysis and interviews, we compare water and related policies prepared in India and the Netherlands. We found that the wastewater paradigms have evolved in the two countries. In India, the wastewater paradigms have realized paradigm changes from 'water resource to meet a basic human need' to 'water as an engine of economic growth' and then to 'water scarcity and beautification of cities'. In the case of the Netherlands, the wastewater paradigms have changed from an emphasis on 'public health and environmental concerns' to the 'circular economy of wastewater'. Although the Netherlands has to still meet the water quality targets of the European Water Directive Framework with regards to micropollutants, the country has made significant progress towards wastewater treatment and reuse in the last four decades. On the contrary, the Indian wastewater policy domain has room for improvement in terms of designing appropriate financial instruments and governance strategies to increase the urban wastewater treatment capacity and reuse. This article concludes that the use of the concept of wastewater paradigm is useful to show the progress and challenges in the two countries.

1. Introduction

Cities are currently accommodating 55.3 % of the world's population and is projected to increase to 60 % by 2030 (United Nations, 2018). With increasing urban agglomeration, the domestic water use has quadrupled and water demand-supply gap has increased in large metropolitan cities (Flörke et al., 2013). Further, the changing climate is posing an additional risk and will probably increase the future water challenges in the cities, leading to groundwater over-abstraction (Asoka et al., 2017; Flörke et al., 2018). There is a scenario of freshwater scarcity emerging in the small and medium-sized cities and even more challenging in the large metropolitan cities of the global South (Aartsen et al., 2018).

In the recent past, treated or partially treated wastewater has mostly been used for irrigation and agriculture purposes, with limited progress on the treatment of wastewater and its fit-for-purpose use in the cities of developing countries. Estimates suggest that lower-middle-income countries (LMIC) on average treat 28 % of the generated wastewater; in low-income countries (LIC), only 8 % of the wastewater generated is treated (Sato et al., 2013). Whilst, some of the developed countries have

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made progress towards treating 100 % of wastewater. The low treatment capacity of LIC and LMIC are mainly attributed to two reasons. First, the investments required for treating wastewater is very high. For instance, the cumulative investment projected for secondary and tertiary treatment plants is EUR 2091 million and EUR 14,800 million respectively (Kumar and Tortajada, 2020). Second, in LIC and LMIC countries precedence is given to solid waste management as compared to wastewater, with varying degrees of treatment. Removal of solid waste such as plastics adds to the beautification of the cities and neighbourhoods, whilst the wastewater canals can easily be covered over by concrete structures.

In this article, we will only emphasise on the wastewater sector in India and the Netherlands. We selected India and the Netherlands as two cases for the underlying reasons. First, both nations have experienced a stark urbanisation trend. India's urban population has increased from 17.9 % (1960) to 34 % (2018), and Netherland's urban population has increased from 59 % (1960) to 91 % (2018) (United Nation Population Division, 2018). By 2030, India is projected to have 68 cities with more than 1 million inhabitants, 13 cities with more than 4 million inhabitants, and 6 megacities with populations of 10 million and more (Mckinsey Global Institute, 2010). LMIC such as India have a limited capacity to treat only 37 % of wastewater. On top of that Indian cities such as Chennai and Bangalore are already facing water scarcity, where groundwater is depleting and often gets polluted and contaminated due to solid waste, untreated sewage and polluted storm water runoff (Jambeck et al., 2015). Such water-scarce cities will find it difficult to improve environmental quality, achieve economic development and to make progress towards the Sustainable Development Goals (SDGs). Wastewater treatment and reuse is crucial to achieving SDG 6 (clean water and sanitation) and related indicators 6.1, 6.2, 6.3 and 6.4 and SDG 11 (sustainable cities and communities). Second, in the recent past, metropolitan cities in India (for instance Chennai in 2018) and the Netherlands (1967, 2018, 2019 and spring of 2020) have faced extreme drought events. With such extreme conditions, it would be interesting to compare how the two countries (developing and developed nations) are preparing their cities to counter such extreme climate events in the future.

Third, it makes sense to analyse the two countries as the Netherlands has been branding itself as a water knowledge expert (see Blue Deal project) and aims to contribute to achieving SDGs 6.3–6.6 (Dutch Water Authorities, 2018). Collaborative projects such as LOTUS-HR[1] aims on technology co-production and international capacity building. Fourth, the Netherlands and India present an interesting comparison of governance and technical scales between the two countries. The Netherlands is an example of a small, but highly urbanized country that manages its wastewater using various centralized and decentralized systems. However, as India with very large cities such as New Delhi, what appears to be centralized systems in the Netherlands, can be considered as decentralized in India. It would be stimulating for researchers and policy actors to compare the policy trends and scientific advancements in the two countries and how the Netherlands want to support countries such as India in achieving SDGs related to water, particularly wastewater and similarly, Netherlands can learn how India manages its complex wastewater issues.

Various policy efforts have emerged in the last three decades to improve sewage and wastewater treatment. However, scholars have noted insufficient progress in India as compared to how the Netherlands have been able to tackle the issue of wastewater treatment and reuse (Kumar and Tortajada, 2020; Pandit and Biswas, 2019; Sedlak, 2014a). In order to map the progress of wastewater technology and reuse, we propose to use the concept of policy paradigms. The term 'paradigm' in the water scholarship incorporates the underlying nature of the system, management intent and ways to solve water-related challenges (Pahl-Wostl et al., 2011). Water paradigms in different sectors are understood and explained by various authors such as Gleick (1998) and Falkenmark and Rockström (2006). However, no extensive work on 'wastewater paradigms' is noted in the literature. Scholars such as Laugesen and Fryd (2009) and Capodaglio (2017) have based their wastewater work on technology-based paradigms. Considering such a research gap, we define 'wastewater paradigm' as an underlying institutionalized idea based on which wastewater policies and plans are prepared by policy actors. This definition of a paradigm has been inspired from the public policy scholarship of Peter Hall (1993) and Giliberto Capano (2003) and more contemporary work of Kern et al. (2014) and Vij et al. (2018). Vij et al. (2018) operationalized policy paradigms using four indicators – (1) framing; (2) policy goals; (3) policy instruments and; (4) meso-level areas.

