


MAPPING OF SCIENTIFIC PRODUCTION ON ACTIONS, PROJECTS AND CHALLENGES TO DEAL WITH FRESH WATER SCARCITY

MAPEAMENTO DA PRODUÇÃO CIENTÍFICA SOBRE AÇÕES, PROJETOS E DESAFIOS PARA LIDAR COM A ESCASSEZ DE ÁGUA DOCE.

Gustavo Yuho Endo*  E-mail: gustavo_endo@yahoo.com.br

José Hugo Leite Junior*  E-mail: jose.leite@ifpr.edu.br

Giane Gonçalves Lenzi*  E-mail: gianeg@utfpr.edu.br

João Luiz Kovaleski*  E-mail: kovaleski@utfpr.edu.br

*Federal University of Technology (UTFPR), Ponta Grossa, PR, Brazil.

Resumo: A preocupação com a água é devido ao aumento da população e com isso houve o aumento do consumo de água, diante de um cenário de escassez de água se faz necessário direcionar esforços para que isso não ocorra, uma das formas que possa suprir a demanda é por meio de tecnologia para o reuso da água. Nesse sentido, a proposta da pesquisa foi realizar uma revisão sistemática e integrativa da literatura sobre a transferência de tecnologia relacionadas com a água com direcionamento para o reuso da água. Ao final foram selecionados 33 artigos sobre a temática. Os principais achados foram que o foco das pesquisas está relacionado com o fomento para o reuso da água e preocupações sobre o consumo da água. As pesquisas elucidam sobre a importância de políticas públicas relacionadas com o consumo e reuso da água e reforçam a importância de compreender a conscientização e aceitação da população em relação a tais aspectos. Uma das alternativas para suprir o cenário de escassez de água foi por meio da dessalinização da água, porém avanços são necessários para vencer a barreira do alto consumo de energia e sobre a geração de resíduos. No que tange a transferência de tecnologia, o compartilhamento de conhecimento a nível global se faz necessário para que a transferência de tecnologia ocorra de forma efetiva e tenha resultados satisfatórios.

Palavras-chave: Antropotecnologia. Transferência de tecnologia. Água. Reutilização de água. Revisão da literatura.

Abstract: The concern over water is due to the increase in population, which has led to an increase in water consumption. Given the context of water scarcity, it is necessary to direct efforts towards preventing this occurrence. One way to meet demand is through technology for water reuse. In this sense, the research proposal was to conduct a systematic and integrative review of the literature on technology transfer related to water, with a focus on water reuse. A total of 33 articles on the subject were selected. The main findings were that research is focused on promoting water reuse and addressing concerns about water consumption. The research highlights the importance of public policies related to water consumption and reuse, as well as the need to understand the population's awareness and acceptance of such aspects. One alternative to meet the water scarcity crisis is through desalination, but progress is needed to overcome the barrier of high energy consumption and waste generation. Regarding technology transfer, sharing knowledge on a global level is necessary for effective technology transfer and satisfactory results.

Keywords: Anthropotechnology. Technology transfer. Water. Water reuse. Literature review.

1 INTRODUCTION

In 2015, with the 2030 Agenda, which contains the 17 sustainable development goals (SDGs) and 169 targets which should guide the behavior of public and private organizations and all individuals on the planet. Highlights the importance of water, specifically SDG 6 – drinking water and sanitation; SDG 9 – industry, innovation, and infrastructure and SDG 12 – responsible consumption and production (ONU, 2015). The SDGs are related to water, as the issues addressed in these SDGs directly impact water consumption.

The concern with water is due to the increase in population and, consequently, the increase in the consumption of fresh water in agriculture for the cultivation of plants, and the lack of water can compromise agriculture; in industries, which are used in the productive processes and the cities, for the consumption of the population (Alcon *et al.*, 2014; Brame; Li; Alvarez, 2011; Manju; Sagar, 2017; Ritchie; Roser, 2017). In addition, large amounts of water are used to produce traditional energy (Brame; Li; Alvarez, 2011). With a possible water shortage, the reuse of water is seen as an alternative so that there is no lack of water for consumption (Angelakis; Snyder, 2015).

Given this scenario in which the global population can be impacted, alternatives such as the recovery and the reuse of water are alternatives that deserve attention to minimize possible water shortages on the planet, thus maintaining sustainability in the long term (Angelakis; Durham, 2008; Helmecke; Fries; Schulte, 2020; Miller, 2006).

Due to the importance of water reuse, water reuse technologies were developed, such as sand filters, filtration coagulation, flocculation, swamp building, ultraviolet radiation, and chlorination. However, it is essential to highlight that it is necessary to improve existing technologies to be sustainably viable in a specific context (Curiel-Esparza *et al.*, 2014).

Still, when aspects of technology are discussed, it is essential to emphasize that technology is used in another context, called technology transfer. It is necessary to observe issues related to the conditions under which the country that intends to use the technology lives, the level of maturity concerning technology, and sociocultural issues are seen as challenges to be faced and overcome (Kirlidog, 1996).

In addition to the challenges mentioned earlier, it is necessary to rupture identified barriers related to water reuse. Being the lack of innovative technologies, the transfer of existing technology, and the understanding of how this technology transfer was carried out; education and public acceptance, and the promotion of public policies, so that there is no shortage of drinking water in the world (Brame; Li; Alvarez, 2011; Manju; Sagar, 2017; Miller, 2006). On the other hand, it is already possible to observe some movements towards including water reuse in water planning (Smith *et al.*, 2018).

However, it is essential to point out that, despite the benefits presented on the reuse of water, issues related to the health of the population and the possible impacts on the environment deserve the attention of stakeholders (Helmecke; Fries; Schulte, 2020). As a result of the concern about the population's health, there is a concern about SARS-CoV-2, which can contaminate individuals through water consumption (Langone *et al.*, 2021).

In this sense, the present study aims to elucidate the research directed towards the transfer of technology related to water directed towards water reuse, which seeks to meet all criteria on aspects of sustainability and technical issues. The following research questions arise: (i) are there research related to water-related technology transfer aimed at water reuse? (ii) in what ways are these surveys treated?

