United Nations University
Institute for Water, Environment and Health

Global Bottled Water Industry: A Review of Impacts and Trends

UNU INWEH

Zeineb Bouhlel
United Nations University Institute for Water, Environment, and Health,
Hamilton, ON, Canada

Jimmy Köpke
United Nations University Institute for Water, Environment, and Health,
Hamilton, ON, Canada

Helmholtz Centre for Environmental Research,
Leipzig, Germany

Mariam Mina
McMaster University,
Hamilton, Canada

Vladimir Smakhtin
United Nations University Institute for Water, Environment, and Health,
Hamilton, ON, Canada

About UNU INWEH

UNU INWEH's mission is to help resolve pressing water challenges that are of concern to the United Nations, its Member States, and their people, through critical analysis and synthesis of existing bodies of scientific discovery; targeted research that identifies emerging policy issues; application of on-the-ground scalable science-based solutions to water issues; and global outreach. UNU INWEH carries out its work in cooperation with the network of other research institutions, international organisations and individual scholars throughout the world.

UNU INWEH is an integral part of the United Nations University (UNU) – an academic arm of the UN, which includes 13 institutes and programmes located in 12 countries around the world, and dealing with various issues of development. UNU INWEH was established, as a public service agency and a subsidiary body of the UNU, in 1996. Its operations are secured through long-term host-country and core-funding agreements with the Government of Canada. The Institute is located in Hamilton, Canada, and its facilities are supported by McMaster University.

UNU INWEH

Suggested Reference: Bouhlel, Z., Köpke, J., Mina, M., and Smakhtin, V., 2023. Global Bottled Water Industry: A Review of Impacts and Trends United Nations, University Institute for Water, Environment and Health, Hamilton, Canada.

Front cover image: Shutterstock, Riccardo Mayer
Back cover image: Shutterstock, Chaiyapruek Youprasert
Design: Art and Words Inc.
Download at: http://inweh.unu.edu/publications/
ISBN: 978-92-808-6114-3

UNU INWEH is supported by the Government of Canada through Global Affairs Canada.

Global Affairs Canada   Affaires mondiales Canada

Contents

SUMMARY

The report examines facts and perceptions about bottled water in the global context. It analyses the geography, structure, trends, and drivers of the global bottled water market. It examines the existing knowledge on the quality of bottled water, its impacts on water resources, and its role in plastic pollution. It raises the question of the bottled water industry's contribution to the sustainable development goal on universal access to safe drinking water. The analysis considered only those types of bottled water that have little or no difference in taste from the tap water provided by regular municipal water supply.

It is shown that bottled water is widely consumed in the both Global North and South although prices can be orders of magnitude higher than tap water. The current global bottled water sales are estimated at almost 270 billion US$ and 350 billion liters. The report maps and ranked the top 50 countries in the world by total and per capita bottled water sales both in dollars and liters. The Asia-Pacific region constitutes about half of the global bottled water market, and the Global South countries together about 60%. The USA, China and Indonesia combined comprise half of the global market. Germany is the biggest market in Europe, Mexico in the LAC region and South Africa in Africa. Singapore and Australia stand out as the leaders in both annual revenue and volume of bottled water sold per capita, with the USA and China per capita indicators being much smaller.

The report indicates that bottled water market drivers differ significantly between the Global North and the Global South. In the former, bottled water is often perceived as a healthier and tastier product than tap water and is more a luxury good than a necessity. In the Global South, bottled water sales are stimulated primarily by the lack or absence of a reliable public water supply.

Based on around 60 case studies from more than 40 countries from every region of the world, the report illustrates that there have been numerous cases of inorganic, organic, and microbiological contamination of hundreds of bottled water brands of all bottled water types and that such contamination often exceeded local or global standards. This represents strong evidence against the misleading perception that bottled water is an unquestionably safe drinking water source and argues that the provision of a safe and reliable drinking water supply in any country may not be achieved at the expense of one water source over another.

Withdrawals for bottled water can contribute to groundwater resource depletion in areas of bottled water procurement, although case studies that illustrate this are rare. However, even if such withdrawals are small in absolute terms globally or compared to larger water consumers like irrigated agriculture, local impacts on water resources may be significant. The lack of data available on water volumes extracted by the bottled water industry is largely due to the lack of transparency and a legal foundation that would have forced bottling companies to publicly disclose extracted water volumes and assess the environmental consequences of their activities. The Global South, where safe drinking tap water is not always available, represents potential future markets for bottled water. Lack of national policies for water management may promote uncontrolled groundwater withdrawals for bottled water procurement with little or no contribution to a sustainable long-term drinking water supply.

The report collates scattered information on plastic pollution associated with bottled water, pointing out that the world currently generates around 600 billion plastic bottles amounting to approximately 25 million tonnes of plastic waste, which is not recycled but is disposed of in landfills or as unregulated waste. While there are signs of growing social awareness of the adverse impacts of plastics on the environment, a breakthrough solution that could radically reduce the environmental impacts of plastics does not yet appear to exist. Hence plastic pollution will likely continue in the years to come.

The report argues that while progress toward universal access to safe drinking water for all is significantly off-track, the expansion of bottled water markets slows this progress down, distracting attention and resources from accelerated public water supply systems development. Estimates suggest that less than half of what the world pays for bottled water annually would be sufficient to ensure clean tap water access for hundreds of millions of people without it – for years. There are recent high-level initiatives that aim to scale up financing for the Sustainable Development Goals, including water-related ones. Such initiatives are an opportunity for the bottled water sector to become an active player in this process and help accelerate the progress toward sustainable water supply, particularly in the Global South.

INTRODUCTION

Bottled/packaged drinking water, the water that is filled into hermetically sealed containers of various compositions, forms, and capacities (*i.e.* bottles, water dispensers, sachets) and that is safe for direct consumption (FAO/WHO, 2007), has at present a large variety of types and brands and is widely consumed around the globe in countries with different levels of economic advancement. For simplicity, the term "bottled water" in this report refers to water packaged in any type of container, for individual and household use.

Bottled water evolved from a niche product to one of the most popular beverages in the world. In Europe, it can be traced as far back as the 16th Century when natural mineral water was sold in glass bottles and was considered a luxury beverage for special occasions (Brei 2018, Hawkins 2017). The first bottled mineral water for public consumption in the USA was in the second half of the 18th century (Hawkins et al. 2015, Pandal 2020), and industrially carbonated water was patented in 1806 (Jain et al. 2019).