For this article, we have made adjustments to the framework, considering our specific focus on wastewater treatment and reuse. We have used three indicators and have not included meso-level areas in the framework. As this study specifically focuses on wastewater, we excluded the use of meso-level areas (sectors). Instead, we included technical instruments as part of the policy instrument indicator because in cases wastewater technology becomes the underlying reason for changing paradigms. For instance, the centralized and decentralized systems of wastewater treatment may use different technologies (Capodaglio, 2017). The use of a certain technology can alter the sustainability of wastewater treatment. Further, we compare policies for the last three decades, highlighting the changes in paradigms through framing, policy goals and technical and financial instruments proposed. Based on this conceptualization of wastewater paradigms, we answer the question, *how different wastewater paradigms have emerged in India and the Netherlands between 1970 and 2020?*

The article progresses in the following way. Section 2 discusses the methodology and key concepts related to wastewater paradigm. The section elaborates the data collection methods, data analysis and how we conceptualized the concepts used. Section 3 presents the key findings based on the documents analysis and key interviews conducted in India and the Netherlands. We elaborate on three indicators used, framing of wastewater as a problem, policy goals and financial and technical instruments. Section 4 reflects on the key findings, followed by a brief conclusion.

2. Methodology and key concepts

This article follows an interpretive approach and employs a case study method to answer the research question. The approach is opposite to the positivist approach where the design of the research process remains flexible. We want to capture what policy documents mean and how interviewees understand and have experienced wastewater paradigms (Rubin and Rubin, 2011).

2.1. Data collection

In policy research, there are two general sources of data: documents and people (Bardach, 2009; Yanow, 2007). Document reading or analysis methods can allow corroborating interview data, or they may refute them, in which case the researcher has the evidence that can be used to clarify, or perhaps, to challenge what is being told during the interviews. We have used both document analysis and key interviews as part of the blended methodology. Water policy and related documents that focus on India and the Netherlands were collected. We also collected policy

[1] LOTUS-HR aims to demonstrate a novel holistic wastewater management approach for the recovery of water, energy and nutrients from urban wastewater that is applicable for megacities all over the world. India and the Netherlands are long-term partners and the bilateral cooperation is based on an overarching government-to-government memorandum of understanding between the Ministry of Economic Affairs and Climate Policy in The Netherlands and the Ministry of Science & Technology in India. For more information, please see https://lotushr.org/

documents related to Delhi, India's capital, giving more specific examples and instances explaining how paradigms have evolved regarding wastewater reuse. For the purpose of this article, we focus on discussions related to urban wastewater treatment and policy emphasis in India and the Netherlands. To keep the analysis coherent, we did not include rural wastewater treatment and solid waste management strategies.

Three data collection strategies were used (see Fig. 1). **Strategy 1** – a Google search was conducted to identify relevant (English language) policy documents using web-search strings (Vij et al., 2018a; Austin et al., 2015). Search queries were created and searched using search terms: for example, 'wastewater', 'policy', 'India', and 'Netherlands' (see page, supplementary material). Policy documents were included in the repository that made explicit reference to wastewater policy. The web-search was concluded after 10 pages or when the results web-page started to repeat and reached consecutive irrelevant results.

Strategy 2 – the above google search repository was complemented by 9 key policy documents mentioned by the interviewees and highlighted on the key ministry websites. Strategy 1 and 2 helped in identifying 33 policy documents (examples of key documents mentioned in Table 1), that were analysed for this research (page 3, supplementary material includes all the 32 documents). **Strategy 3** – 16 key interviews (personal and telephone based) were conducted between August 2019 and March 2020 in English (see page 2, supplementary material for more details). The interview respondents were identified from the network of researchers and referral by the interviewees. The interview respondents represented government and semi-government agencies in India and the Netherlands, private consultants involved in wastewater treatment planning and donor agencies investing in wastewater treatment. A semi-structured interview method was applied to understand various wastewater paradigms evolved in the past. Among the three strategies employed, more emphasis has been laid on policy document analysis.

2.2. Data analysis

Policy documents and interviews are analysed to capture framing, identify policy goals and ascertain key financial and technical instruments proposed to achieve the policy goals (England et al., 2018). We consider a paradigm change when there is a modification or alteration in the three aspects of a wastewater paradigm (framing, policy goals and policy instruments). To capture the framing in the policy documents, we systematically checked them for text that explains the problem around wastewater and how policy actors identify solutions for it. For instance, certain policy documents explain that wastewater reuse can reduce water scarcity in India, suggesting to invest in large water and sewerage infrastructure at the basin level. Whilst, other policy documents argue in favour of the decentralized systems (on-site treatment), where small-scale infrastructure can be developed to counter the challenges of wastewater issues in the Netherlands. We realized that the use of words such as wastewater reuse attribute to focus on reducing water scarcity in large metropolitan cities of India. We used such excerpts from the policy documents to discuss our findings.

Similarly, to interpret policy goals and instruments, we specifically captured text from sections such as 'vision of the policy' or 'mission' or 'goals' in the policy documents. We define policy goals as the desired outcomes that the government or policy actors aim to achieve through policy or plans (Henstra, 2016). Framing and policy goals are interconnected, framing influences the policy goals and gives direction to the choice of policy instruments chosen to achieve policy goals. Whilst, the technical and financial instruments are the tools by which policy goals are achieved and policy challenges are tackled. Usually, a state uses financial instruments to intervene and implement policy goals. For this study, we searched for references to financial benefits such as funds, subsidies, tax benefits, grants, interest-free loan, private investments and credit waivers in the policy documents (Henstra et al., 2020). We

Table 1
Key policy document on wastewater – India and the Netherlands.

