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Articles

Bottled water consumption in Mexico in view of a circular economy

Consumo de agua embotellada en México ante una economía circular

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Abstract

The objective *is* to analyse bottled water consumption in Mexico in view of a circular economy. The paper evaluates the rates of bottled water consumption and the key causal factors. Furthermore, it compares the role played by the private and public sectors in exacerbating demand for bottled water. The paper implemented a systematic review that identified articles mainly from the Web of Science and Scopus databases from November 01 to December 31, 2022. There were utilised three strategies for the search process, including keying in free-text words, implementing Boolean operators, and citation searching. The systematic review was conducted in line with the PRISMA statement/methodology. Forty-eight articles were identified after the complete search. The summations direct that bottled water consumption is high in Mexico due to the below-par conventional drinking water supply. Most customers cited organoleptic and health reasons as key factors influencing their preference for bottled drinking water. Conversely, the demand for bottled water contributes to high Polyethylene Terephthalate bottles, which contribute to environmental degradation. The implementation of the circular economy can reduce the associated negative effects through decreasing and optimization strategies. There were conglomerates findings from various articles while defining the key gaps and areas for improvement. The paper is seminal in bridging the dearth of knowledge on the circular economy and its application in the water industry while providing recommendations for policymakers.

Keywords: Bottled water consumption, circular economy, demand, health, mega corporations, supply.

Resumen

El objetivo es analizar el consumo de agua embotellada en México con miras a una economía circular. El documento evalúa las tasas de consumo de agua embotellada y los factores causales clave. Además, compara el rol que juegan los sectores público y privado en la exacerbación de la demanda de agua embotellada. El documento implementó una revisión sistemática que identificó artículos principalmente de las bases de datos Web of Science y Scopus del 1 de noviembre al 31 de diciembre de 2022. Se utilizaron tres estrategias para el proceso de búsqueda, incluida la introducción de palabras de texto libre, la implementación de operadores booleanos y búsqueda de citas. La revisión sistemática se realizó de acuerdo con la declaración/metodología PRISMA. Cuarenta y ocho artículos fueron identificados después de la búsqueda completa. Los resúmenes indican que el consumo de agua embotellada es alto en México debido al suministro de agua potable convencional por debajo de la media. La mayoría de los clientes mencionaron razones organolépticas y de salud como factores clave que influyeron en su preferencia por el agua potable embotellada. Por el contrario, la demanda de agua embotellada contribuye a las botellas con alto contenido de tereftalato de polietileno, lo que contribuye a la degradación ambiental. La implementación de la economía circular puede reducir los efectos negativos asociados a través de estrategias de reducción y optimización. Se agruparon los hallazgos de varios artículos mientras se definieron las brechas clave y las áreas de mejora. El documento es fundamental para salvar la escasez de conocimiento sobre la economía circular y su aplicación en la industria del

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agua, al tiempo que proporciona recomendaciones para los responsables de la formulación de políticas.

Palabras clave: consumo de agua envasada, economía circular, demanda, salud, megacorporaciones, oferta.

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Introduction

Ever since the turn of the century, the international community has placed primal emphasis on the need to guarantee equivalent access to clean drinking water for every person. According to the UN Women (2022), achieving universal access to affordable drinking water is seminal in driving society in the right direction. Even though some governments have initiated the requisite framework to attain the sustainable development goal, there seem to be some nations that lag (UN Women, 2022). Mexico is a prime cautionary tale and example of a nation that has thus far failed in its ameliorative mandate to provide its people with collective and impartial access to drinking water (Biswas & Uitto, 1999). Statistical data derived from Macrotrends (2022) reports that the percentage of people with access to drinking water in 2019 was 43.03 %. This was an increase from the previous 42.94 % reported in 2018, which leaves over 50 % of the population facing water shortage (Macrotrends, 2022). A prescriptive review of the water situation and infrastructure in

the country reveals that it has insufficient water sources, which cannot cater to the needs of the population. Considering this, a staggering sixty-five million people are faced with water scarcity which predisposes them to the consumption of bottled water (The Borgen Project, 2022).

Bottled water consumption in Mexico has become a subject of numerous works of erudition, with scholars and practitioners connecting the demand to the lack of effective water infrastructure. Greene (2014) defines bottled water as the commodification of water which renders water the requisite mobility and profitability. A comparative analysis of Mexico's bottled water and municipal water systems reveals that the former is consumed at high levels. Estrada (2016) adumbrates that Mexico consumes at least 12 % of the global volume of bottled water. Statistical data by the authors shows that Mexicans consumed close to 253 litres of bottled water per person in 2014. This rate is high compared to the 94.3 litres reported by people in Europe and the 37 litres per person consumed by the international community (Estrada, 2016).

We package most of the bottled water in Mexico using Polyethylene Terephthalate, which is lauded by some as environmentally friendly but also a risk to the environment (Packaging Europe, 2022; WtERT, 2022). The Canadian Beverage Association (2022) highlights that PET bottles are valuable and crucial in creating a circular recycling economy. On the contrary, their value is yet to be realised in Mexico due to the lax water laws and lack of emphasis on environmental protection (Canadian Beverage Association, 2022; Greene, 2014). The high level of bottled water consumption has, however, been associated with a spike in

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pollution, especially from the production of bottles. Furthermore, the bottles are disposed of in the environment, contributing to degradation.