In this sense, to answer the research questions, the general objective of the research was to carry out a systematic and integrative review of the literature on technology transfer related to water with a focus on water reuse. The specific objectives are: (i) to identify the scientific production on the subject; (ii) present the evolution of publications on the subject over time; (iii) to analyze in an integrative way the identified articles; (iv) propose a research agenda on future directions on the subject and, finally, (v) discuss the practical and managerial implications of research related to the transfer of technology related to water.

2 METHODOLOGY

The present research is characterized as a systematic and integrative review of related research on water-related technology transfer aimed at water reuse. The databases consulted were: (i) Web of Science; (ii) Scopus, and; (iii) Science Direct. Furthermore, the Methodi Ordinatio was used.

The research is characterized as a systematic review since the objective proposed by the research is clear. The research questions are: (i) are there researches related to technology transfer of water directed to water reuse? (ii) In what ways are these surveys being treated? In addition, the inclusion and exclusion criteria are clearly described throughout the methodology. To identify the most relevant research on the subject, the InOrdinatio Index was used, which will be explained later in this section. Finally, a summary of the primary research on the topic is presented (Aromataris; Pearson, 2014).

The research developed fits as an integrative review. It aims to identify the primary research on the subject under study, seeking to advance knowledge about technology transfer related to water directed to water reuse. (Whittemore; Knafl, 2005). The integrative review protocol is based on the model presented by (Whittemore, 2005), which seeks problem identification, literature search, data evaluations, data analysis, and presentation.

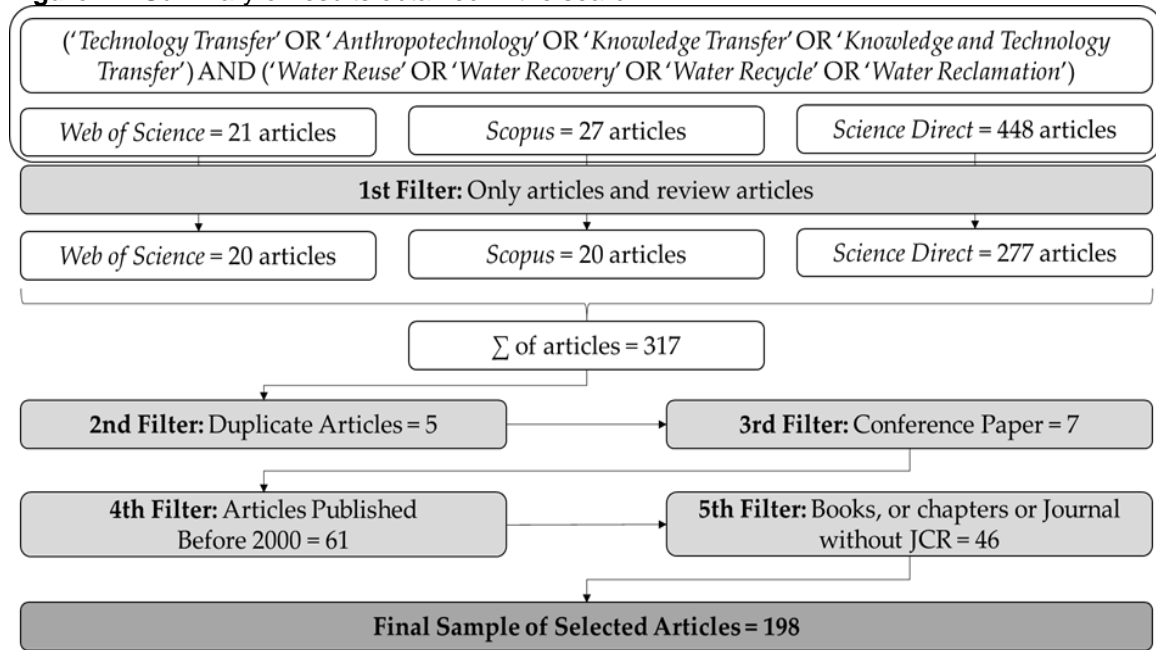
Seeking to make the research methodologically robust, the Methodi Ordinatio proposed by (Pagani; Kovaleski; Resende, 2015) presents criteria for the choice of scientific articles. This methodology has proved to be efficient to the proposals for identifying the most relevant research on the subject.

The first stage of the research was carried out by defining the search strings. It used the following combinations: ('Technology Transfer' OR 'Anthropotechnology' OR 'Knowledge Transfer' OR 'Knowledge and Technology Transfer') AND ('Water Reuse' OR 'Water Recovery' OR 'Water Recycle' OR 'Water Reclamation'), which aimed to identify research related to the transfer of technology related to water with a focus on water reuse.

The second stage of the research in January 2022 used the strings mentioned above in selected databases and applied five filters to exclude articles. Selected only articles and review articles in the first filter. In the second filter, duplicate articles were excluded. In the third filter, papers from conferences were identified and excluded. In the fourth filter, articles published before 2000 were excluded, in which the authors defined the time frame of 30 years. Finally, in the last filter, books or book chapters still in the sample of articles and journals that did not have the Journal Citation Reports (JCR) were excluded.

As shown in Figure 1, the results obtained with the steps mentioned in the previous paragraph have presented the sample of articles initially has a total of 496 and, at the end of the exclusion criteria, identified 198 articles.

Figure 1 – Summary of results obtained in the search



Source: Prepared by the authors (2022).