Mineral water in sachet container sold in Yaounde, Cameroon. By StreetVJ, Shutterstock

Despite the decrease in the cost of glass, bottled water consumption remained relatively low until the middle of the 20th century (Brei and Tadajewski 2015, Foltz 1999, Hawkins 2017, Marty 2005, Spar 2008). This began to change in the late 1960s and 1970s with the emerging interest in general fitness and the increased European mineral water imports to the USA (Hawkins, 2017, Jain et al. 2019). The introduction of polyethylene terephthalate plastic (PET) in the late 1970s further accelerated bottled water sales (Hawkins 2017). In the 1980s, big food and beverage corporations such as Nestlé and Danone seized the opportunity to diversify their beverage products by producing "water" and in the 1990s, PepsiCo and Coca-Cola also entered the market (Green 2014, Hawkins 2017).

The following decades were marked by a rapid global market expansion, product diversification (e.g., "functional water" or "vitamin water") and even the replacement of tap water with bottled water as the main drinking water commodity in some countries. These processes occurred simultaneously with a general underinvestment in public water supply and distribution systems (Cohen and Ray 2018) and increasingly negative perceptions of tap water quality and concerns over its impacts on health (Jaffee and Newman 2013, Rodwan 2018, Wilk 2006). Beverage corporations marketed bottled water as a 'safe alternative' to tap water and drew consumers' attention to water quality (Opel 1999, Wilk 2006) by using isolated public water system failures such as the cholera outbreak in Mexico (1985) and the cryptosporidium crisis in Sydney (1998) (Cohen and Ray 2018, Greene 2014). At the same time, bottled water rarely faced the same rigorous public health and environmental regulations as tap water (Brei 2018, Hawkins 2017).

At present, the global market for all non-alcoholic packaged beverages generates revenues of over $1,225 billion. Bottled water makes 17–24% of this number depending on how "beverage market" and "bottled water" are defined (Ross 2021, Statista 2022b). With such significant "weight", the bottled water sector can play a major role in global sustainable development processes, particularly considering how critical water is to humans.

At the same time, the controversy surrounding bottled water is also significant, and the overarching question in this context is whether the bottled water sector already contributes to such development, and if so, where, how, and to what extent. Consequently, the report makes an attempt to develop a comprehensive look at the bottled water sector globally. Accordingly, the report objectives are to:

- Evaluate the current state of and trends in the global bottled water market.
- Examine the existing knowledge and quantitatively summarize the key health and environmental impacts of the bottled water industry.
- Determine if and how the above bottled water market measures, trends, and drivers on one hand, and bottled water impacts on the other, affect the achievement of the SDGs and water-related ones – in particular.

BOTTLED WATER MARKET: STATUS AND TRENDS

Bottled water types

The market today contains a wide range of bottled water types. Definitions of these types provided by various international and governmental sources, such as the Codex Alimentarius Commission (FAO and WHO, 2007), the International Council of Bottled Water Associations (ICBWA, 2022), the International Bottled Water Association (IBWA 2022b), the Drinking Water Research Foundation (DWRF 2022) and others vary significantly. However, the main criteria for the most common categorization appear to include *geological origin* (where the water is collected), *chemical composition* (whether it contains minerals and if they are stable), and *carbonation* (whether or not water has carbon dioxide in it) and hence, whether it is sparkling or still. In addition, all waters that are bottled can essentially be separated into two large categories – *natural* and *treated*, although such a simple categorization *alone* may not be reflective of the wide range of bottled water types. This report considered primarily those bottled water types that have little or no difference in taste from tap water provided by municipal water supply. Such types can be grouped into three main categories.

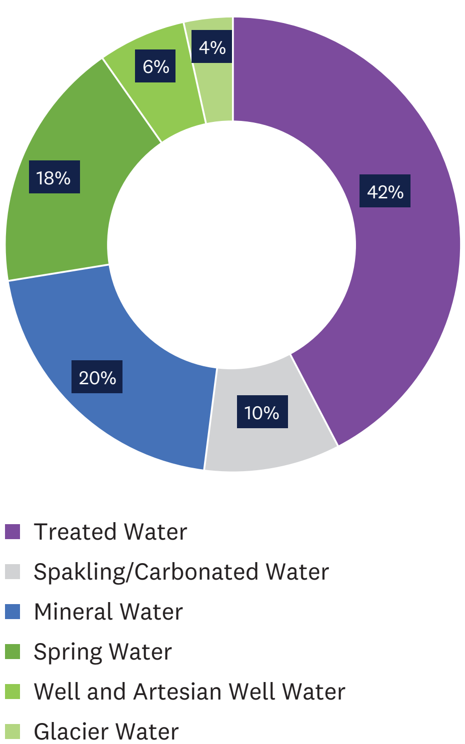

FIGURE 1. Market structure by volume of bottled water type (2021)

Natural mineral water (Figure 1). This water comes from groundwater sources where the water is naturally protected from pollution and is characterized by the presence of minerals and trace elements. The composition of elements varies with the geographical location and gives the water a characteristic taste and commercial name (e.g., Evian, Fiji Natural Artesian). There is no clear consensus, however, on the concentration of minerals at which the water is considered 'mineral'. For instance, The International Bottled Water Association (IBWA) standard is 250 ppm, while that of the European Federation of Bottled water is 50 ppm. It is critical for mineral bottled water that its mineral composition remains unchanged from the source to the consumer and receives no treatment. Its mineral composition, origin, and source should be clearly indicated. (In the rest of this report, "*natural mineral water*" is referred to simply as "*mineral*" water).

Other natural water. Water in this category comes predominantly from groundwater sources such as wells and springs. Glacier water is also included in this category (Figure 1). The water source gives the product its taste and commercial name. The product should be free of pollutants, should not be subjected to any major treatment, and may or may not contain minerals. Other natural water differs from natural mineral water in several ways: i) for well and spring water, the mineral composition doesn't need to be constant from source to the consumer: ii) packaging can be done far from the source, and iii) listing mineral composition is not required even though bottled water companies often do so for commercial purposes. In the rest of this report, "*other natural water*" is referred to simply as "*natural*" water.

Treated water. Treated water is sometimes called purified, prepared, processed, or table water. Its origin is not relevant to its branding and there are no legal obligations to disclose this information. It could come from a municipal or community water system, a surface water source, or an unconfined aquifer. This water is subjected to required treatments and disinfection, including chlorination, to make it safe for consumption. Treatment may be by reverse osmosis, distillation, deionization, or other processes.

Bottled water in any category can be 'still' or 'sparkling' (i.e., carbonated, either naturally or industrially). To ensure conformity in interpretations and comparisons between tap and bottled water, only still water is considered in this report. Sparkling water constitutes only 10% of the bottled water market (Figure 1) and its taste differs from tap water. Bottled waters that have been modified by the addition of minerals, flavors, or supplements are not considered in this report as they are considerably different from regular tap water and represent a small portion of the bottled water market (Brei 2018).