The burgeoning pollution problem amid high consumption necessitates a shift towards embracing a circular economy in Mexico. The circular economy is a systems solution that targets production and consumption to handle global challenges like pollution, waste, and climate change (Haigh, 2022; Heshmati, 2015; Klein, Ramos, & Deutz, 2020; Korhonen, Nuur, Feldmann, & Birkie, 2018). In the Mexican context, the circular economy draws attention to water as an indispensable element for life sustenance (The World Bank, 2021). Currently, there is a dearth of knowledge about how the circular economy ideologies can be applied in Mexico in response to the existent rectilinear framework of "take, make, consume and waste" (Vickers, 2019; Ekins *et al*., 2019; Geissdoerfer, Savaget, Bocken, & Hultink, 2017). Moreover, the Mexican water sector has been excluded from vital consultations regarding the circular economy due to the risk the concept poses on the conventional companies in the bottling industry like Coca-Cola and the like.

The overarching objective of this study is to conduct a systematic review of bottled water consumption in Mexico in view of a circular economy. The research explores divergent works of erudition that focus on the circular economy, with connections drawn with the rising level of bottled water consumption (Sartal, Ozcelik, & Rodríguez, 2020). The research utilises the PRISMA methodology to narrow down the requisite papers that can be used to inform the topic. Subsequently, the paper is divided into the methodology, results, discussion, and conclusions. The research also provides recommendations to the bottled water industry

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and the Mexican society at large on how they can reduce pollution, increase conservation, and ensure equal access to clean water as per sustainable development goal 6.

Methodology

The novel stature of the research topic required an in-depth evaluation of the seminal gaps in research regarding bottled water consumption in Mexico in view of a circular economy. It was chosen a systematic review due to its seminal focus on a clearly formulated research question (Gopalakrishnan & Ganeshkumar, 2013). The systematic review involves using systematic and explicit methods to identify, define and assess research (Levett, 2022; Mallett, Hagen-Zanker, Slater, & Duvendack, 2012; Martinic, Pieper, Glatt, & Puljak, 2019). The research utilised the PRISMA statement, which helped break down the literature identification process into a series of steps (Figure 1). Systematizing the findings of an investigation using the PRISMA methodology is crucial to ensure a thorough and transparent presentation of systematic reviews and meta-analyses. The PRISMA statement provides a standardized set of elements that researchers must adhere to when reporting their results (Pollock & Berge, 2018; Tawfik *et al*., 2019).

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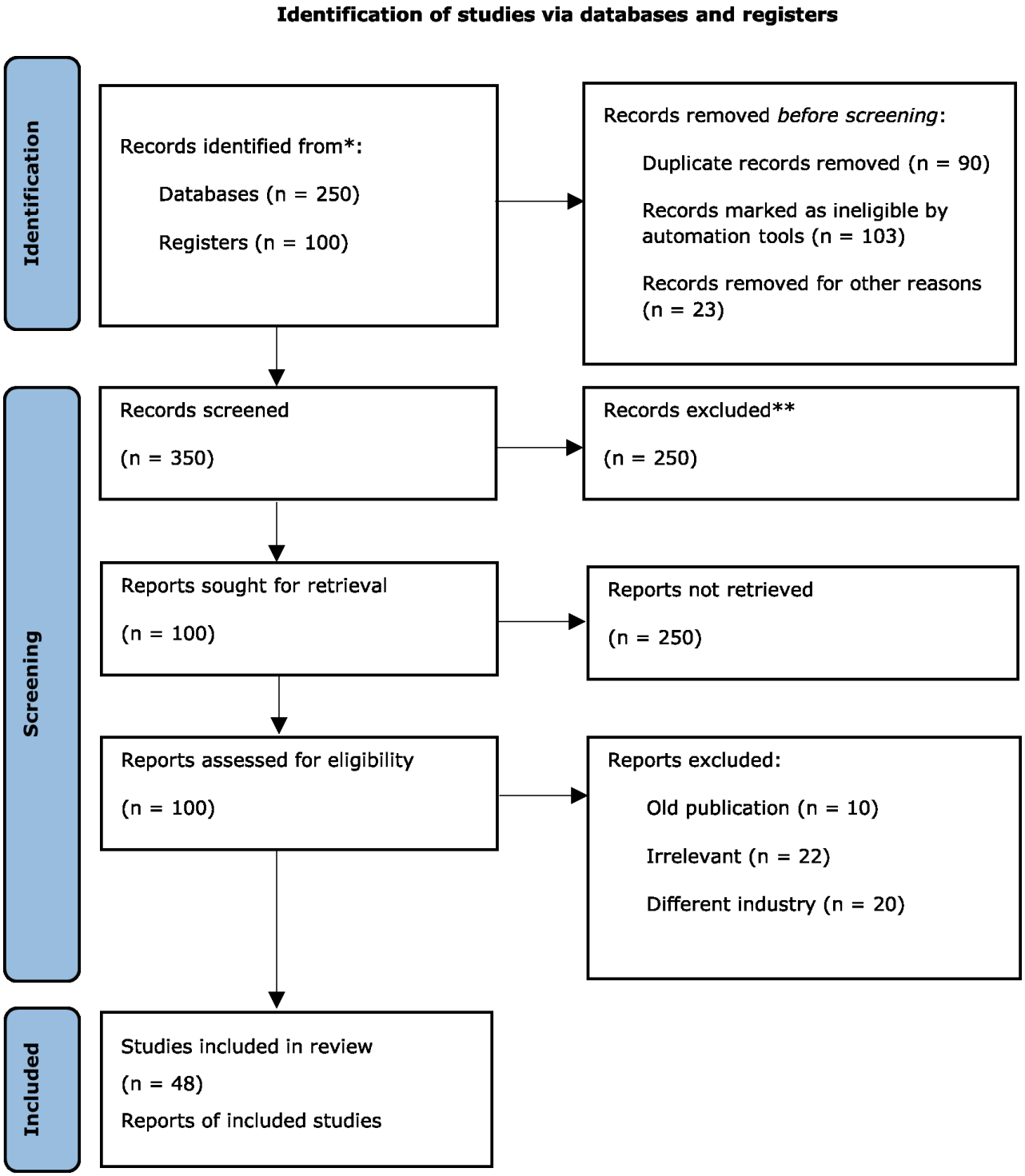