Continuing the methodological process followed, with the Methodi Ordinatio, the InOrdinatio index is presented. Which Formula 1 is presented, which takes into account the impact factor (IF), α being the weighting to the year attributed by the researcher, with 1 being little importance and 10 being very important; in addition to the year of publication and the number of citations (ci). With the InOrdinatio index, it is possible to identify the most relevant articles on a given topic (Pagani; Kovaleski; Resende, 2015).

$$InOrdinatio = \left(\frac{IF}{1000} \right) + \alpha * [10 - (Year\ of\ Research - Year\ of\ Publication)] + \left(\sum ci \right) \quad \dots(1)$$

In Formula 2, the calculation of the InOrdinatio Index of the most relevant article on the subject under study is presented, being: IF the JCR of 9.501 from the journal Desalination; 10 was assigned to α , which considered the year of publication of the article important; the year in which the survey was carried out was in 2022; the year of publication of the article was 2006 and, finally, ci being 517 the number of citations that

the research has in Google Scholar, thus obtaining the InOrdinatio index of 457.01. With the help of Microsoft Excel 2019, the InOrdinatio index of the 198 articles identified on water-related technology transfer aimed at water reuse was calculated.

$$\text{InOrdinatio} = \left(\frac{9,501}{1000} \right) + 10 * [10 - (2022 - 2006)] + (517) \quad \dots(2)$$
$$\text{InOrdinatio} = 457.01$$

After calculating the InOrdinatio index, the articles with the InOrdinatio index ≥ 100.00 were selected for the subsequent analysis stage; adopting this criterion, 129 articles were excluded, leaving 69 articles that obtained ≥ 100.00 . The next step in selecting articles was to read titles, abstracts and keywords. Only 33 remaining articles were analyzed, excluding 36 of them due to not being in the scope of the research.

Finally, the 33 articles were analyzed, and it was possible to identify five categories, as follows: (i) promotion of water reuse – 14 articles; (ii) concern with water consumption – 12 articles; (iii) water in agriculture – 5 articles; (iv) pharmaceutical waste – one article and; (v) SARS-CoV2 – one article.

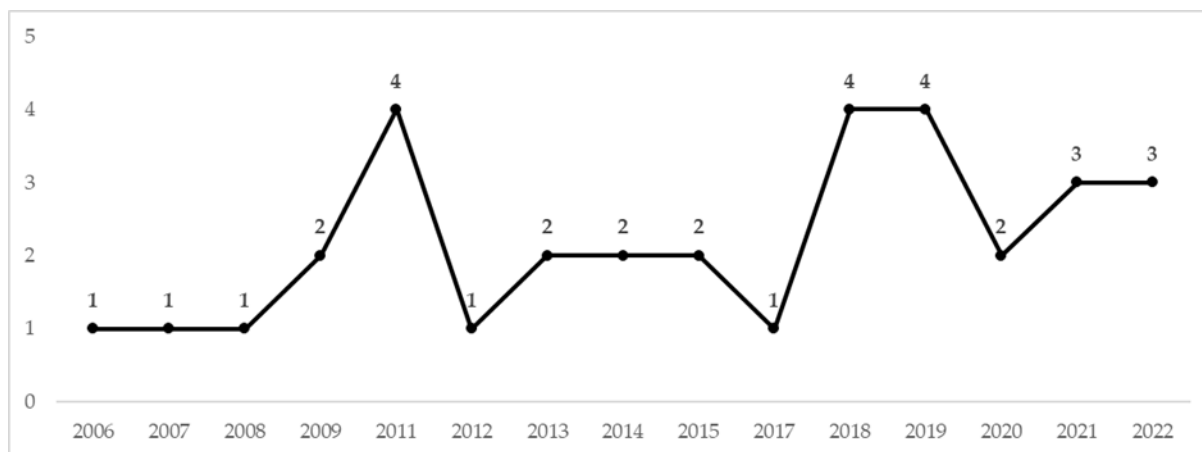
The results obtained from the research are organized as follows: it begins by presenting the history of publications; then the articles classified according to the InOrdinatio index are given; the most relevant journals are presented, pointing out the journals with the most publications; word clouds of the titles and keywords of the 33 selected articles; then the articles are discussed according to their categories; prepared a future research agenda based on the insights generated from the analysis of the articles and, finally, the practical and managerial implications are discussed.

3 ANALYSIS AND DISCUSSION OF RESULTS

This section begins the presentation and discussions based on the Web of Science, Scopus and ScienceDirect databases review. From the inclusion and exclusion criteria detailed in the previous section, 33 articles were analyzed in total. In Figure 2, it is presented the history of publications on the theme proposed in the study. It is observed that the years with the most publications were 2011, 2018, and 2019

with four publications in each year. The research was carried out in January 2022, and in that same year, it already had three published articles.

Figure 2 – History of publications on technology transfer related to water directed towards reuse



Source: Prepared by the authors (2022).

It is possible to observe the journals with the most published articles on the subject. It is concluded that the prominent journals are: the Journal of Cleaner Production, the Journal of Environmental Management, and Desalination being the three journals with the most publications.

Reading the titles and abstracts of the 33 articles made it possible to categorize the articles according to the theme worked in each of them. The category with the most publications identified was the promotion of water reuse, in which 14 articles were identified that discuss this theme, which in Table 2 presents objectives and the main findings of the research.

Table 2 – Summaries of the articles in the Category Promotion for Water Reuse selected in chronological order

Authors/Year	Main results
(Miller, 2006)	Issues related to water reuse were already observed in the US, Australia, Europe and other regions. The importance of reusing water in different ways was reinforced. There was already a lack of government support for these practices and resistance on individuals.
(Downward; Taylor, 2007)	Due to the high water consumption for irrigation and the high domestic consumption, Almería suffered from water shortages. Given this scenario, alternatives such as water desalination, increase in water tariffs and water reuse are alternatives to minimize such scarcity. In particular, the desalination of water can meet the need for water and improve environmental issues;