Sr. No.	Water policy documents (India)	Water policy documents (the Netherlands)
1	National Water Policy, 1987	National Water Plan, 2016–21
2	National Water Framework Bill, 2016	The National Waste Management Plan, 2003
3	National Water Mission, Vol. 1, 2011	Waste management policy – note, 2013–14
4	National status of waste water generation & treatment, 2019	Water Act, 2010
5	Water Pollution Act (1974)	Water Boards Act (2009)
6	Draft Water policy of Delhi, 2016	Urban Waste Water Treatment Directive, 1991
7	Delhi water Tariff policy, 2009	Drinking Water Directive, 1998
8	Draft Policy on National Urban Faecal Sludge and Septage Management, 2017	Water Framework Directive, 2000
9	Water Pollution in India, Report No. 21 of 2011–12 (Comptroller and Auditor General of India 2011)	Dutch Roadmap for Wastewater treatment of 2030
10	National River Conservation Plan, 1995	Blue Deal Framework, 2018

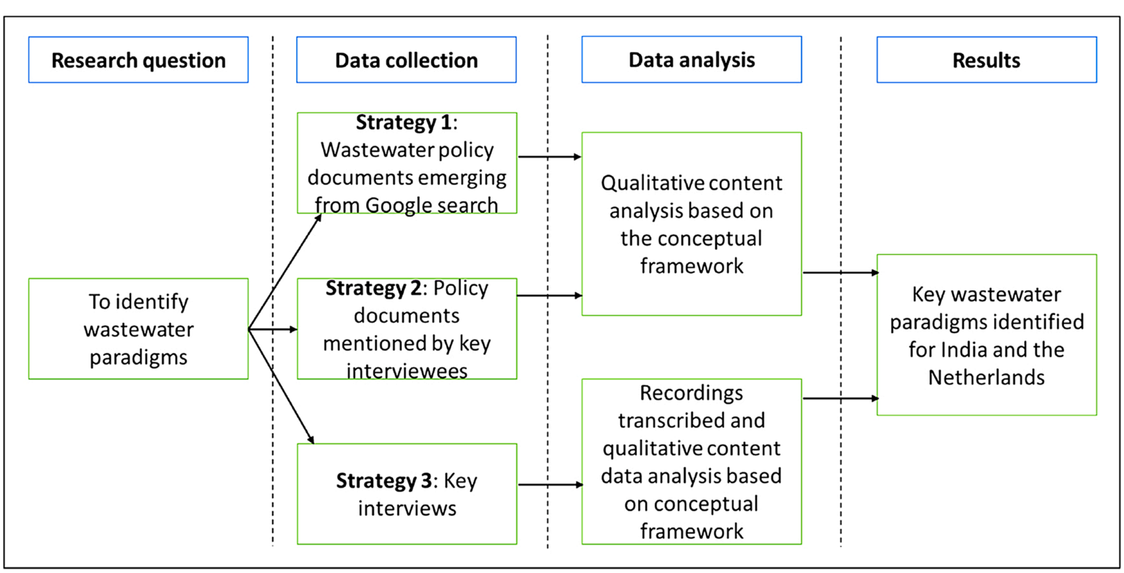

Fig. 1. Strategies for data collection and analysis.

also describe each paradigm and explain the underlying reasons for the change from one paradigm to another.

3. Findings

3.1. Wastewater paradigms in India

Sewage generated in the cities of India remains largely untreated. According to Ministry of Environment, Forest and Climate Change, in 2018, the combined wastewater generation from cities and towns was 61,948 million litres daily (MLD) whereas sewage treatment capacity was only 23,277 MLD. The below-par treatment is due to low treatment capacity, inadequate piped water and sewage connections, water losses in freshwater (mostly drinking water) pipes and sewage systems within the city/ towns and village networks (high non-revenue water), lack of financial instruments to invest in wastewater treatment capacity and clear policy directives to enhance wastewater reuse in Indian cities. With these main challenges, we present the key wastewater paradigms that have emerged in India since the 1970s, with few examples of these paradigms in Delhi.

3.1.1. Paradigm 1: Water resource to meet a basic human need (1974−1995)

The first National Water Policy of India was drafted in 1987. The water policy did not elaborate on measures of controlling water pollution, neither emphasised on wastewater reuse. During the late 1980s and early 1990s, the framing of policies remained towards water resource planning and focused towards its use for agriculture, drinking water and hydropower generation purposes. The policy aligned itself to the objectives of the International Drinking Water Supply and Sanitation Decade Programme (1981–1991), to supply drinking water to both the urban and rural population. No specific policy goals on wastewater treatment and reuse are mentioned in the Water Policy (1987). The only other legal instruments that discussed wastewater in India were the Water Pollution Act of 1974 and the Water Cess Act of 1977. The former aims to prevent and control water pollution and to maintain and restore the wholesomeness of water by establishing Central and State Pollution Control Boards (CPCB and SPCBs). The act defines the composition of the boards and the terms and conditions of service of their members. The CPCB and SPCBs prepare manuals, codes and guidelines relating to the treatment and disposal of sewage and trade effluents and disseminate information related to the same. The policy goals were also limited to control and prevent water pollution, without any clear directive on wastewater treatment and reuse. Whilst, the Water Cess Act (1977) provides for the levy and collection of a cess (tax) on water consumed by persons operating and carrying on certain types of industrial activities to augment the resources of the CPCB and SPCBs, but there are no clear financial or technical instruments proposed in the policy documents.