Figure 1. PRISMA flowchart.

According to the PRISMA guidelines, researchers need to follow a 27-item checklist and a 4-phase flow diagram to present their systematic reviews and meta-analyses accurately. This checklist and flow diagram are designed to enhance the quality and credibility of the research, allowing readers to assess the strengths and weaknesses of the review, and enabling the replication of review methods if needed (Pollock & Berge, 2018; Tawfik *et al*., 2019).

The first step involved identifying and defining the research question. There were noted gaps in research regarding the circular economy and its application in the bottled water industry. Considering this, it was developed a research question that focused on answering "what is the state of bottled water consumption in Mexico in view of the circular economy?" The research question played a major role in narrowing the scope of the review and guiding in identifying and critically appraising the necessary data sources.

The second step in the PRISMA statement involved defining the search strategy. We searched mainly the necessary articles through the Web of Science and Scopus databases from November 01 to December 31, 2022. The search process involved keying in free-text words, including "Mexico bottled water consumption", "service quality", "circular economy", "pollution", and "Polyethylene Terephthalate". The subject terms and keywords were mixed, thereby expanding the final number of articles identified (Pollock & Berge, 2018; Tawfik *et al*., 2019).

The search strategy involved using Boolean operators to combine the search terms. The two databases provided Boolean operators in their

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drop-down menus, which improved the search process (The University of Tasmania, 2022). The key search terms that were involved in this strategy involved "Mexico and bottled water consumption," "bottled water consumption and pollution," as well as "bottled water or municipal water". The Boolean operators' search strategy was complemented with citation searching, whereby there were identified articles that other authors had cited. The citation searching was substantial in finding more recent papers on the circular economy, considering its novelty.

The citation searching guided the research in understanding how the concept has been confirmed, improved, applied, extended, or corrected in divergent economies (Wright, Golder, & Rodriguez-Lopez, 2014). Throughout the search process, there were applied limits intending to narrow results for article retrieval. The research limited the search by focusing on the article/publication type, publication dates, and subject.

The third step in the PRISMA statement was correlated with the search limit strategy mentioned prior. In this step, the research set up eligibility criteria which helped in the selection process. The eligibility criteria contain both an inclusion and exclusion criterion. The inclusion criterion required that every article is published between 2000 and 2022. The main reason it sets the publication date or year range is that the circular economy came into conception in the 21st century. The concept was formulated in line with the sustainable development goals; ergo, it was substantial to find recent articles to understand how it is applied.

The articles used in the final study were supposed to be written in English. Additionally, the research included articles that explored the pollution levels associated with the production of bottles. On the other

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hand, the exclusion criterion removed any articles that did not focus on water consumption in Mexico.

The fourth step in the PRISMA statement/methodology involved the selection of the articles. The step initially involved reviewing the title and abstract for every research to determine its applicability based on the eligibility criteria. Before commencing the title screening, there were removed the duplicate records (Martinic *et al*., 2019). After that, three reviewers were included in the screening process who checked the titles to determine their acceptability.

The selection process also involved analysing the introduction and full text. The main reason for focusing on the introduction was to determine if the authors could provide information about the topic. Furthermore, the full-text analysis involved checking if the provided information is viable and applicable to answer the research question. The research avoided previous meta-analyses and focused on journal articles, websites, and policy papers since they provided information that could be used to bridge the existent dearth of knowledge.

The final step involved data extraction, with the research utilizing critical dimensions to categorise each article. The articles were classified according to the title, document type, authors, and main findings, as shown in Table 1. The critical dimensions also helped define the validity, quality, and ingenuity of the articles while reducing the risk of bias. Qualitative data synthesis that helped the research identify the theme and content also complemented the extraction (Mallett *et al*., 2012). The themes from each paper were conglomerated and written down to be discussed in the next section.

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Table 1. Selected Literature.