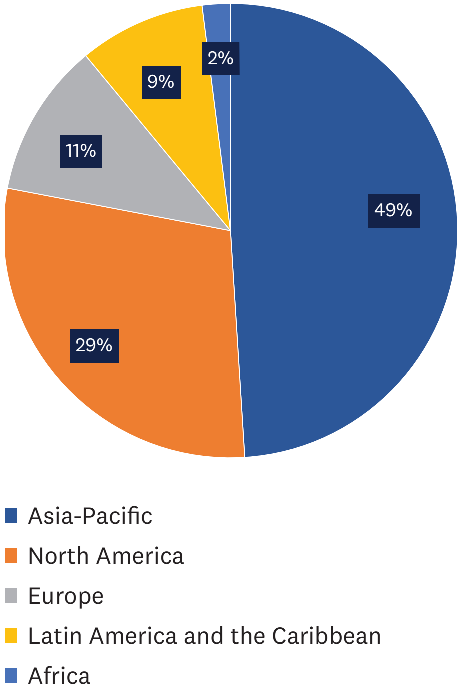

FIGURE 2. Global bottled water market structure by major geographical region in 2021 (percent of global US$ revenue)

Market size, structure, and geography

The global market for the above three main types of bottled water is estimated to be almost 270 billion US$ from sales of 350 billion liters in 2021. The market has increased by 73% during the last decade, making it one of the fastest-growing markets in the world (Statista 2020).

Current bottled water total sales vary significantly between major geographical regions (Figure 2). The Asia-Pacific region represents the largest regional market both in dollar terms and liters (consumption), followed by North America and Europe. The Global South combined (Asia-Pacific, Africa, Latin America and the Caribbean) represents around 60% of the global sales both in dollars and liters.

Treated water was the largest market component in 2021 by volume, representing almost half of all bottled water consumed globally (47%), followed by mineral water (33%) (Figure 3, right). A similar pattern has been observed as confirmed by other market analyses (Grand View Research 2022, Statista 2020). However, the category "natural water" appears to be the most profitable market segment (Figure 3, left).

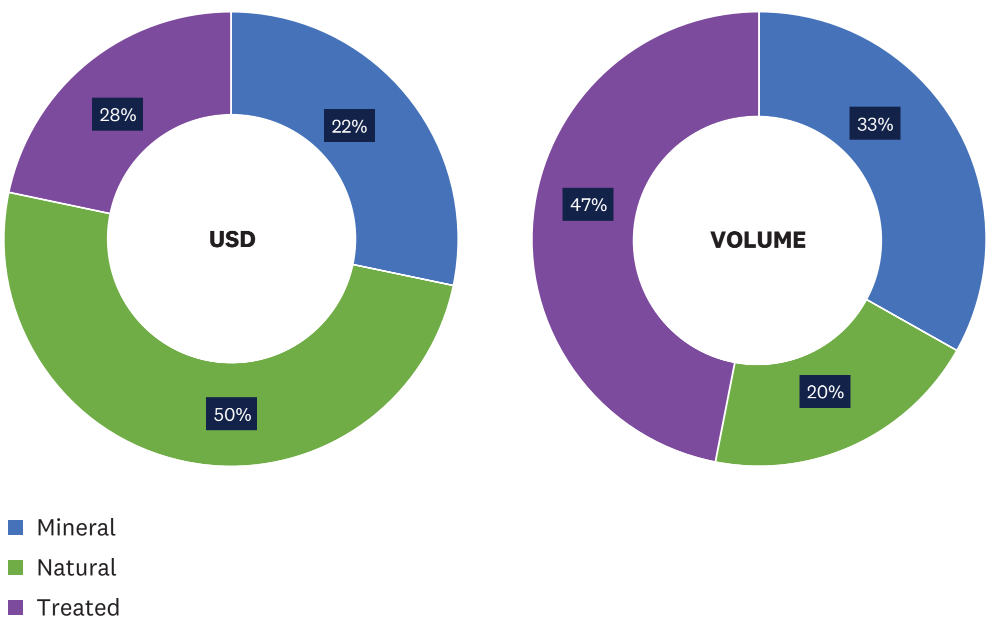

FIGURE 3. Global bottled water market structure by three main water types in 2021 (percent of global US$ revenue and consumption volume in liters)

The bottled water market comprises a range of companies from multinational to local. PepsiCo, Inc., Coca-Cola Company, Nestlé S.A., Danone S.A, and Primo Corporation are the five companies with a share of the global market exceeding 2% each and have combined sales of $65 billion (over 25% of the total market by sales, Figure 4). Collectively, smaller local businesses have a significant influence over the sector. Over 70% of bottled water products are produced locally and transported regionally, although some large national markets like the USA and China import sometimes millions of liters of bottled water (Ross 2021, UN Comtrade 2021).

On a country level, the largest market is the USA with total revenue of around $64 billion, followed by China (almost $50 billion) and Indonesia (almost $22 billion) (Figure 5 and Figure 6). These three countries combined earn half the global total revenue (24%, 18% and 8% respectively).

Germany is the biggest market in Europe, Mexico in the Latin America and Caribbean region (LAC), and South Africa in Africa (Figure 5). Although both high-income countries (HIC) and low and middle-income countries (LMIC) appear among the top 50 biggest bottled water markets, the market value for a specific country can be related to either a high price per unit sold or a high quantity sold. For instance, the price for a unit of bottled water in North American and European countries is around $2.5 per unit on average, which is more than double that in Asia, Africa and LAC ($0.80, $0.90 and $1 respectively). Australia, the fifth largest market, has the highest price per unit on average ($3.57) (Statista 2020, 2022a).

Total consumption of bottled water in liters follows a similar pattern to sales in US$, with the USA, China, and Indonesia being the largest consumers, collectively accounting for nearly 40% of the global bottled water volume. Figure 7 shows the top 50 countries by total bottled water consumed while illustrating the structure of this consumption by the three main water types.