3.1.2. Paradigm 2: Water as an engine of economic growth (2000−2010)

Moving forward, the second water policy was formulated in 2002. The 2002 policy document was not very different and as elaborate as compared to 1987 document, with very limited discussion on water quality. Its water policy (2002) states that "*effluents should be treated to acceptable levels and standards before discharging them into natural streams*" and it followed the principle of 'polluters pay' for managing the polluted bodies (National Water Policy, 2002). The CPCB suggests that a major part of the cost of waste management should be borne by the urban population, which can be applied to domestic and industrial dischargers to induce waste reduction and treatment and can provide a source of revenue to finance investments in wastewater treatment. To progress this idea, the National Urban Sanitation Policy (2008) was formulated to create sanitized, healthy and liveable cities. The policy further directed the state governments to prepare state urban sanitation policies, under which the cities can develop their sanitation strategies. The policy insisted on participatory processes, but slow enactment and implementation of structured community participation law has been a bottleneck in urban sanitation policy implementation, especially for schemes such as Jawaharlal Nehru National Urban Renewal Mission (JNNURM). During this period, only 11 out of 28 states finalized and adopted their water policies and three states adopted the National Water Policy (2002). Considering technical instruments, until the late 2000s, technical instruments (treatment technologies) such as waste stabilization ponds (oxidation ponds, maturation ponds, and duckweed ponds) were tested in India (in Hyderabad and Bhubaneswar) and were suggested to be used for smaller towns with better land availability for treatment plants and demand for treated wastewater in agriculture. Whilst, for large urban settlements with land scarcity for the establishment of sewerage treatment plants (STPs) and less demand for irrigation, mechanical treatment systems such as activated sludge process, trickling filter, Up-flow Anaerobic Sludge Blanket (USAB), and aerated lagoons were recommended. Various technologies in India were tested by numerous private and state initiatives in towns, cities and metropolitan areas (Kamyotra and Bhardwaj, 2011). However, the financial instruments required for investments to meet the treatment capacity were inadequate. Given the high cost of sewage networks, the difficulty of adding sewerage to the existing sewage networks in densely populated cities, weak financial capacities of local bodies, decentralized treatments plants were also encouraged during this period. Financial instruments such as grants and loans were limited to meet the demand. However, attempts were made under time-limited projects such as the Jawaharlal Nehru National Urban Renewal Mission (JNNURM), Urban Infrastructure Development Scheme for Small & Medium Towns (UIDSSMT), Integrated Housing & Slum Development Program (IHSDP), Urban Solid Waste Management & Rajiv Gandhi Urban Development Mission. These urban development schemes were developed based on the principles of participative and democratic governance, but there has been criticism of lack of participatory processes followed in the development of the projects under these schemes (Kundu, 2014). For instance, the pace of implementation has been extremely slow for community participation law in majority of the Indian states.

3.1.3. Paradigm 3: Water scarcity and beautification of cities (2010–2020)

In 2012, the new National Water Policy (NWP) of India was launched. The policy made relevant inclusions such as climate change challenges, water scarcity and economic value of water. It specifically included the idea of recycling and reuse of urban water effluents from residential and industrial areas for the first time. Without clearly mentioning the standards, one of the policy goals is '*to recycle and reuse of water, after treatment to specified standards*' (NWP, 2012). Following this, the Central Public Health and Environmental Engineering Organization (CPHEEO), in collaboration with Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), had also published a Manual for Sewerage and Sewage treatment (2016), to guide all urban areas in the country towards sustainable solid waste management, adopting waste minimization at the source with an emphasis on reduce, reuse and recycle (3R, CPHEEO, 2016). The manual deals in detail with all aspects of municipal solid waste management, including planning, institutional, financial and technical. Although the guidelines do not address wastewater treatment and reuse, it relates only to water pollution aspects relating to solid waste.

In 2014, Clean India Mission was launched to clean up the streets, roads and other infrastructure of cities, towns, and rural areas. It aimed to eliminate open defecation through the construction of household-owned and community-owned toilets and establishing an accountable mechanism of monitoring toilet use in rural areas. For urban areas, the focus is to reduce solid-waste and eliminate plastic use, aiming towards the beautification of the cities. This large government initiative did not focus on wastewater aspects, contrary it aligned towards solid-waste management in cities and towns. Further, the National Urban Faecal Sludge and Septage Management Policy (2017) states that faecal sludge and sewerage must be addressed holistically, with a strategy that takes into account and appropriates contextual local situation and conditions, directing towards decentralized systems to manage wastewater and sludge issues.

Considering the technical instruments, India changed its approach of cleaning parts of the river within cities to the entire basin. For instance, the Clean Ganga Mission (2011) aims to set-up sewage treatment plants in the entire Ganges basin in India. Ninety-seven sewerage projects along the river Ganges covering large cities like Allahabad, Kanpur, Patna and Kolkata will be implemented by a single private operator to improve coordination between the plants. There is also an allocation of financial support to implement these projects in the Ganges basin, including a hybrid-annuity model based on a public-private partnership model. However, clear directives of financial instruments are missing in the NWP (2012). It states that "*subsidies and incentives should be implemented to encourage the recovery of industrial pollutants and recycling/ reuse, which are otherwise capital intensive.*" (NWP, 2012, pg. 11).

3.2. Paradigm changes in India

The first paradigm change was from water as a resource to meet the basic human need (paradigm 1) to water as an engine of economic growth (paradigm 2). Following are the two main underlying reasons for this change. With the economic liberalization of Indian economy in early 1991, various private enterprises and business opportunities emerged in urban India. Demand for water in various small and large towns and cities increased and the population from rural areas started to slowly migrate to urban centres for employment and to generate more income (Vij and Narain, 2016).