Title	Type of document	Authors	Comments on main findings
Impulsa cólera agua embotellada	Article	Zapata (2000)	The article explores the increased demand for bottled water due to the health risk related to municipal drinking water. The demand is correlated with a surge in the consumption of PET bottles.
Fluoride concentration of bottled water, tap water, and fluoridated salt from two communities in Mexico	Journal article	Martínez-Mier Martínez-Mier, Soto-Rojas, Buckley, and Zero (2005)	The authors adumbrate that bottled water consumption has been accentuated in the nation due to the increase of fluoride compounds in tap water.
Plastic water bottles should no longer be a wasted resource	Article	Franklin (2006)	The article shows that plastic water bottles can be recycled and reused, thereby minimizing increased environmental pollution.
A battle against the bottles: Building, claiming, and regaining tap-water trustworthiness	Journal article	Parag and Roberts (2007)	Parag and Roberts highlight that bottled water consumption is correlated with an increase in pollution, especially in the production, transportation, and storage phases.
Minerals in drinking water: Impacts on taste and importance to consumer health	Journal article	Whelton, Dietrich, Burlingame, Schechs, and Duncan (2007)	The article shows that increased consumption of specific minerals and compounds in bottled water can contribute to long-term health issues.
Danone Bonafont	Article	Danone Group (2009)	The article explores the advent of renowned companies like Danone into the Mexican market after the gap in service caused by the conventional water supply system.

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Title	Type of document	Authors	Comments on main findings
Hydrocarbons derived from petroleum in bottled drinking water from Mexico City	Journal article	Vega *et al*. (2011)	The authors highlight that bottled water production is linked with a surge in the risk of health issues. In most cases, people who consume bottled water are at risk of exposing themselves to aliphatic hydrocarbons and polycyclic aromatic hydrocarbons.
Mexico's water war	Article	Castano (2012)	The article explores the role played by the government in shifting demand towards bottled water due to the issues and complexities in the conventional water supply system.
Bottled-water habit keeps tight grip on Mexicans	Article	Malkin (2012)	The article expatiates that the high demand for bottled water is correlated with increased health concerns.
exploring beliefs about bottled water and intentions to reduce consumption: The dual-Effect of social norm activation and persuasive information	Journal article	Linden (2013)	Linden indicates that the rise in demand for bottled water has caused a spike in PET-associated environmental pollution and degradation.
Life cycle assessment of PET bottle recycling: A case study for Mexico	Article	Nogueda (2013)	The article explores the negative impact of PET bottle production and how it can be negated through recycling processes.
Mexico's bottled water addiction	Article	Webber (2013)	The article shows that most Mexicans are paying more to gain access to bottled water.
The Bottled Water Industry in Mexico	Article	Greene (2014)	The article explores the growth of the industry amid shifts in demand and supply.

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Title	Type of document	Authors	Comments on main findings
Water at the heart of the circular economy	Policy paper	Veolia (2014)	The results indicate that the circular economy hinges on the water for efficiency.
Bottled water consumption up in Mexico	Article	Bnamericas (2015)	The article highlights that the rise in consumption is because of inefficient water supply systems.
Drinking water quality in a Mexico City university community: Perception and preferences	Journal article	Espinosa-García *et al*. (2015)	The author denotes that the surge in demand for bottled water is associated with health and organoleptic reasons.
A Shared vision for the Cutzamala System: A model basin in water management	Article	National Water Commission, Engineering Institute of the National Autonomous University of Mexico, Mexican Institute for Water Technology, and The World Bank (2015)	The article explores the existent water supply system in Mexico.
Circular economy and the opportunity cost of not 'closing the loop' of the water industry: The case of Jordan	Journal article	Abu-Ghunmi, Abu-Ghumni, Kayal, and Bino (2016)	The journal article denotes that the circular economy is seminal in reducing the inefficiencies caused by the existing system.
Water in Mexico: A human right, bottled	Article	Estrada (2016)	The article evaluates how bottled water has become a norm in Mexico, with the government not providing the people with the necessary access to safe drinking water.

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Title	Type of document	Authors	Comments on main findings
Water utility pathways in a circular economy	Policy paper	IWA (2016)	The article explores the application of circular economy principles for water utilities.
PetStar PET bottle-to-bottle recycling system, a zero-waste circular economy business model	Article	Cámara-Creixell and Scheel-Mayenberger (2019)	The article analyses the strides made by PetStar in implementing a circular economy that reduces the deleterious effects of bottled water on the environment.
Tap *versus* bottled water consumption: The influence of social norms, affect and image on consumer choice	Journal article	Etale, Jobin, and Siegrist (2018)	The authors highlight that most people prefer bottled water because it provides safety and convenience compared to tap water.
Bottled water in Mexico: The rise of new access to water paradigm	Journal article	Greene (2018)	The article shows that the rise in demand for bottled water in Mexico is correlated with the declining efficiency of the traditional water system.
Energy recovery from the water cycle: Thermal energy from drinking water	Journal article	Van Der Hoek *et al*. (2018)	The article argues that there is a need for water utilities to implement the necessary infrastructure that can reduce energy consumption during the production of bottled water.
Barriers and drivers in a circular economy: The case of the built environment	Journal article	Hart, Adams, Jannik, Tingley, and Pomponi (2019)	The findings cite that the circular economy's efficiency is marred by regulations.
Mexico leads the world in per-capita consumption of bottled water	Article	Mexico News Daily (2019)	The article highlights that Mexican customers are leading the world when it comes to the demand and supply of bottled water.
Market opportunities on circular economy in Mexico	Policy paper	Netherlands Enterprise Agency (2019)	The article shows that the Mexican economy is ripe for the circular economy as long as the