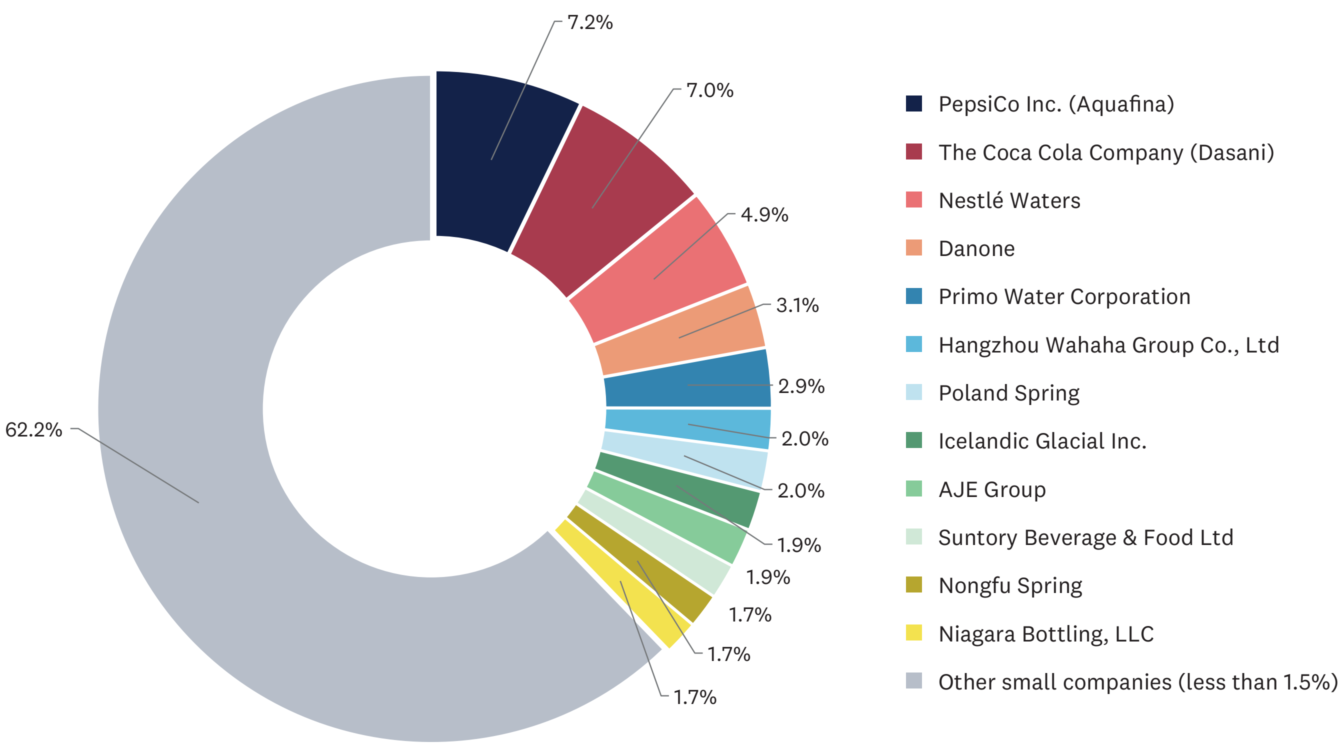

FIGURE 4. Global bottled water market structure by company in 2021 (percent of global US$ revenue)

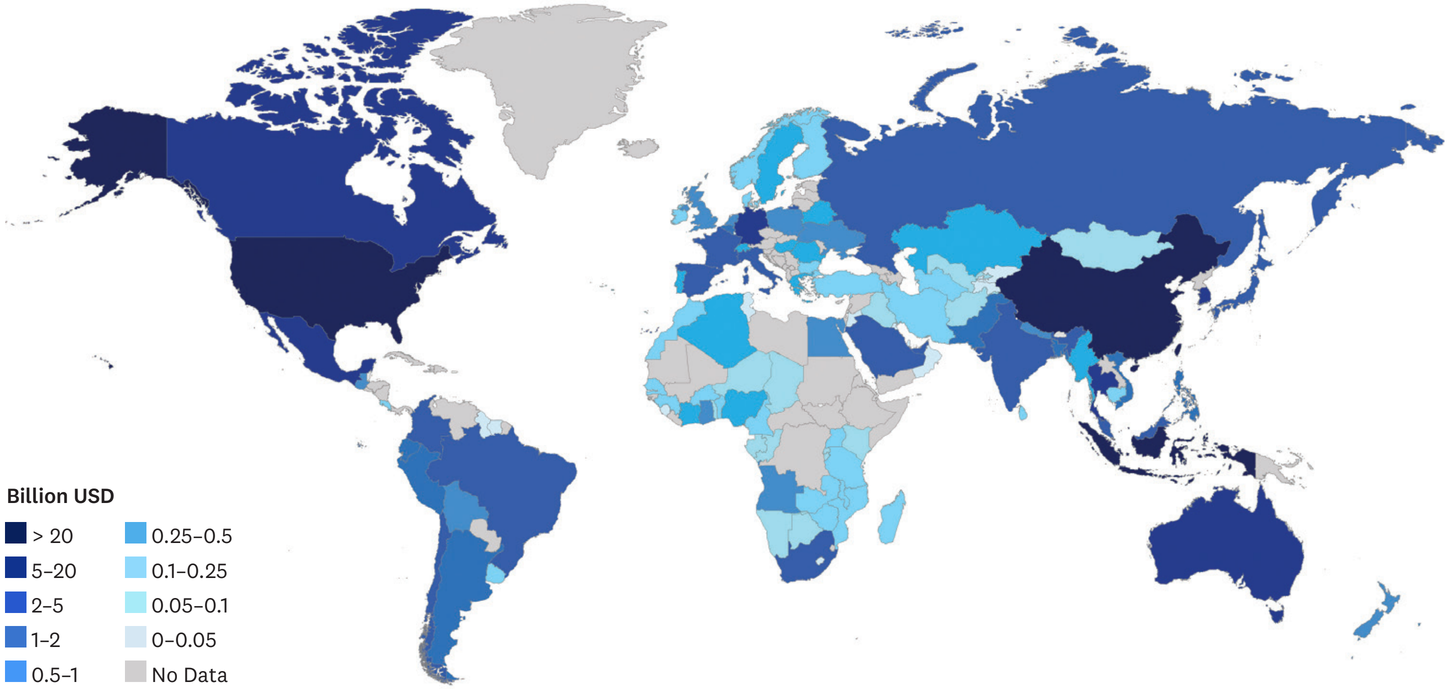

FIGURE 5. Bottled water market size (billion US$) by country (2021)

Bottled water sales per capita reveal a different picture (Figure 8). Singapore and Australia emerge as the leaders in both annual revenue and volume of bottled water sold (Singapore: 1,129 liters and $1,348 per capita in 2021; Australia: 504 liters and $386 per capita the same year). There is a large drop in both indicators between Singapore and Australia, after which the per capita numbers are much lower (Figures 9 and 10). The USA, Indonesia, and particularly China, rank much lower in terms of both per capita bottled water consumption and revenue compared to their corresponding total numbers.

At a compound annual growth rate of 5.2% since 2021 (UN Stats 2021), the bottled water market has been growing faster than other beverage markets such as coffee (3.5%) during the same period (Statista 2021a, 2022a). From 2022, the market is projected to increase at an even faster rate of approximately 7% and reach $500 billion by 2025–2030. This gives bottled water the highest growth potential among all soft drink products (BlueWeave 2022, Grand View Research 2022, Statista 2021a and 2022b).