	however, issues related to the cost of investment, the need for energy and the generation of waste deserve managers' attention.
(Angelakis; Durham, 2008)	The main findings of the research highlight the importance of communication between the countries that make up the EUREAU on projects related to water reuse, in particular making it clear to those involved what are the main benefits of water reuse. They also highlight the importance of countries agreeing to have satisfactory results for all.
(Blanco Gálvez; García-Rodríguez; Martín-Mateos, 2009)	Through the MEDESOL Project, sustainable development is possible, as it is possible to improve the efficiency of desalination and financial gains to other familiar systems.
(Kim <i>et al.</i> , 2009)	Through a review, the authors elucidated the issues related to large-scale desalination plants. The research highlights the importance of knowing the complex system of reverse osmosis networks in full.
(Mankad; Tapsuwan, 2011)	According to the research findings, the community is open to new water sources for domestic consumption. However, there is concern about the risks and threats that these new water sources can offer. The authors highlight the importance of understanding the population's acceptance before investing in water reuse technologies.
(Brame; Li; Alvarez, 2011)	Nanotechnology is seen as a technology that can be considered cheap, efficient and flexible, mainly assisting water desalination. However, a caveat to such technology is that some nanomaterials can risk the population's health.
(Binz <i>et al.</i> , 2012)	In the context of wastewater, an interaction between Chinese actors and those from other countries was observed, in which China seeks technological leadership. The research findings point to the importance of social incorporation for new technologies, as it is necessary to combine this social incorporation with technology to have satisfactory results.
(Geng <i>et al.</i> , 2013)	The study was carried out at Shenyang University in China. This university has been directing efforts towards sustainability, mainly to energy, waste generation and water recycling. This university is already seen as a model to be followed, and it is highlighted that in green universities, it is possible to train students with environmental awareness.
(Manju; Sagar, 2017)	In the context of India, the research focus on water desalination is seen as a sustainable and intelligent alternative. The envisaged alternative is the combination of desalination with the renewable energies available in the country. However, India needs to identify countries that already use such technologies to carry out technology transfer in a powerful way.
(Smith <i>et al.</i> , 2018)	The research results highlight the importance of carrying out awareness-raising work and providing information about water reuse, thus breaking down barriers that the population may have to water reuse.
(Skouteris <i>et al.</i> , 2018)	A survey was carried out in a brick factory, in which water recovery schemes were explored in production (water reuse and regeneration). In both schemes, there was a decrease in water consumption for the manufacture of bricks.
(Ly <i>et al.</i> , 2019)	The findings suggest that new membrane materials should be explored in wastewater to facilitate knowledge transfer.
(Parakala; Moulik; Sridhar, 2019)	The research made it possible to observe that the water recovery process was successful using the vacuum membrane. It was possible to notice that integrating processes can benefit the industrial economy, primarily if the renewable energies operate the vacuum membrane.

Source: Prepared by the authors (2022).

Based on the research findings, the importance that the USA, Australia and Europe (Miller, 2006); Spain (Blanco Gálvez; García-Rodríguez; Martín-Mateos, 2009; Downward; Taylor, 2007); China (Binz *et al.*, 2012; Geng *et al.*, 2013); India (Manju;

Sagar, 2017); all countries that are part of the EurEau - European Federation of National Associations of Water & Waste Water Services (Angelakis; Durham, 2008); the Mexico (Blanco Gálvez; García-Rodríguez; Martín-Mateos, 2009) already visualized the importance of water reuse.

It is noteworthy that, contributions to the state of the art with research, is that the practice of water reuse to be carried out in different contexts around the world, it is necessary to encourage governments (Binz *et al.*, 2012; Manju; Sagar, 2017; Miller, 2006); the resistance of individuals with water reuse is a barrier to be overcome (Miller, 2006), mainly due to the risks and threats to the water reuse (Mankad; Tapsuwan, 2011); have assertive and accurate communication highlighting the main benefits and public awareness of water reuse (Angelakis; Durham, 2008; Manju; Sagar, 2017; Smith *et al.*, 2018) are aspects to be taken into account.

In a water scarcity scenario, desalination is seen as an opportunity to meet possible water shortages and has been attracting attention from researchers (Blanco Gálvez; García-Rodríguez; Martín-Mateos, 2009; Downward; Taylor, 2007; Kim *et al.*, 2009; Manju; Sagar, 2017). Desalination is considered an environmentally friendly process that can obtain fresh water to be used by the community, primarily if it uses solar energy (Blanco Gálvez; García-Rodríguez; Martín-Mateos, 2009). Nanotechnology makes it possible to assist water desalination (Brame; Li; Alvarez, 2011). However, aspects related to the high investment and concern with energy consumption and waste generation deserve the attention of those involved (Downward; Taylor, 2007; Manju; Sagar, 2017).

As stated, there are technological alternatives for water reuse. However, before investing in these technologies, it is necessary to understand the population's acceptance of water reuse (Binz *et al.*, 2012; Manju; Sagar, 2017; Mankad; Tapsuwan, 2011). In addition, it is necessary to identify other locations that are already used to carry out a visit to understand the best ways to carry out the transfer of technology in a powerful way, thus obtaining satisfactory results (Manju; Sagar, 2017). When it comes to technology and knowledge, there are already green universities that direct attention to aspects of sustainability in which it is possible to train individuals with environmental awareness (Geng *et al.*, 2013).

Directions regarding individuals are related to anthropotechnology issues and geographic, demographic, epidemiological, sociological, economic, linguistic, anthropological, and historical issues. All this makes it possible to improve technology transfer (Wisner, 2004) because if these aspects are not understood, it can compromise the effective use of technology (Corsi; Kovaleski; Pagani, 2021) by the contemplated society.

In a manufacturing context, but specifically in the manufacture of bricks, it was studied, which used the reuse and regeneration of water, which was possible to reduce the total consumption of water for the manufacture of bricks (Skouteris *et al.*, 2018).

The next category to be analyzed is the concern with water consumption. As shown in Table 3, the research discusses several aspects related to water consumption.