Our respondents mentioned that during the 1990s, India's national focus was on providing domestic and particularly drinking water supply in the urban areas. This priority is also reflected in the water policy and other policy documents prepared between the 1980s and early 1990s. In urban areas, investments were made to enhance the piped (potable) water network in cities such as Delhi, Mumbai and Chennai through various projects and programmes funded by multilateral agencies (the World Bank; Asian Development Bank) and government support. This prioritization also percolated down to other smaller cities and towns (Class I and Class II)[2] . Wastewater treatment and reuse was not the priority and the policy and financial progress made in developing infrastructures were minimal. For instance, until the early 2000s, only 234 STPs were constructed in India under various river action plans and only cover 5 % of the entire cities (CPCB, 2005). These STPs were of various capacity with technologies employed such as oxidation ponds, activated sludge and anaerobic sludge blanket. Delhi and Mumbai generate around 17 % of the country's sewage and have 40 % of the country's installed capacity (Shah, 2016). It becomes even worse as some of these plants are underutilised and often get defunct due to high recurring costs (WaterAid, 2017). Further, the NWP (2002) and (2012) show that the prioritization of potable water allocation has always aligned with drinking and domestic purposes. It demonstrates that India has prioritized usage of drinking water in urban areas and minimal focus has been laid out for wastewater treatment and reuse for domestic purposes.

Although there are wastewater guidelines and manuals developed by CPCB/SPCB to maintain water quality measures in India, on-the-ground implementation of the guidelines has been extremely weak. A respondent confirmed that this is particularly due to limited human resources, the ill-equipped laboratories at the state-level to measures pollutant parameters and weak legal and institutional rules (Starkl et al., 2013; GoI, 2013). CPCB/SPCB are not allowed to penalize polluters, instead, the boards have to pursue the polluter via legal action. There are no substantial efforts to strengthen the CPCB/SPCB, which can eventually reduce the pollution in the water bodies. Moreover, CPCB/SPCB have been able to deliver results due to stronger state-market nexus and industries and small factories as they contribute to the economic growth of India.

The second paradigm change was from water as an engine of economic growth (paradigm 2) to water scarcity and beautification of cities (paradigm 3). This change was mostly due to depletion of quantity and quality of groundwater in India. With extremely fragile groundwater regulations and sanction systems, India stands as the largest groundwater consumer in the world (Shah, 2016). Fifty-six per cent of metropolitan, Class-I and Class-II cities are dependent on groundwater either fully or partially (NIUA, 2005) and unaccounted water in urban areas exceeds 50 % (CGWB, 2011). In case of rural India, 85–90 % groundwater provides the drinking water supplies (World Bank, 2010). Nearly 70 % of irrigated agriculture in India depends on groundwater (Lata, 2019). Furthermore, due to the rapid depletion of groundwater tables and unplanned urban agglomeration, the carrying capacity of Indian cities is negatively affected. Cities such as Chennai, Bengaluru, Delhi, Jaipur, and Ahmedabad are facing extreme events such as droughts and floods, with increasing resource conflicts (Yadav et al., 2020; Punjabi and Johnson, 2019; Vij et al., 2018a). For instance, Chennai faced a flood in 2015 and a drought in 2018. The lakes that supply Chennai's drinking water are still dry, the Krishna river scheme could not provide enough support, including various other projects have proved insufficient to meet the city's water demand. Groundwater reserves have depleted, leaving Chennai dependent on desalination plants. However, policy actors in Chennai are sceptical of desalination, with precarious of water pricing mechanisms (Brunner et al., 2014). With such concerns emerging, the national government has aimed to meet water demand through wastewater reuse and have made the initiative to invest in a variety of STPs to improve the quality and quantity of groundwater situation in India. In the river Ganges major investments are proposed to improve the ecological flow of the river and prevent the contamination of the groundwater reservoirs.

3.3. Wastewater paradigms in the Netherlands

Studies such as Ampe et al. (2020); Sedlak (2014), and Guest et al. (2009) have already discussed the history of wastewater treatment in the Netherlands. For the purpose of this article, we only consider the paradigmatic changes in wastewater system since the 1970s, with the onset of public health and environmental concerns institutionalized at the Dutch and European Union (EU) level. It also allows us to make a relevant temporal comparison to India's case in terms of policy goals, technology and financial instruments. Prior to 1970s, water was transported to the outside of cities for treatment, where technologies such as activated sludge were used to remove pathogens (Sedlak, 2014a). Even now most of the treatment plants are located outside the cities due to the long lifespan of the infrastructure.

3.3.1. Paradigm 1: Wastewater treatment for public health and the environment (1970–2005)

Since, the 1970s the wastewater system aimed to improve the quality of the surface water, including the canals within the cities. Interview respondents mentioned that '*the ditches, channels, and rivers were stinking and we could see eutrophication and foam layer in the water bodies*' (respondents referred to eutrophication as *green pea soup*). In 1970, the formulation of Pollution of surface Water Act helped in regulation of biochemical oxygen demand (BOD)/ chemical oxygen demand (COD). Moreover, it was found that water contained various pathogens and pesticides. For this purpose, both public health and environmental protection became the policy focus in the Netherlands. Various policy

[2] A town or urban agglomeration with a population of 100,000 or above is categorized as Class I, while Class II towns/UAs are between a population of 50,000 and 99,999 people. Around 70% of India's urban population live in Class I towns. According to Census (2011), Greater Mumbai (18.4 million), Delhi (16.3 million) and Kolkata (14.1 million) have more than 10 million residents and are known as the mega-cities.

documents at the European level such as the Urban Waste Water Treatment Directive (1991) or the Drinking Water Directive (1998) were formulated and considered by the Netherlands to further develop and retrofit their wastewater treatment system. The infrastructure was developed during this time to maintain the standards for (BOD)/ (COD) levels in the Netherlands. In 1990s, the treatment plants were upgraded to remove nitrogen and phosphorous from the wastewater system to further improve the surface water quality against eutrophication.