Market growth differs by bottled water type. Treated and natural mineral water are the fastest-growing markets since 2018 (10% and 12% respectively) whereas the market for natural water is growing at a slower rate at around 5% for the same period (BlueWeave 2022).

Table 1 lists the top 10 fastest-growing country markets by water type. Egypt has the fastest-growing treated water market overall (40%). Seven other countries from the Global South are in the top 10 fastest-growing treated water markets with growth rates of 10–17% (Algeria, Brazil, Indonesia, UAE, India, Morocco and Saudi Arabia). India (27%), Egypt (18%) and Algeria (17%) are among the top 10 fastest-growing markets of mineral water, competing with South Korea (28%), Japan (24%), France, Peru, South Africa and Malaysia (13–16%). For natural waters, the leaders are all from Europe (Belgium, Netherlands, UK, and France) with a range of 6–9%), where spring water is the most appealing bottled water product (NMWE 2021).

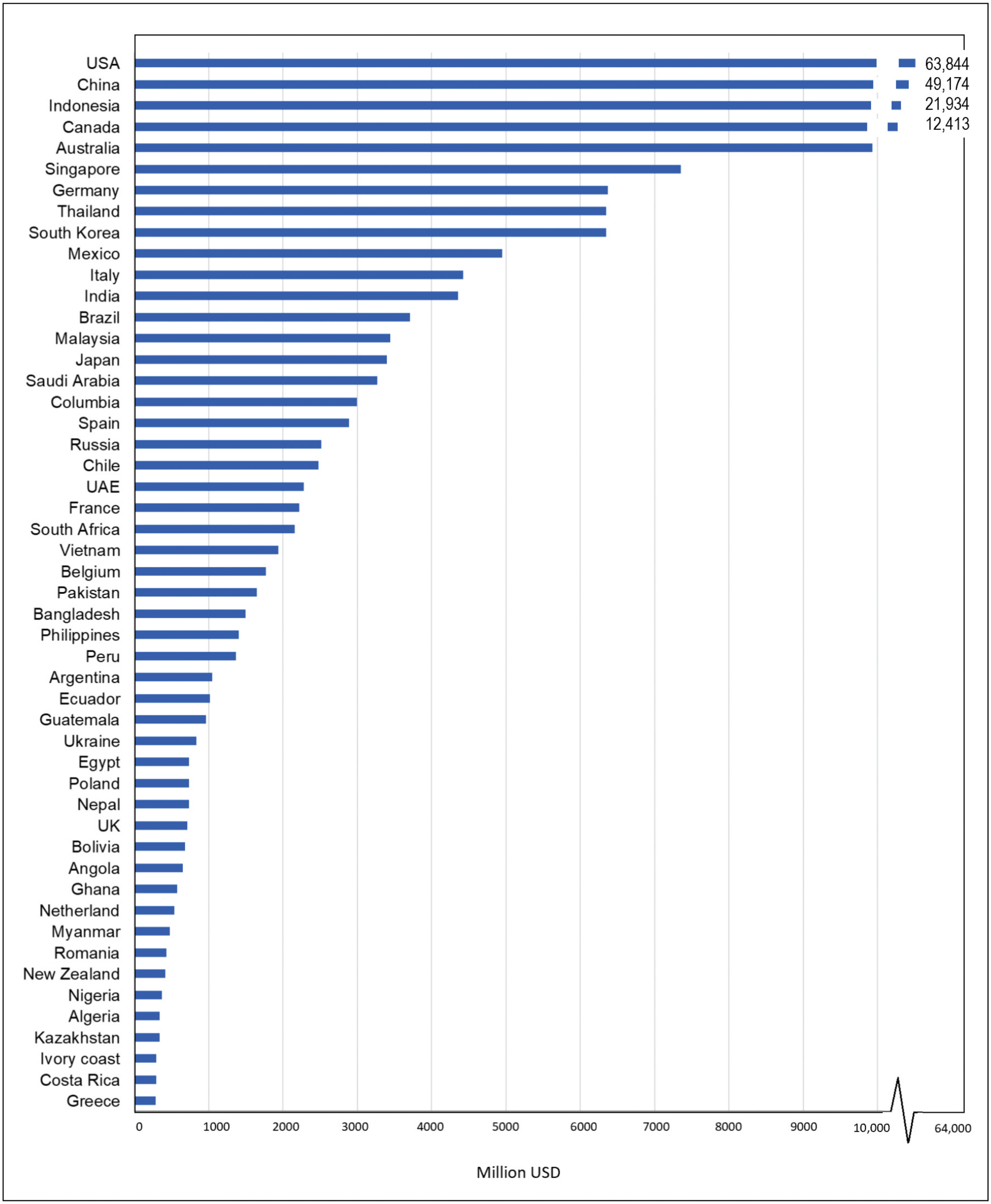

FIGURE 6. Top 50 countries in 2021 by their bottled water sales (US$ million)