Table 3 – Summaries of the articles in the Concern about Water Consumption Category selected in chronological order

Authors/Year	Main results
(Zhang; Platten; Shen, 2011)	The findings made it possible to observe the lack of knowledge regarding existing green technologies. Water reuse and devices that reduce water consumption were used among these green technologies. However, barriers need to be overcome, especially the high cost of implementing green technologies.
(Iglesias <i>et al.</i> , 2011)	The article highlights the importance of public policies related to water resources seeking to preserve the ecosystem. The authors emphasize the importance of technology and knowledge transfer related to water but emphasize the difficulty for less favoured countries to have access due to cost.
(Lienert; Schnetzer; Ingold, 2013)	The main results point to a misalignment between the parties involved in water resources planning. Planning is carried out by local authorities and engineers and is not considered the long term. Planning must be aligned with public policies seeking unconventional solutions for planning, and water professionals must focus on long-term sustainability.
(Dong <i>et al.</i> , 2014)	One of the alternatives for the more developed regions facing water scarcity is importing virtual water, seeking to mitigate the scarcity. The authors highlight the importance of public policies, but all country regions must be analyzed to develop public policies that consider all contexts.
(Duić; Urbaniec; Huisingh, 2015)	Issues related to the supply and storage of water for consumption by the population, industries and agriculture were discussed. In regions where water scarcity exists, mathematical models and life cycle assessment issues can help identify alternatives for these situations. Technological innovations to prevent and reduce water consumption have been drawing the attention of researchers and deserve attention.
(Wehn; Montalvo, 2018)	Based on the findings, there is a lack of related studies on water innovations in recent years. For innovations, it is necessary to work on organizational and individual learning, as they are aspects seen as crucial for innovations to be used properly. Water innovations are essential to maintaining a water-safe world.
(Koop; Van Dorssen;	The main results highlight how individuals become aware of behavioural

Brouwer, 2019)	aspects about the consciousness of water use. Given this importance, managers and public-policy makers need to pay attention to aspects of population awareness.
(Li; See; Chi, 2019)	In the context studied, it was possible to verify an improvement in sustainable growth due to green technological progress. This progress is due to the high investments in research and development to wastewater, increase in the level of schooling and the price of water. Fostering these green technological innovations is necessary for long-term environmental sustainability.
(Nizkorodov, 2021)	When carefully evaluated, public-private partnerships can generate satisfactory results in water resources diversification projects and improve the operations of water distributors. The great challenge of public-private partnerships is economic issues, as both aims are misaligned.
(Mao <i>et al.</i> , 2022)	The period analyzed from 1973 to 2020 on patents on industrial effluent treatment has consistently increased over the years. China stands out as the country with the most patents. Over time, it was observed that from single technologies to combined technologies was developed.
(Castellani <i>et al.</i> , 2022)	From the findings, it was noted that most research deals with recombinant innovation, in which local knowledge is of paramount importance and the external knowledge brought is little explored.
(Kileshye Onema <i>et al.</i> , 2022)	AfriAlliance's proposal is sharing knowledge related to water and climate between Africa and the European Union. This proposal reinforces the importance of contact with innovations and knowledge exchange through the network.

Source: Prepared by the authors (2022).

Concern about water consumption was observed in countries, such as in China (Dong *et al.*, 2014; Li; See; Chi, 2019; Zhang; Platten; Shen, 2011); in Switzerland (Lienert; Schnetzer; Ingold, 2013); in the Mediterranean region (Iglesias *et al.*, 2011); in the United States of America (Nizkorodov, 2021) and on the African continent (Kileshye Onema *et al.*, 2022).

Concerns about water consumption were identified in real estate projects (Zhang; Platten; Shen, 2011); in water resources planning (Lienert; Schnetzer; Ingold, 2013); were discussed about public-private partnerships (Nizkorodov, 2021); in studies related to effluent treatment patents, China stands out as the country with the most patents (Mao *et al.*, 2022), In terms of patent issues, China is seen as an outlier than other countries (Tatum; Leitão Russo, 2020; Yuan *et al.*, 2010). Due to the vital participation of Chinese universities and companies which seek global trends and can collaborate with the Chinese government's public policies (Yuan *et al.*, 2010) in the context of the geography of eco(innovation) (Castellani *et al.*, 2022).

Due to the concern with water consumption, projects related to green technologies and innovations were identified (Duić; Urbaniec; Huisingh, 2015; Li; See; Chi, 2019; Wehn; Montalvo, 2018; Zhang; Platten; Shen, 2011); these technologies related to water reuse and appliances that reduce water consumption (Zhang; Platten;

Shen, 2011). However, to implement these technologies, it is necessary to overcome the barrier of high investments (Zhang; Platten; Shen, 2011). In addition, efforts should be directed towards organizational and individual learning with the proposed innovations (Wehn; Montalvo, 2018).

In addition to technological issues, it is necessary to implement public policies that can preserve water resources and be designed for long-term sustainability (Dong *Et Al.*, 2014; Iglesias *et al.*, 2011; Koop; Van Dorssen; Brouwer, 2019; Lienert; Schnetzer; Ingold, 2013). For this to occur, investment in research and development is necessary (Li; See; Chi, 2019). One of the possible alternatives is to monitor the behaviour of consumers with demand and the rates charged (Dong *et al.*, 2014; Iglesias *et al.*, 2011; Li; See; Chi, 2019); reinforce the importance of public awareness (Koop; Van Dorssen; Brouwer, 2019; Lienert; Schnetzer; Ingold, 2013).

Finally, aspects related to technology transfer deserve the attention of stakeholders due to its importance and because economically less favoured countries may have difficulties in having access to technologies (Iglesias *et al.*, 2011). Technology transfer must be aligned with public policies linked to standards. Therefore, laboratories and universities can effectively serve the population (Barton; Slade; Anderson, 2021).

Knowledge transfer is seen as weak, and the available information is misused by stakeholders or is little explored (Castellani *et al.*, 2022; Iglesias *at al.*, 2011). This knowledge exchange can occur through events related to water innovations (Kileshye Onema *et al.*, 2022). For progress about green technology innovations to occur, it is vital that the level of education of individuals increases (Li; See; Chi, 2019).

Table 4 discusses the research related to specific aspects of water in agriculture, in which five articles have been identified that deal with this theme.