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Title	Type of document	Authors	Comments on main findings
			necessary regulations and infrastructure are put in place.
(Re) theorizing the politics of bottled water: Water insecurity in the context of weak regulatory regimes	Journal article	Pacheco-Vega (2019)	The article shows that the demand for bottled water in Mexico is correlated with a surge in water insecurity.
PET-bottled water consumption in view of a circular economy: The case study of Salento (South Italy)	Journal article	Gambino *et al*. (2020)	The authors highlight that there is a need for water utilities to reduce bottled water consumption and signify a shift towards tap water so as to implement a circular economy.
Microbiological quality of bottled water obtained from Mexican small water purification plants: a pilot study, carried out in Morelia (Central Mexico)	Journal article	Soria-Herrera *et al*. (2020)	The article shows that bottled water contains compounds that can negatively harm the health of consumers.
Plastic pollution in Mexico	Policy paper	UNEP (2022)	The article explores the increase in pollution caused by plastic water bottles.
The bottled water industry & environmental sustainability	Article	Culora (2021)	The author denotes that it is imperative for the water industry to apply sustainable processes which will reduce pollution associated with bottled water consumption.
The potential risk of BPA and phthalates in commercial water bottles: A minireview	Journal article	Da Silva-Costa *et al*. (2021)	The authors contend that the production and consumption of bottled water are connected with an increase in the risk of exposure to bisphenol and phthalates.

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Title	Type of document	Authors	Comments on main findings
Water in circular economy and resilience	Policy paper	Delgado, Rodriguez, Amadei, and Makino (2021)	The article highlights that implementing a circular economy will increase resilience and reduce the problems associated with water shortages.
Enhancing a transition to a circular economy in the water sector: The EU project WIDER UPTAKE	Journal article	Mannina *et al*. (2021)	The author opines that the circular economy is influenced by regulatory conditions imposed by domestic and international agencies.
A systemic view on circular economy in the water industry: Learnings from a Belgian and Dutch case	Journal article	Mbavarira and Grimm (2021)	The article recommends the adoption of the 6Rs in the circular economy to improve efficiency.
Circular economy in Mexico	Article	Munoz-Melendez, Delgado-Ramos, and Diaz-Chavez (2021)	The article shows that the circular economy in Mexico is relatively new, with the current policies being ineffective.
Bottled water sales rose globally as the pandemic took hold	Article	Broom (2022)	The article shows that the occurrence of the coronavirus pandemic caused a surge in demand for bottled water in Mexico, thereby undermining the tap water supply.
Polyethylene terephthalate (PET) bottle-to-bottle recycling for the beverage industry: A review	Journal article	Benyathiar, Kumar, Carpenter, Brace, and Mishra (2022)	The authors argue that the recycling processes of PET bottles can help decrease the associated pollution rates and concerns.
Bottled water - sustainable solutions for a circular economy	Article	Canadian Beverage Association (2022)	The author argues that the introduction of sustainable solutions, such as recycling processes, can help support the circular economy.

Title	Type of document	Authors	Comments on main findings
Advances in polyethylene terephthalate beverage bottle optimization: A mini review	Journal article	Ge-Zhang *et al*. (2022)	The authors argue that there is a need to optimise plastic bottle production processes in order to reduce pollution.
Circular economy of water: definition, strategies, and challenges	Journal article	Morseletto, Mooren, and Munaretto (2022)	The article defines the circular economy as it relates to the water industry.
How will the PET industry deliver its sustainability targets?	Article	Packaging Europe (2022)	The article shows that the PET industry will attain sustainability through the introduction of recycling and reuse strategies in its processes.
The horrific scam that water billionaires are running on poor countries	Article	Pearson (2022)	The article shows that major companies exploit the poor in Mexico by selling them bottled water derived from their water sources.
Water-smart circular economy – Conceptualisation, transitional policy instruments, and stakeholder perception	Journal article	Salminen *et al*. (2022)	The authors argue that the circular economy can be enhanced through effective policies and stakeholder involvement.
Coca-Cola in Mexico breaks the ban on the use of PET in bottles	Article	Sanlucar-Chirinos (2022)	The article highlights that the major beverage companies in Mexico flout the environmental protection rules and contribute to increased pollution rates in the nation.

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Title	Type of document	Authors	Comments on main findings
Implementing a circular economy in Mexico through PET recycling	Article	WtERT (2022)	The article explores the use of recycling solutions to implement a circular economy. The author shows that recycling helps reduce the levels of pollution in the environment.
Utilization of plastic waste as an eco-friendly construction material	Journal article	Zainuri, Yanti, and Megasari (2022)	The article highlights that reusing plastic bottles can help minimise environmental pollution.

Results

The PRISMA statement and methodology helped the research identify 350 articles during the search process. The selection process narrowed down the list to 48 articles, as shown in Figure 1 and Table 1. The articles were evaluated conclusively, with the identification of the gaps to be filled concerning water consumption in Mexico.