The investments during this long time period came through the Nederlandse Waterschapsbank (NWB). The bank was specially established to support the regional water authorities[3] and other water infrastructure activities in the Netherlands. NWB helps in providing risk-free capital to water authorities, supports public health services and education for water and other related projects. The risk-free capital was guaranteed because the regional water authorities are entitled to have their own tax system and generate revenue to operate, maintain and upgrade their treatment plants. Technological advancements were made during this period. Until the 1990s, the focus was on treating wastewater using primary and secondary treatments with activated sludge systems and anaerobic digestion for treatment of the generated biosolids and biogas production (for STPs developed between from 1995). Between the mid-1990s and 2005, major advancements were also made by retrofitting more advanced technology in treatment plants, with biological treatment of nitrogen (N) and phosphorous (P) from the wastewater. Our respondent confirmed that this had a positive impact in improving the overall surface water quality in the Netherlands.

3.3.2. Paradigm 2: Circular economy (2006 onwards)

By 2000, the Netherlands was already aware that they have to follow the Water Framework Directive (2000) from the EU. The directive was an overarching policy document with the aim to meet the water quality targets by 2027, with intermediary targets in 2009 and 2015. The Netherlands and other EU countries were not prepared to make large investments to treat micropollutants[4] in the wastewater for various reasons. First, it is challenging to forbid private companies producing certain compounds, necessary for various consumer products. Second, the Water Framework Directive is unclear about the removal standards of micropollutants in the wastewater. Moreover, our respondents also mentioned that the existing treatment techniques can largely deal with only point source micropollutants as compared to diffused sources. Lastly, water authorities mandate only allow them implement legislative with clear and strict guidelines and sanctions. Currently, there are no sanction on micropollutants for the Netherlands for not complying to the Water Framework Directive (2000).

Our respondents also mentioned that water authorities also started making efforts to start collecting sewage from rural areas. During this period, there have been amendments in the Water Act (2010) and the Water Boards Act (2009), ensuring coordination of responsibilities and competencies including the independent intake, collection and treatment of wastewater with a view to coordinated and efficient water management. The Water Act (2010) aims to make the Dutch water law more transparent and simplify the implementation of European water rights, particularly the Water Framework Directive. With such policy goals, in 2012 the framing of the Dutch wastewater system shifted towards creating circular systems by introducing the concept of ‘energy, nutrient and water factory’[5] . The aim is to produce maximum energy using wastewater treatment and also generate resources. Financial and technological investments are made to replace and retrofit the technologies to develop sewerage treatment plants for the future. Further, the initiatives such as ‘zoetwaterfabriek’ are also being piloted by Stowa, Deltafonds, Evides and Waterschap (Water Authority) Vallei en Veluwe to remove medicine residues, pesticides, hormone-disrupting substances from the wastewater. Financial instruments such as taxes generated by the regional water authorities will be used to develop circular wastewater treatment systems and position these efforts as ‘green’ initiatives, making them viable and useful water organizations for the future.

3.4. Paradigms changes in the Netherlands

The paradigm change from wastewater treatment for public health and environment to the circular economy in the Netherlands is guided by the following underlying reasons. First, the EU Framework Directive is still to be adopted completely and there are micropollutants parameters that the Netherlands is not able to comply. It can be partly associated with unclear regulation and sanction from EU on micropollutants standards. Second, the Dutch government has an ambition for the Netherlands to become a circular economy by 2050. The ambition of the circular economy also relates to water usage and treatment. Considering water as an important part of the circular economy, the wastewater treatment process is stimulated by Dutch Roadmap for Wastewater treatment of 2030, developed by Foundation for Applied Water Research (STOWA, 2010)[6] . Our respondents mentioned that the circular economy approach is receiving attention as the large part of network sewerage system in the Netherlands is reaching its technical life span. Replacing such a large network of infrastructure is very expensive, therefore, better integration of discharge, conveyance and treatment (i. e. circular water) could reduce upcoming investments significantly. Lastly, respondents mentioned that the two cumulative drought seasons of 2018 and 2019 (and, as it looks now, 2020) caused various problems for the shipping and agriculture sectors. The drought situation has forced the government (Rijkswaterstraat and regional water authorities) to use the ‘resource factory’ idea for potential solutions for droughts.

4. Discussion

In this study we described the emergence of different wastewater paradigms in India and the Netherlands. We explored various aspects of a wastewater paradigm such as the framing (idea) shaping the paradigm, policy goal(s) to implement the idea and technical and financial instruments to achieve the policy goals. Based on our findings, we reflect on the key differences and gaps between the wastewater paradigms between India and the Netherlands (see Table 2). We will reflect on the differences between paradigms in terms of policy approaches and practices followed. Moreover, it will support in identifying areas that require immediate focus to attain wastewater reuse.

The central and state pollution boards in India have been unsuccessful to maintain water quality measures as they are not allowed to penalize polluters, instead, the boards have to pursue the polluter via legal action. Moreover, they also do not collect taxes for creating urban

[3] In 1955 there were 2488 waterboard: big ones and many small ones that were gradually taken over by big ones. Today there 21 regional water authorities.

[4] Micropollutants can be defined as anthropogenic chemicals that occur in the (aquatic) environment well above a (potential) natural background level due to human activities but with concentrations remaining at trace levels (up to the microgram per litre range). Thousands of chemicals fall into this category. MPs can consist of purely synthetic chemicals, such as strongly halogenated molecules (e.g. fluorinated surfactants), or of natural compounds such as antibiotics (e.g. penicillin’s) or oestrogens. MPs may originate from a wide range of sources (e.g. agriculture, households, traffic networks or industries) and enter water bodies through diverse entry paths. Retrieved from Stamm et al (2016).

[5] This initiative evolved to the energy and resource factory (www.efgf.nl).