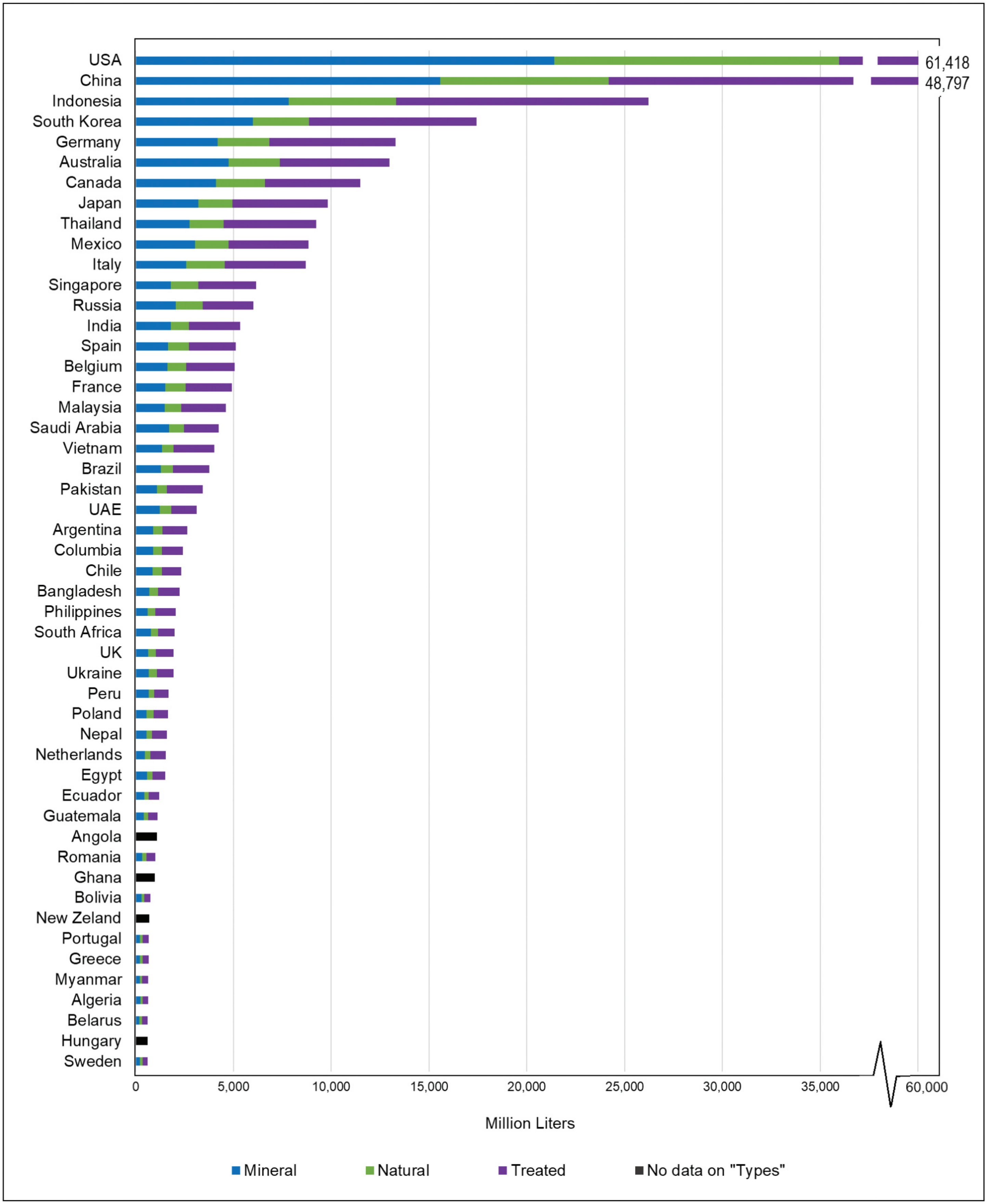

FIGURE 7. Top 50 countries in 2021 by total bottled water consumption and composition by water type.
("*No data on types*" indicates cases where only totals are available)

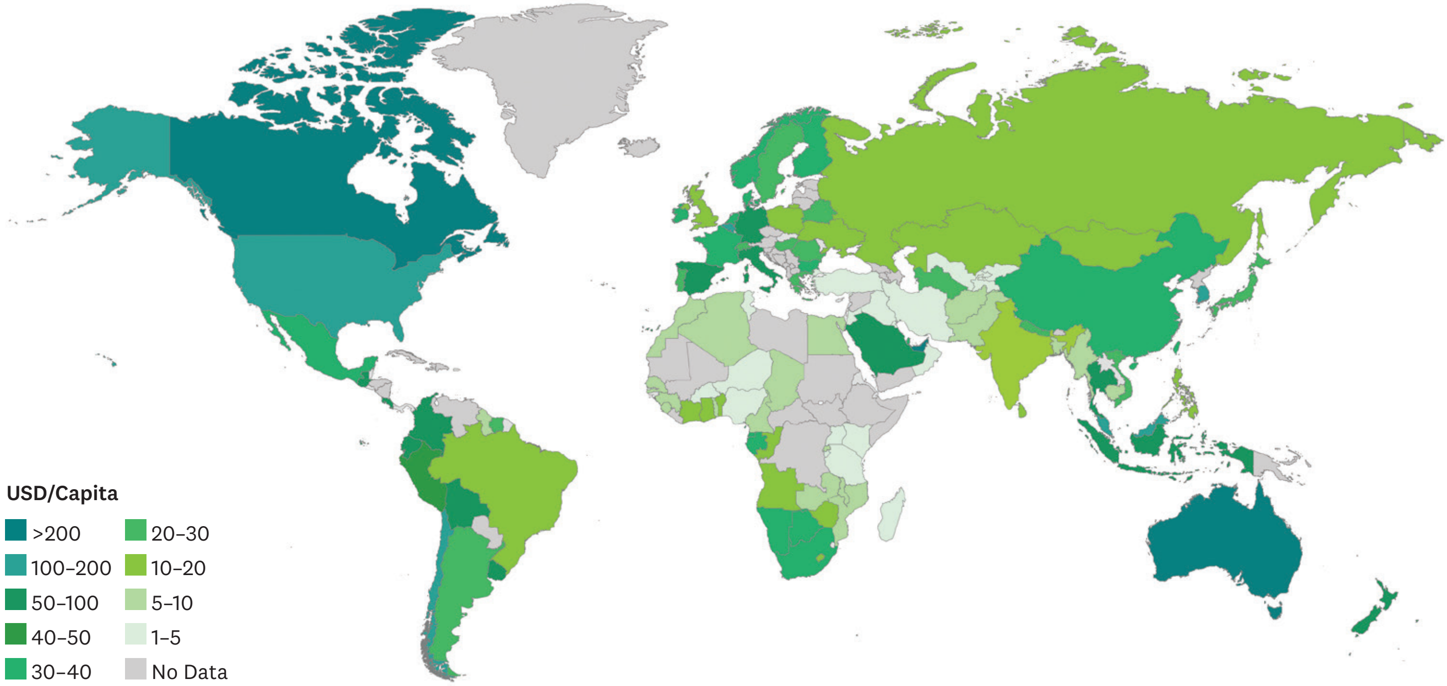

FIGURE 8. Bottled water sales in US$ per capita (2021)

Key drivers

Bottled water market drivers vary significantly by country. In high-income countries, bottled water consumption is often high despite well-developed domestic water supply systems, and a significant percentage of the population prefers bottled water. About 31% and 38% of Canadians and Americans use bottled water as their primary drinking source (Johnstone and Serret 2012, Vieux et al. 2020). In France, bottled water accounts for 64% of the soft drinks market, even though bottled water can be almost 350 times more expensive than tap water (Brei 2018). Bottled water appears to be the main drinking water source for around 60% of Italians (Johnstone and Serret 2012) and Koreans (Cha and Lee 2020). According to multiple sources (Brei 2018, Clarke 2007, Hawkins et al. 2015, Opel 1999, Stoler 2017) high bottled water consumption in the Global North countries is related to:

- Health concerns: bottled water is seen as a healthier product than tap water.
- Taste concerns: bottled water is perceived to taste better, due to its mineral composition and because tap water may carry a taste of chlorine.
- Active marketing by water companies exploiting the idea of bottled water purity and providing brands for specific target groups like pregnant women, children, and sports-minded people.
- Convenience and lifestyle aspects: bottled water is easy to purchase and carry and the bottles are easy to dispose of.