Discussion

Bottled Water Consumption in Mexico

According to Bnamericas (2015), Mexico is the number one nation renowned for its heavy consumption of bottled water, with each person consuming at least 67gl on an annual basis. The findings are backed by Soria-Herrera *et al*. (2020), who alludes that the nation accounts for 9 % of the global volume, which translates to 9.5 billion. The average intake in Mexico went from "64.5 gals in 2013 to 72.4 gal in 2020" (Soria-Herrera

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et al., 2020). The increase in consumption was correlated to a surge in demand due to the coronavirus pandemic in the latter year (Soria-Herrera *et al*., 2020). Broom (2022) reports that bottled water sales increased by 140 %, which is higher than in previous years. Furthermore, it was showed that the percentage of income spent by low-income households on bottled water rose from 15 to 36 %, which in turn contributed to the success of the water bottling industry (Broom, 2022). Furthermore, the success was correlated with a large influx in water purification plants, with most being small businesses that sterilise, bottle, and distribute water to the locals in 20 l jugs (Water.org, 2022). Soria-Herrera *et al*. (2020) argue that the 20 l jug size is purchased by 98 % of Mexican households. Broom (2022) reports that the rise in the consumption of water in 2020 contributed to the shift in the sizes of the bottles purchased. The locals resorted to purchasing the 20 l and 10 l containers since convenience markets, street vendors, and bars had closed operations during the pandemic.

In most cases, Mexican people purchase bottled water due to the perception that it is devoid of bacteria and impurities (Espinosa-García *et al*., 2015). The perception is also correlated with the fact that people surmise that bottled water is handled better compared to public water. Broom (2022) collected qualitative data from locals, with most of them arguing that bottled water was handled as private property; thus, the quality was better compared to tap water. Vega *et al*. (2011) dispute this assumption by noting that bottled water in Mexico poses a similar or higher risk than tap water. Bottled water contains hydrocarbons and fluoride, which exposes consumers to a wide range of health issues. Da Silva Costa *et al*. (2021) concur with this notion by highlighting that the

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bottles have phthalates and bisphenol, which are associated with negative estrogenic effects. In most cases, a spike in the consumption of oestrogens can lead to digestive system issues and increased healthcare costs (Whelton *et al*., 2007).

The surge in the consumption of bottled water has thus far created a new problem in Mexico in the form of pollution (Greene 2014; Greene 2018). Nogueda (2013) opines that plastics account for 10.9 % of municipal solid waste in the nation, with the rate increasing over the years. Out of the 10.9 %, at least 10 % is made up of Polyethylene terephthalate (PET) products which are produced locally. There were 90 PET bottle companies in Mexico as of 2013, which produced between 700 and 800 tons of bottles per year (Nogueda, 2013). Nogueda (2013) highlights that the amount of PET is likely to grow due to increased consumption at an annual rate of 13 %.

The growing consumption is also attributed to the fact that water coming from municipal pipes and the national water system is not possible. The lack of mobility and convenience inadvertently predisposes people to consume bottled water. Another major variable is that Mexico is the biggest soft drink consumer per capita in the world (Nogueda, 2013). Comparative analyses reveal that each Mexican consumes a total of 163 litres annually and discards up to 8.7 kilograms of Polyethylene terephthalate (Nogueda, 2013; WtERT, 2022). The enormous consumption combined with the lack of recycling awareness has, in turn, turned polyethylene terephthalate bottles into a national environmental problem (UNEP, 2022; IWA, 2016). There are millions of bottles that are disposed of on roads and public places, which endanger wildlife and

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degrade the environment. The PET bottles have also been associated with the clogging of sewage systems which causes floods and the seeping of sewage into the conventional drinking water supply system.

Nogueda (2013) reports that the national PET recycling rate is set at 6.7 %, which is quite low considering the high consumption of bottled water. The low recycling is correlated with lax laws and regulations, which allow for companies like Danone and the Coca-Cola group to produce and sell bottled water with no hassles. Danone made its way into the Mexican market in 1992, with the company setting up a production plant that derived water from the springs (Danone Group, 2009). The company has thus far grown to become the main beverage sector machine manufacturer for packaging solutions and bottled water. It is imperative to note that Danone's entry into the market came when the nation was reeling from the deleterious effects of the cholera outbreak (Castano, 2012; Zapata, 2000). The surge in cholera cases forced people to shift from traditional water sources to bottled water. Additionally, Coca-Cola had already set up operations in the nation with a favourable regime allowing it to break the ban on the use of PET in bottles. Sanlucar-Chirinos (2022) denotes that at least 200 bottles are produced by Coca-Cola for every citizen annually. Out of the 200, 52.8 % are for soft drinks and 17 % for water (Sanlucar-Chirinos, 2022). The 17 % for bottled water is a huge number because Mexico produces 300 million tons of plastic annually, with only 3 % being recycled (Sanlucar-Chirinos, 2022).

Pearson (2022) goes further to argue that mega-corporations like Danone and Coca-Cola have thus far used the market gaps and demand to their advantage. The companies make 494 times more than they spend

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by bottling water in Mexico (Pearson, 2022). The bottled water is then sold back to the locals, who have no other choice but to purchase it (Salminen *et al*., 2022; Netherlands Enterprise Agency, 2019). The cycle creates a milieu whereby the mega corporations produce bottles that are consumed and dumped into the water sources and the environment (Salminen *et al*., 2022; WtERT, 2022; Packaging Europe, 2022). The Mexicans give the major bottling corporations at least 66 billion dollars a year, with the companies extracting over 133 billion litres of water (Pearson, 2022).