[6] STOWA is the knowledge centre of the regional water managers (mostly the Dutch Water Authorities) in the Netherlands. Its mission is to develop, collect, distribute and implement applied knowledge, which the water managers need in order to adequately carry out the tasks that their work supports. This expertise can cover applied technical, scientific, administrative-legal or social science fields.

Table 2
Aspects of wastewater paradigms in India and the Netherlands.

Wastewater Paradigms	Framing*	Policy goals**	Technical and financial instruments***
India			
Water resource to meet basic human needs (1974–1995)	Use water to reduce poverty in India	To use water for irrigation, hydropower generation and domestic purposes	Conventional technologies, mostly primary treatment for irrigation (e.g. primary sedimentation tanks).
Water as an engine of economic growth (2000–2010 onwards)	Use water to supply water in urban centres of India	Use water for domestic and drinking purposes and feed industries/ factories	Wastewater treatment systems within major metropolitan cities with various pilots and testing
Water scarcity and beautification of cities (2011–2020)	Reuse water is important for water sufficient India and cities water infrastructure needs improvements	Recycle and reuse water, with different models of governance – including public-private models	Centralised and decentralized systems emerged in various Class I and Class II Both chemical and biological treatments (primary, secondary and tertiary) used in different contexts
The Netherlands			
Wastewater treatment for public health and the environment (1960–2005)	Improve public health and quality of surface water bodies	Improving the chemical and ecological status of water systems; and allowing water systems to fulfil societal functions	Centralised and decentralized systems emerged in various cities Advanced mechanical, chemical and biological treatment technologies in use for various purposes
Circular economy in wastewater treatment (2006 onwards)	Improve water quality and generate resources (energy, water and nutrients)	To become a circular economy by 2050	A few decentralized systems emerged The technology used to create circular wastewater systems that are water, energy and nutrient efficient

* underlying thinking or idea of the policy document.
** key policy goal(s) of the policy prepared.
*** key technical basis /technology to be used and funds allocation to achieve policy goals.

wastewater infrastructure. Separate municipal or state authorities such as Delhi Jal Board (DJB) of Delhi are responsible for collecting taxes and maintaining wastewater infrastructure. The DJB implements water cess, but merely generates enough to invest and build wastewater treatment plants. It is estimated that DJB was in a deficit of EUR 78 million in 2018–19 (The Hindu, 2019). A study by Kumar and Tortajada (2020) suggests that India's projected investments in secondary treatment plants is EUR 970 million in the short-term, EUR 783 million in the medium term, and EUR 338 million in the long-term. Further, the investment projected for tertiary treatment plants is EUR 7480 million in the medium term (between 2 and 5 years) and EUR 6960 million in the long-term (more than 10 years). These investments are only possible if they are assured by a stable financial system to support both centralized and decentralized treatment systems. Further, the current financial investments for treatment of wastewater might not be sufficient to meet the new standards by National Green Tribunal order (April 2019), which are stricter as compared to EUs standards of water treatment. Therefore, it would be suitable that each city, town and metropolitan area develop its own financial model to meet these stricter standards to upgrade their existing treatment plants or install new ones. Such a process is extremely time and resource consuming, but it allows to develop context specific investment and technological models.

Further, to change the face of wastewater treatment and reuse in India, it is important to rethink policy measures. We propose two measures. First, comprehensive research has to be conducted to assess different technologies and financial instruments that have been successfully tested in different cities (including Class I, Class II and metropolitan areas) of India. Based on this assessment, a roadmap should be laid out to upscale technological and financial models. The assessment can be developed into a tool box that can eventually be used by variety of policy actors to make decisions about technical and financial model choices for a particular city. Technical choices such as C-TECH provides benefits on land requirement, effluent quality and lower maintenance costs can be included in the tool box (Kulkarni et al., 2016). Although in the past, both financial and technical plans are made coherently but due to upscaling issues, there are fall-outs. A more viable business model and a structure for financial support for wastewater treatment has to be developed. The second measure relates to the upcoming water policies in India. The Water Framework Bill (2016) should be given statutory support and be legally binding. This will help in creating a balance between supply-side and demand-side measures in wastewater treatment and reuse, where both private and public authorities can work together. Further, the upcoming National Water Policy (2020) should include a directive on wastewater treatment and reuse, with emphasis to develop by-laws to improve taxation and tariff systems for each state and large metropolitan cities for the small, medium and large industries, household and agriculture sectors. Along with the policy measures, the thresholds for the effluents of sewage treatment plants have to be standardised across states and cities. Changing of standards to meet policy goals will not create a positive environment for agencies such as CPCB to enforce these standards, especially if India wants to tackle water scarcity through water recycling for irrigation and other non-potable reuse options (Starkl et al., 2018). Moreover, innovative concepts such as 'city as a spaceship' may be used to develop vision for developing sustainable infrastructure and quality of life in Indian cities (Mohanty, 2010). Such ambitious measures and developments may help India to move out of the water crisis and generate resources to treat wastewater.

Whereas in the Netherlands, regional water authorities (boards) are responsible for wastewater treatment and maintaining the quality of surface water, as well as the protection against flooding (Havekes et al., 2017). These authorities are bestowed with political and statutory powers to generate funds to develop infrastructure. The regional water authorities collect separate taxes and are also financially and politically independent as compared to provinces and municipalities, who are dependent on the federal government. Regional water authorities (boards) have become financially more independent and powerful after the regional water authorities (modernization) Act of 2009. For instance, the wastewater treatment levy only relates to the costs of the treatment of wastewater. The costs that the regional water authority incurs to protect and improve the water quality of the surface water are financed employing the water system levy and the water pollution levy. In cases, where industrial wastewater systems fail to meet the set targets, the units have to pay heavy fines. Further, in the Netherlands, tax and tariffs are determined using other tax principles too, including the beneficiary pays principle; the polluter pays principle; the cost-recovery principle; the solidarity principle; and the legality principle. Each of these principles supports the regional water authorities to generate taxes, enabling them to self-finance their activities. Hence, the necessary investments in water control do not have to compete with other governmental water expenditures. This financial system facilitates authorities to attract long-term loans to make large investments. As water authorities are allowed to collect taxes, banks are assured that the loan will be paid back.