Table 4 – Summaries of the Water in Agriculture Category articles selected chronologically

Authors/Year	Main results
(Alcon <i>et al.</i> , 2014)	With the results obtained, it was possible to note that farmers are willing to pay more for water as long as they guarantee supply for irrigation of their culture. However, farmers are less flexible for institutional actions that can help the government. Farmers well regard issues related to water reuse and water transfer between basins. Finally, it is possible to observe the misalignment between the farmers and the government.
(Iglesias; Garrote, 2015)	The findings discovered that the issues related to technologies make use of the available ones, and technological changes in the long term are not considered. It

	is necessary to reformulate water policies, invest in training farmers and ensure farmers access to financing mechanisms.
(König <i>et al.</i> , 2018)	The research discusses aquaponics, which combines recirculation aquaculture and soilless cultivation. Aquaponics is seen as sustainable technological innovation, but it is necessary to share this knowledge to overcome suspicions about this technology.
(Helmecke; Fries; Schulte, 2020)	The alternative of reusing water in irrigation may be of interest to farmers. However, it is necessary to identify whether this water does not contain chemical contaminants, which could compromise the quality of the products and individuals' health. So that this does not happen, the transfer of knowledge between those involved is necessary for riskless irrigation.
(Ahmed; Turchini, 2021)	The main obstacles related to RAS are high energy consumption and greenhouse gas emissions. RAS is seen mainly in highly developed countries, as it is a complex and expensive system. However, as a positive aspect, RAS can produce large amounts of fish in a smaller water volume than other forms of production.

Source: Prepared by the authors (2022).

Concern about water in agriculture was observed in Spain (Alcon *et al.*, 2014) and Germany (König *et al.*, 2018). The concern of farmers to water is that they lack irrigation of their plantations (Alcon *et al.*, 2014). To prevent this from happening, they are willing to pay more for water, as long as they guarantee supply (Alcon *et al.*, 2014). In addition, small-scale water reservoirs on rural properties can be an alternative for farmers (Iglesias; Garrote, 2015). The alternative of water reuse in irrigation was considered, but it is necessary to verify the existence of chemical contaminants that can compromise irrigation without risks (Helmecke; Fries; Schulte, 2020).

The identified difficulty related to water in agriculture is the lack of alignment between the interests of farmers and the government (Alcon *et al.*, 2014). However, farmers must invest in their training and be aware of technological changes not being considered (Iglesias; Garrote, 2015). A technology that is seen as sustainable is aquaponics, being the combination of pisciculture and the cultivation of soilless culture, but there is distrust about this technology (König *et al.*, 2018).

In addition to the research exposed so far, research was identified in which it directs its attention to pharmaceutical residues in the water. Sustainable technologies are necessary to treat them, and, in some cases, specific technologies are necessary to identify these types of residues. The main techniques used are chromatographic (Oliveira *et al.*, 2020). Recently, due to SARS-CoV2, water managers need to direct their attention, as contamination by water is possible, so it is necessary to optimize processes that can identify whether SARS-CoV2 contaminates the water.

Consequently, public water services must direct their attention to low-income communities with poor sanitation (Langone *et al.*, 2021).

After discussing the 33 articles on the subject of the research, it is observed that the discussion is not exhausted. It is necessary to conduct more research to supply the insights generated from the discussions. Thus, it was possible to present an agenda of future research, the suggestions being:

(i) There was a predominance of studies carried out in China (Binz *et al.*, 2012; Dong *et al.*, 2014; Geng *et al.*, 2013; Li; See; Chi, 2019; Zhang; Platten; Shen, 2011) and in European countries such as Germany (König *et al.*, 2018), Spain (Alcon *et al.*, 2014; Blanco Gálvez; García-Rodríguez; Martín-Mateos, 2009; Downward; Taylor, 2007) and Switzerland (Lienert; Schnetzer; Ingold, 2013). Due to the research concentration in these places, the importance of studies related to water consumption, technology transfer and water reuse in other contexts is understood.

(ii) The predominance of theoretical studies on the subject under study was noted. To better understand the situations experienced in different contexts, more empirical research on the subject is needed.

(iii) Researches that identifies countries that already use a particular technology for water reuse and that identifies countries looking for this technology, those the technology transfer process is monitored deserve the attention of researchers so that it is possible to understand how this should be done. In order to carry out technology transfer to obtain satisfactory levels (Manju; Sagar, 2017).

(iv) Efforts to understand the population to be adept at water reuse in different ways in different contexts deserve the attention of researchers, given the adoption of water reuse is seen as a barrier to be overcome (Mankad; Tapsuwan, 2011).

(v) Direct attention to contexts that already use population awareness about the consumption and water reuse and analyze the population's awareness levels longitudinally from actions taken (Koop; Van Dorssen; Brouwer, 2019).

(vi) Research that analyzes contexts in which water reuse is a reality due to water scarcity is necessary since several studies are carried out in theoretical contexts. That is, water reuse remains an option and not necessarily an obligation of the population (Smith *et al.*, 2018).

(vii) Public policies related to the consumption and water reuse are seen as an essential factor in the face of possible water scarcity. So discussing public policies in different contexts and identifying the costs and potential benefits for the population, in addition to discussing whether these public policies are in line with what the population expects (Alcon *et al.*, 2014; Iglesias *et al.*, 2011).

(viii) Carry out a mapping of water innovations on water treatment and present the costs and benefits generated by these innovations. It would be possible to use these innovations (Wehn; Montalvo, 2018).

(ix) The proposal presented by Skouteris *et al.* (2018) directs attention to sustainable consumption strategies in brick manufacture. It was possible to produce bricks with little water, which is a path several manufacturers should direct their eyes.

It is essential to highlight that even with the discussions held and the proposal for a future research agenda, the field that relates technology transfer and the transfer of knowledge for water consumption and reuse is a fertile field. The discussions are far from finishing.

Finally, this research's practical and managerial implications highlight the importance that public policies impact consumption and water reuse. However, the government's interest in these public policies is essential to consider the population's interest to have effective results. It reinforces the attention managers should have to the population since awareness of water consumption, and water reuse is feasible for effective results. Thus, the section of analysis and discussion of the results ends, and the next section discusses the final considerations of the study.

4 FINAL CONSIDERATIONS

Entering the final considerations, given the different scenarios exposed during the research, it is worth mentioning that the global population must direct efforts to save drinking water in homes, industries, and agriculture. Seeking greater efficiency in processes involving water consumption and reducing water waste are aspects to be considered a priority at the global level (Helmecke; Fries; Schulte, 2020).

In addition, it was possible to answer the proposed research questions. The first one was possible to identify studies that relate the transfer of technologies related to water. The research findings made it possible to identify that the research is related to

promoting water reuse, the concern about water consumption, water in agriculture, and pharmaceutical waste and SARS-CoV2.