Some of the above perceptions are overrated (as the next section of this report will illustrate) and overall, based on the above, it may be argued that in high-income countries bottled water is largely a “luxury good”.

In mid- and low-income countries, bottled water consumption is linked to poor tap water quality and often unreliable public water supply systems. These problems are often caused by corruption and chronic underinvestment in piped water infrastructure (Greene 2014, Hawkins 2017, Jaffee and Case 2018, Pacheco-Vega 2019).

In Mexico, distrust in tap water increased significantly after several cholera outbreaks following the 1985 Mexico-city earthquake that affected public water utilities and people turned to bottled water (Greene 2014). Only about 20% of Mexicans are satisfied with the quality of publicly supplied tap water, with over 90% of those citing health concerns. About 80% of the population use bottled water and 10% home-purified water as their primary drinking water source (Johnstone and Serret 2012). In the Dominican Republic, 60% of households use bottled water as their primary water source, but there is a strong positive correlation between income and bottled water consumption (McLennan 2015, National Population Commission 2013).

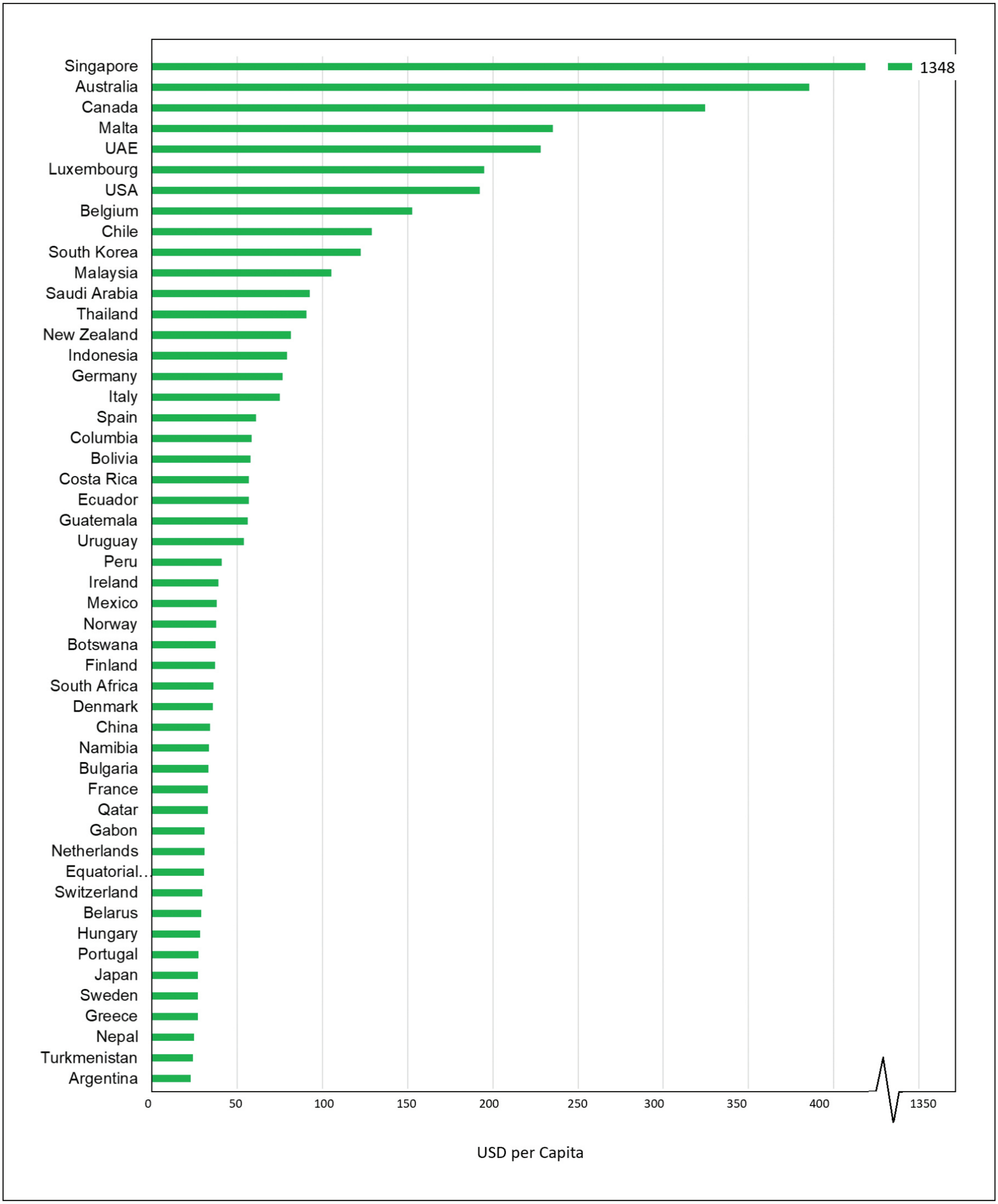

FIGURE 9. Top 50 countries in 2021 by their bottled water sales per capita

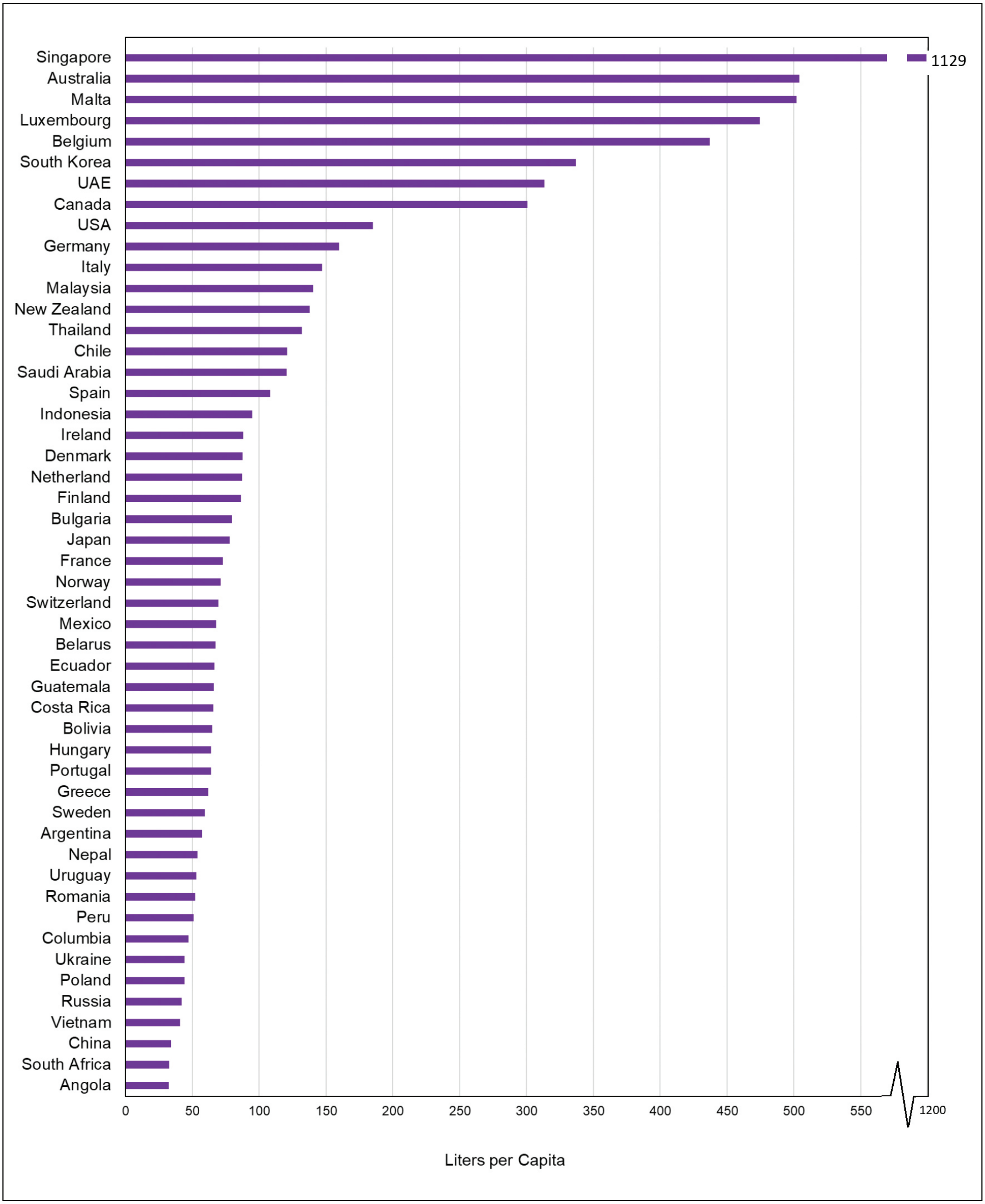

FIGURE 10. Top 50 countries by per capita consumption in 2021

TABLE 1. Bottled water market growth rates during 2018–2021 among 10 fastest-growing national markets for each of three main bottled water types

	Mineral		Natural		Treated	
Rank	Country	CAGR*, %	Country	CAGR*, %	Country	CAGR*, %
1	South Korea	28.0	Belgium	9.4	Egypt	43.3
2	India	27.1	Netherland	7.8	Algeria	17.5
3	Japan	24.2	Argentina	7.5	Brazil	17.2
4	Egypt	17.7	UK	7.1	Indonesia	14.8
5	Algeria	16.6	France	6.3	UAE	12.9
6	France	16.1	Japan	6.0	India	12.5
7	South Africa	13.2	Spain	5.9	Netherland	10.6
8	Peru	13.0	Mexico	5.6	South Korea	10.3
9	Malaysia	12.3	Nepal	5.4	Morocco	10.3
10	Australia	12.3	Singapore	5.4	Saudi Arabia	10.1

** CAGR- compound annual growth rate*

Bottled water is a common option for self-supply in Asia and Pacific region countries that have low levels of access to publicly provided piped water sources (Foster et al. 2021, WHO and UNICEF 2021). This explains a high and growing reliance on bottled water in countries such as Indonesia, Thailand and the Philippines (Foster et al. 2021, Francisco 2014).

In Africa, sachet packaged water is a significant primary drinking water source (Howell et al. 2020, Olukoju 2007, Stoler 2017, Stoler et al. 2013). In Ghana, sachet water constitutes up to 43% of urban and up to 12% of rural household drinking water (Ghana Statistical Service 2009 and 2013, Morinville 2017, Wright et al. 2016). In Nigeria, sachet water is a primary source for 12% of urban households (National Population Commission 2013). The growing use of bottled water by poor communities in Rwanda, Uganda, Kenya and Ghana is driven by a desire for clean, safe drinking water (Howell et al. 2020, Quansah et al. 2015).