Gambino *et al*. (2020), and Parag and Roberts (2009) show that the choice of drinking water is correlated with increased environmental pollution. The two journal articles show PET bottles have chemical stability, making them highly resistant to biodegradation. The bottles take up to 500 years before they can degrade, with their slow degradation contributing to waste accumulation (Gambino *et al*., 2020). To make matters worse, PET bottle production requires intensive energy levels, with one bottle using up to 100 MJ of energy. The subsequent phases, sealing, bottling, or transport, use energy levels ranging from 5.6 to 10.2 MJ l^{-1} (Gambino *et al*., 2020).

Bottled water consumption and the circular economy

The circular economy is a novel concept in Mexico, with the government and regulators seemingly unaware of what it entails. A prescriptive review of the regulatory infrastructure in Mexico reveals that the Congress of the State of Oaxaca launched a reform in 2019 aimed at promoting the circular economy (Sanlucar-Chirinos, 2022). The reform targeted the use

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of PET bottles for bottled water while banning their production and subsequent marketing. Furthermore, the government set up a one-year transitional period for the organizations in the water industry to comply, which they did not do primarily due to the high demand and profits associated with bottled water (Sanlucar-Chirinos, 2022).

A comparative analysis of the circular economy reform launched by Mexico and the universally accepted version reveals stark differences. According to Delgado *et al*. (2021), the circular economy is based on the UN 2030 agenda, which indicates that nations must meet the objectives of economic, social, and environmental sustainability together. On the other hand, Mexico's reform focused on attaining the objectives separately, with the lack of commitment between the public and private sector leaders creating a gap for the mega-corporations to exploit (Delgado *et al*., 2021).

Considering the surge in demand, there is a need for the Mexican government to use the circular economy to transform consumption patterns and decouple economic growth associated with water exploitation by mega-corporations (Malkin, 2012; Linden, 2013; Zainuri *et al*., 2022). The circular economy is a viable alternative to most nations' business-as-usual or linear model. In this approach, bottled water consumption will be explored in three pathways: water, energy, and materials (Sehnem, Vazquez-Brust, Pereira, & Campos, 2019; Valavanidis, 2018; Wautelet, 2018). The water pathway focuses on improving bottled water quality, thereby reducing the risk of hydrocarbons, fluoride phthalates, and bisphenol (Martínez-Mier *et al*., 2005). On the other hand, the energy pathway involves reducing the

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amount of energy used in production, sealing, bottling, or even transport. Culora (2021) indicates that the circular economy can also allow bottled water production companies to shift towards supply-based changes. The changes are implemented with conservation in mind, whereby cutting-edge technologies help plants reduce their environmental impact (Abu-Ghunmi *et al*., 2016). The plants can shift towards LED or automated lighting, decreasing the energy used for lighting purposes. The materials pathway is focused on reducing the harmful and non-biodegradable materials used in the production of PETs. Culora (2021) and the United Nations Environmental Program (UNEP, 2022) denote that bottled water companies should use plastic containers that are 100 % recyclable, including the cap. Using recyclable materials will ensure a decline in the amount of waste in the environment.

Delgado *et al*. (2021) expatiate that the circular economy adopts a systems perspective and mimics the natural water cycle. The economy avoids water utilization and closes loops by minimizing waste and emphasizing the 6 Rs of reduce, reuse, recycle, replenish, recover, and retain (Van Der Hoek *et al*., 2018; Netherlands Enterprise Agency, 2019; Hart *et al*., 2019). The Mexican system has been designed in a linear manner which introduces negative externalities and causes immense impacts on the natural resources. By adopting the circular economy, the government will preserve and enhance the natural capital (water) by introducing regenerative practices (Franklin, 2006). Furthermore, it will ensure that the mega-corporations mitigate emissions of greenhouse gases through improved and energy conducive operations.

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Morseletto *et al*. (2022), however, dispute the use of the traditional circular economy strategy coined by Van Der Hoek *et al*. (2018) as well as Delgado *et al*. (2021). The authors highlight that the traditional conception of the circular economy refers to general resources and types of industrial production that do not entirely fit the water context. Morseletto *et al*. (2022) allude that focusing on the circular economy's repair, refurbishing, and remanufacturing prongs targets manufactured products while repurposing focuses on discarded products. Considering this, there is a need for the bottled water industry to recalibrate some of the strategies and ensure that they are specific to the consumption rates. The proposed model focuses on rethinking bottled water consumption in Mexico (Morseletto *et al*., 2022).

Morseletto *et al*. (2022) allude that the circular economy needs to reconfigure and reconceptualize how water is consumed. In Mexico, rethinking means restructuring the operative aspects of water production and consumption while emphasizing policies and processes. The circular economy is lauded for its role in causing transformational changes that influence consumption from the individual to the national level.

The rethink component is an overarching strategy that provides guidance and content to governments and private companies while creating synergistic links between them. The rethink component is divided into three aspects, namely "decrease," "optimize," and "retain" (Pacheco-Vega, 2019; Morseletto *et al*., 2022).