Consequently, it was possible to achieve all the aims proposed in the research, and the years with the most publications were 2011, 2018, and 2019. The research of (Miller, 2006) was the highest InOrdinatio index, which is considered the most relevant article. The prominent journals identified were: Journal of Cleaner Production, Journal of Environmental Management and Desalination.

In addition, it was possible to discuss the 33 articles identified in the research, which made it possible to visualize the panorama of research considering the identified categories. From these discussions, it was possible to propose a future research agenda. Finally, some practical managerial implications were regarding the subject under study were discussed. It is reinforced that the present research does not exhaust the discussion on the subject. On the contrary, the intention is to encourage more research to advance its knowledge.

Finally, the present research has the following limitations: (i) only articles that had the InOrdinatio index greater than or equal to 100.0 were analyzed due to this index cut, which may have left research of interest for the present research aside ; (ii) for the categorization and selection of articles, only the titles, abstracts and keywords were read, which may have left out research that could contribute to the research findings and, finally, (iii) the strings used in search engines, and there may be other combinations of keywords.

To the identified limitations, it is suggested as future research: (i) in a new review of the scientific production to analyze all the articles identified over time; (ii) direct efforts to carry out specific reviews for the identified categories, such as a review only on technology transfer for water reuse or a review aiming to identify the technologies that are used for water reuse.

REFERENCES

AHMED, N.; TURCHINI, G. M. Recirculating aquaculture systems (RAS): Environmental solution and climate change adaptation. **Journal of Cleaner Production**, v. 297, p. 126604, 2021.

ALCON, F. *et al.* Adoption of irrigation water policies to guarantee water supply: A choice experiment. **Environmental Science and Policy**, v. 44, p. 226–236, 2014.

ANGELAKIS, A. N.; DURHAM, B. Water recycling and reuse in EUREAU countries: Trends and challenges. **Desalination**, v. 218, n. 1–3, p. 3–12, 2008.

ANGELAKIS, A. N.; SNYDER, S. A. Wastewater treatment and reuse: Past, present, and future. **Water (Switzerland)**, v. 7, n. 9, p. 4887–4895, 2015.

AROMATARIS, E.; PEARSON, A. The Systematic Review : An Overview. **AJN The American Journal of Nursing**, v. 114, n. 3, p. 53–58, 2014.

BARTON, C. J.; SLADE, C. P.; ANDERSON, D. M. Norm Transfer in US Technology Transfer: A Lesson for Policy Makers. **Journal of technology management & innovation**, v. 16, n. 3, p. 35–46, 2021.

BINZ, C. *et al.* Conceptualizing leapfrogging with spatially coupled innovation systems: The case of onsite wastewater treatment in China. **Technological Forecasting and Social Change**, v. 79, n. 1, p. 155–171, 2012.

BLANCO GÁLVEZ, J.; GARCÍA-RODRÍGUEZ, L.; MARTÍN-MATEOS, I. Seawater desalination by an innovative solar-powered membrane distillation system: the MEDESOL project. **Desalination**, v. 246, n. 1–3, p. 567–576, 2009.

BRAME, J.; LI, Q.; ALVAREZ, P. J. J. Nanotechnology-enabled water treatment and reuse: Emerging opportunities and challenges for developing countries. **Trends in Food Science and Technology**, v. 22, n. 11, p. 618–624, 2011.

CASTELLANI, D. *et al.* Greenfield foreign direct investments and regional environmental technologies. **Research Policy**, v. 51, n. 1, p. 104405, 2022.

CORSI, A.; KOVALESKI, J. L.; PAGANI, R. N. Technology Transfer , Anthroptotechnology and Sustainable Development : How Do the Themes Relate ? **Journal of Technology Management & Innovation**, v. 16, n. 4, p. 96–108, 2021.

CURIEL-ESPARZA, J. *et al.* Selecting a sustainable disinfection technique for wastewater reuse projects. **Water (Switzerland)**, v. 6, n. 9, p. 2732–2747, 2014.

DE OLIVEIRA, M. *et al.* Pharmaceuticals residues and xenobiotics contaminants: Occurrence, analytical techniques and sustainable alternatives for wastewater treatment. **Science of the Total Environment**, v. 705, p. 135568, 2020.

DONG, H. *et al.* Uncovering regional disparity of China's water footprint and inter-provincial virtual water flows. **Science of the Total Environment**, v. 500–501, p. 120–130, 2014.

DOWNWARD, S. R.; TAYLOR, R. An assessment of Spain's Programa AGUA and its implications for sustainable water management in the province of Almería, southeast Spain. **Journal of Environmental Management**, v. 82, n. 2, p. 277–289, 2007.

DUIĆ, N.; URBANIEC, K.; HUISINGH, D. Components and structures of the pillars of sustainability. **Journal of Cleaner Production**, v. 88, p. 1–12, 2015.

GENG, Y. *et al.* Creating a “green university” in China: A case of Shenyang University. **Journal of Cleaner Production**, v. 61, p. 13–19, 2013.

HELMECKE, M.; FRIES, E.; SCHULTE, C. Regulating water reuse for agricultural irrigation: risks related to organic micro-contaminants. **ENVIRONMENTAL SCIENCES EUROPE**, v. 32, n. 1, jan. 2020.

IGLESIAS, A. *et al.* Re-thinking water policy priorities in the Mediterranean region in view of climate change. **Environmental Science and Policy**, v. 14, n. 7, p. 744–757, 2011.

IGLESIAS, A.; GARROTE, L. Adaptation strategies for agricultural water management under climate change in Europe. **Agricultural Water Management**, v. 155, p. 113–124, 2015.

KILESHYE ONEMA, J. M. *et al.* Fostering uptake of innovations and solutions for water and climate challenges in Africa: Lessons from the AfriAlliance Knowledge Brokerage Events. **Environmental Science and Policy**, v. 128, n. November 2021, p. 310–316, 2022.

KIM, Y. M. *et al.* Overview of systems engineering approaches for a large-scale seawater desalination plant with a reverse osmosis network. **Desalination**, v. 238, n. 1–3, p. 312–332, 2009.