However, in the Netherlands there have been a discourse that regional authorities such as the water authorities are superfluous and can be abolished (OECD, 2014). It is also often unclear to the public what the role of water authorities in the Dutch water management is. For the time being, the water authorities continue to perform their responsibilities, showcasing themselves as 'green' and climate-smart.

5. Conclusion

In this article we answered the question *how different wastewater paradigms have emerged in India and the Netherlands between 1970 and 2020.* The wastewater paradigms of the two countries have evolved in the last few decades. In the case of India the wastewater paradigms have realized changes from 'water resource to meet basic human needs' to 'water scarcity and beautification of cities'. Whilst, in the Netherlands, the wastewater paradigms have changed from an emphasis on 'public health and environmental concerns' to the 'circular economy of wastewater'. The concept of paradigms is useful in such an analysis, explaining the underlying thinking of plans and policies towards wastewater reuse and treatment in two very distinct countries. It also illustrates the gaps in governing wastewater in developing and developed countries, presenting normative as well as reality of wastewater governance. In India, there are gaps between the changes desired in the policy documents as compared to the situation on-the-ground. For instance, there is a failure of introducing appropriate pricing mechanisms and tax structure to protect the water usage. The pricing structures are highly subsidized and do not reflect the marginal supply cost, eventually failing to incentivise the usage of wastewater for industrial or household purposes. Further, the national policy directives towards wastewater have been extremely weak and merely a 'feel good' document (Pandit and Biswas, 2019). The three NWPs (1987; 2002 and 2012) have continuously pushed for basin level interventions to control pollution and maintaining the ecological flow of the rivers, but not even a single sub-basin management plan has been prepared and implemented successfully. Historically, India has failed to come up with a basin-wide plan, with no signs in the future to treat wastewater at a basin level. To counter such weak policies, it might help to rethink and reformulate the national water policy and other state water policies, taking the direction of wastewater treatment and reuse measures.

CRediT authorship contribution statement

Sumit Vij: Conceptualization, Methodology, Writing - original draft, Writing - review & editing, Visualization. **Eddy Moors:** Conceptualization, Writing - review & editing. **Katarzyna Kujawa-Roeleveld:** Conceptualization, Writing - review & editing. **Ralph E.F. Lindeboom:** Conceptualization, Writing - review & editing. **Tanya Singh:** Conceptualization, Writing - review & editing. **Merle K. de Kreuk:** Conceptualization, Writing - review & editing.

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.

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Appendix A

Examples of the search queries used for data collection

Sr. No.	Search Queries used
1	("wastewater" OR "reuse" OR "treatment") policy (water OR wastewater) (India OR Indian) filetype:pdf 1970..2019
2	("wastewater" OR "reuse" OR "treatment") policy (water OR wastewater) (Netherlands OR Dutch) filetype:pdf 1970..2019
3	("wastewater" OR "reuse" OR "treatment") policy (water OR wastewater) (European OR EU) filetype:pdf 1970..2019

Types of interview respondents

Types of respondents	Case countries	
	India	Netherlands
Serving water bureaucrats/ professionals	1	2
Retired water bureaucrats	1	1
Expert consultants	2	1
Academics involved in policy-making	3	2
Representatives of water-focused private organizations	2	1
Sub-total	**9**	**7**
Total respondents	**16**	

Policy documents included in the analysis

Sr. No.	Water policy documents (India)	Sr. No.	Water policy documents (the Netherlands)
1	National Water Policy, 1987	1	National Water Plan, 2016−21

(*continued on next page*)

(*continued*)

Sr. No.	Water policy documents (India)	Sr. No.	Water policy documents (the Netherlands)
2	National Water Framework Bill, 2016	2	The National Waste Management Plan, 2003
3	National Water Mission, Vol. 1, 2011	3	Waste management policy – note, 2013−14
4	National status of waste water generation & treatment, 2019	4	Water Act, 2010
5	Water Pollution Act (1974)	5	Water Boards Act (2009)
6	Draft Water policy of Delhi, 2016	6	Urban Waste Water Treatment Directive, 1991
7	Delhi water Tariff policy, 2009	7	Drinking Water Directive, 1998
8	Draft Policy on National Urban Faecal Sludge and Septage Management, 2017	8	Water Framework Directive, 2000
9	Water Pollution in India, Report No. 21 of 2011–12 (Comptroller and Auditor General of India 2011)	9	Dutch Roadmap for Wastewater treatment of 2030
10	National River Conservation Plan, 1995	10	Blue Deal Framework, 2018
11	National Water Policy, 2002	11	Dutch Water Authorities. (2017, December 15). Waterschappen: voorkom medicijnresten in water [Water boards: prevent pharmaceuticals in water].
12	National Water Policy, 2012	12	EU Water Alliance. Opportunity and necessity for Europe to build a water-smart society and circular economy
13	Water Cess Act (1977)	13	Europe water, Reply to the public consultation on Urban Waste Water Treatment Directive
14	Functions of CPCB/SPCB, retrieved from https://cpcb.nic.in/functions/ on February 2020	14	EU water, Value of Water, Multiple Waters for Multiple Purposes and Users Towards a Future-Proof Model for a European Water-Smart Society
15	Composite water management index, NITI Aayog, 2019		
16	Manual on sewerage and sewage treatment, 1993		
17	Manual on sewerage and sewage treatment systems, 2013		
18	Envistats India 2018, Supplement of environmental accounts		
19	National Green Tribunal Order (April 2019)		

Appendix B. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.envsci.2020.09.015.

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