The first aspect, "decrease," explores key strategies like avoiding, reducing, or replacing. Morseletto *et al*. (2022) highlight that the avoidance strategy is seminal in preventing water use. This strategy can

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be applied in the Mexican context to prevent increased reliance on bottled water and decreased confidence in the traditional water supply system. The strategy is commingled with reducing consumption which means using less bottled water. The reduction strategy will allow the locals to balance between tap and bottled water (Etale *et al*., 2018). Furthermore, it will play a major role in reducing the amount of income spent by people on bottled water. As it stands, the average Mexican spends about $1.07 or 14.28 dollars on bottled water which is higher than the global average line (National Water Commission *et al*., 2015; Webber, 2013; Mexico News Daily, 2019).

Moreover, the minimum wage in the nation is set at 3.65 dollars; thus, not every denizen can buy bottled water line (Webber, 2013; Mexico News Daily, 2019). The next strategy is replacement, whereby the government can replace the demand for bottled water with tap water. The only way to attain this is by improving the service quality and efficiency of the conventional drinking water supply system. Furthermore, this can be attained by increasing confidence among the people regarding the system, thereby reducing the organoleptic and health reasons associated with tap water (Estrada, 2016; IWA, 2016; Veolia, 2014).

Morseletto *et al*. (2022) introduce the second aspect of optimization, which involves devising strategies to use plastic bottles more efficiently and intensively. This aspect contains two strategies, namely, reuse and recycle. The reuse strategy is substantial in the management of PET bottles especially considering the slow adoption of the reforms mentioned above. Instead of disposing of them in the environment, people can be trained and informed on how to reuse the bottles (Benyathiar *et al*., 2022;

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Ge-Zhang *et al*., 2022). Culora (2021) recommends using 100 % recycled PET plastic (Rpet) to reduce pollution and biodegradation cycles. The reuse strategy is linked with recycling, whereby the bottles can be returned to the factories where they will be remanufactured (Mannina *et al*., 2021; Mbavarira & Grimm, 2021). Some of the water used in the production of PET bottles can be treated and recycled through the removal of chemical/biological contaminants. According to Pearson (2022), the mega-corporations in Mexico extract 133 billion litres of water and dump at least 110 billion litres of contaminated water back into the water basins and aquifers. The wastewater can be treated to enhance quality and reduce pollution, thereby ensuring that the high demand does not equal increased environmental degradation (Benyathiar *et al*., 2022; Munoz-Melendez *et al*., 2021; Zainuri *et al*., 2022; Ge-Zhang *et al*., 2022; Van Der Hoek *et al*., 2018).

Cámara-Creixell and Scheel-Mayenberger (2019) highlight that the only way to manage bottled water consumption and its associated effects is by thinking of the phenomenon from the lens of PET materials. The authors argue that PET in water bottles has the highest recycling rate in Mexico, but only 7 % are recycled in a closed loop (Cámara-Creixell & Scheel-Mayenberger, 2019). The low rates present an opportunity for the government to capitalize on, especially by revising the Ley General del Equilibrio Ecológico y Protección al Ambiente and the Ley General para la Prevención y Gestión Integral de Los Residuos. Revising the two laws will increase the recycling of solid waste consisting of PET (Whelton *et al*., 2007; Webber, 2013). On the contrary, the adoption of the circular economy in Mexico is compounded by myriad issues, with the topmost being normative challenges. These challenges include new legislation or

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revising current regulations (Zainuri *et al*., 2022). Suffice it to say that the Mexican regulatory environment is quite lax, with water legislation being complex, wide-ranging, and fragmented (Munoz-Melendez *et al*., 2021). Considering this, passing regulations to enhance the circular economy will prove arduous. Subsequently, the circular economy is undermined by governance challenges brought about by the decentralized nature of Mexico's drinking water supply system. The decentralization has contributed to confusion regarding who can implement the circular economy strategies (Culora, 2021; Franklin, 2006). There is a lack of clarity on the government and private sector's role in developing the most effective water governance mechanisms and arrangements.

The preceding systematic review explores the levels of bottled water consumption in Mexico in view of the circular economy. Most of the papers presented results and findings which helped the research draw a correlation between the circular economy and bottled water consumption. On the contrary, there is an apparent gap in knowledge into which specific circular economy aspects and strategies can be used. Each researcher gives different recommendations on production and consumption, thus necessitating further research into the topic.

Conclusion

The increased consumption of bottled water in Mexico presents a dilemma for society, the private sector, and the government. On one end, bottled water is prefered by society due to the low risk it offers compared to tap water. Most people find bottled water more effective and accessible; thus,

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they are willing to pay more for convenience. Contrarily, the increased demand for bottled water generates profits for private stakeholders like Coca-Cola and Danone, who benefit at the expense of society. The increased consumption contributes to environmental pollution since PET bottles are non-biodegradable. Furthermore, the government faces a dilemma in terms of stopping bottled water production and causing a shift to the conventional supply system. However, the conventional drinking water supply system is marred by concerns about its quality and the risk of waterborne diseases.

The findings from this research show that implementing the circular economy will help quell the dilemma faced by society, the government, and the private sector. The circular economy will guide the government in developing regulations controlling PET production and marketing. Furthermore, the research is seminal in delineating and disputing the assumption that bottled water is safer than tap water. The research also offers insight to the private sector on how it can initiate recycling and reusing strategies to curb increased environmental pollution. Further research is, however, required into how the circular economy can be defined to fit the context of the water industry.

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