KIRLIDOG, M. Information technology transfer to a developing country: Executive information systems in Turkey. **Information Technology & People**, v. 9, n. 3, p. 55–84, 1996.

KÖNIG, B. *et al.* Analysis of aquaponics as an emerging technological innovation system. **Journal of Cleaner Production**, v. 180, p. 232–243, 2018.

KOOP, S. H. A.; VAN DORSSSEN, A. J.; BROUWER, S. Enhancing domestic water conservation behaviour: A review of empirical studies on influencing tactics. **Journal of Environmental Management**, v. 247, n. June, p. 867–876, 2019.

LANGONE, M. *et al.* SARS-CoV-2 in water services: Presence and impacts. **Environmental Pollution**, v. 268, p. 115806, 2021.

LI, J.; SEE, K. F.; CHI, J. Water resources and water pollution emissions in China's industrial sector: A green-biased technological progress analysis. **Journal of Cleaner Production**, v. 229, p. 1412–1426, 2019.

LIENERT, J.; SCHNETZER, F.; INGOLD, K. Stakeholder analysis combined with social network analysis provides fine-grained insights into water infrastructure

planning processes. **Journal of Environmental Management**, v. 125, p. 134–148, 2013.

LY, Q. V. *et al.* Characteristics and influencing factors of organic fouling in forward osmosis operation for wastewater applications: A comprehensive review.

Environment International, v. 129, n. March, p. 164–184, 2019.

MANJU, S.; SAGAR, N. Renewable energy integrated desalination: A sustainable solution to overcome future fresh-water scarcity in India. **Renewable and Sustainable Energy Reviews**, v. 73, n. January, p. 594–609, 2017.

MANKAD, A.; TAPSUWAN, S. Review of socio-economic drivers of community acceptance and adoption of decentralised water systems. **Journal of Environmental Management**, v. 92, n. 3, p. 380–391, 2011.

MAO, G. *et al.* Technology status and trends of industrial wastewater treatment: A patent analysis. **Chemosphere**, v. 288, n. P2, p. 132483, 2022.

MILLER, G. W. Integrated concepts in water reuse: managing global water needs. **DESALINATION**, v. 187, n. 1–3, p. 65–75, 2006.

NIZKORODOV, E. Evaluating risk allocation and project impacts of sustainability-oriented water public–private partnerships in Southern California: A comparative case analysis. **World Development**, v. 140, p. 105232, 2021.

ONU, O. DAS N. U. **Plataforma Agenda 2030**. Disponível em: <http://www.agenda2030.org.br/>. Acesso em: 14 jun. 2021.

PAGANI, R. N.; KOVALESKI, J. L.; RESENDE, L. M. Methodi Ordinatio: a proposed methodology to select and rank relevant scientific papers encompassing the impact factor, number of citation, and year of publication. **Scientometrics**, v. 105, n. 3, p. 2109–2135, 2015.

PARAKALA, S.; MOULIK, S.; SRIDHAR, S. Effective separation of methylene blue dye from aqueous solutions by integration of micellar enhanced ultrafiltration with vacuum membrane distillation. **Chemical Engineering Journal**, v. 375, n. June, p. 122015, 2019.

RITCHIE, H.; ROSER, M. **Water Use and Stress**. Disponível em: <https://ourworldindata.org/water-use-stress>. Acesso em: 14 jun. 2021.

SKOUTERIS, G. *et al.* Water footprint and water pinch analysis techniques for sustainable water management in the brick-manufacturing industry. **Journal of Cleaner Production**, v. 172, p. 786–794, 2018.

SMITH, H. M. *et al.* Public responses to water reuse – Understanding the evidence. **Journal of Environmental Management**, v. 207, p. 43–50, 2018.

TATUM, C. T. S.; LEITÃO RUSSO, S. Patent mapping in emerging countries. **Journal of Technology Management and Innovation**, v. 15, n. 2, p. 103–115, 2020.

WEHN, U.; MONTALVO, C. Exploring the dynamics of water innovation: Foundations for water innovation studies. **Journal of Cleaner Production**, v. 171, p. S1–S19, 2018.

WHITTEMORE, R. Analysis of Integration in Nursing Science and Practice. **Journal of Nursing Scholarship**, v. 37, n. 3, p. 261–267, 2005.

WHITTEMORE, R.; KNAFL, K. The integrative review : updated methodology. n. Broome 1993, p. 546–553, 2005.

WISNER, A. 7. Towards an anthropotechnology. X. A new activity for the united nations in the service of economic development: specifying requirements for technology transfers in given geographical and anthropological locations. In: KAPLAN, M. (Ed.). **Cultural Ergonomics**. Advances in Human Performance and Cognitive Engineering Research. [s.l.] Emerald Group Publishing Limited, 2004. v. 4p. 215–221.

YUAN, J. P. *et al.* Patent activity on water pollution and treatment in China-a scientometric perspective. **Scientometrics**, v. 83, n. 3, p. 639–651, 2010.

ZHANG, X.; PLATTEN, A.; SHEN, L. Green property development practice in China: Costs and barriers. **Building and Environment**, v. 46, n. 11, p. 2153–2160, 2011.

Biografia dos Autores

Gustavo Yuho Endo

Professor na Business School Unoeste. Doutorando em Engenharia de Produção no PPGE/UTFPR.

José Hugo Leite Junior

Professor no Instituto Federal do Paraná – IFPR. Doutorando em Engenharia de Produção no PPGE/UTFPR.

Giane Gonçalves Lenzi

Professora da Universidade Tecnológica Federal do Paraná (UTFPR). Doutora em Engenharia Química pela Universidade Estadual de Maringá (UEM).

João Luiz Kovaleski

Professor da Universidade Tecnológica Federal do Paraná (UTFPR). Doutorado em Instrumentação Industrial - Université de Grenoble I (Scientifique Et Medicale - Joseph Fourier).



Artigo recebido em: 26/06/2023 e aceito para publicação em: 15/08/2023

DOI: <https://doi.org/10.14488/1676-1901.v23i2.4929>