Market growth in the Global South may also be influenced by factors ranging from the lack of regulations covering beverage company operations (Greene 2018, Rosemann 2005) to increasing urbanization and growing cities that cannot rely on groundwater wells (Foster et al. 2021). Overall, the pattern of bottled water consumption in low- and middle-income countries appears to be determined by the following factors (Ferrier et al. 2001, Hawking et al. 2016, Race et al. 2015, Race 2012, Packialakshmi et al. 2011, Zhelaeve et al. 2021):

- The need to ensure reliable and safe supplies of clean drinking water.
- Government failures to provide quality drinking water through local water utilities.
- Increasing urbanization but limited water delivery infrastructure to and within urban centers.
- Marketing campaigns by the bottled water industry aimed at discrediting tap water and promoting the concept of bottled water purity.

Public water supply systems in low- and middle-income countries need improvement. It is only natural that in the absence of a reliable public water supply, communities will seek alternative solutions such as bottled water.

THE QUESTION OF QUALITY

Bottled water is often seen as a product for those concerned with high health standards compared to tap water (IBWA 2021, Poškus et al. 2021). The massive and appealing marketing of bottled water by the beverage industry has gradually changed perceptions of bottled and tap water (Cohen et al. 2022, Hawkins 2017, Jaffee and Newman 2013, Jain et al. 2019, Rodwan 2018, Valavanidis 2020). While there are examples of water quality issues with public tap water, it is generally of good quality and safe to drink with or without filtering in most high-income countries. Provision is highly regulated, and frequently tested, and water quality parameters are publicly disclosed (Cohen et al. 2022, Diduch et al. 2011, Geerts et al. 2020, Valavanidis, 2020). In contrast, bottled water is generally not nearly as well-regulated and is tested less frequently and for fewer parameters (Abd El-Salam et al. 2008, Cohen et al., 2022, Diduch et al. 2013, Parag and Opher 2011). Strict water quality standards for tap water are rarely applied to bottled water and even if such analyses are carried out, the results seldom make it to the public domain (Ferrier 2001, Parag and Opher 2011, Valavanidis 2020).

Workers carefully inspecting bottles in a bottling plant in the Maldives. By Asian Development Bank

A range of factors can adversely affect bottled water quality. For example, water origin plays an important role in quality (Diduch et al. 2011, Ikem et al. 2002). The mineral composition of bottled water can vary significantly between different brands, within the same brand in different countries, and even between different bottles of the same batch (Abd El-Salam et al. 2008, Chidya et al. 2019, Dindarloo et al. 2016, Ikem et al. 2002, Mihayo and Mkoma 2012). Treatment processes such as chlorination, ultraviolet disinfection, ozonation and reverse osmosis (Ahmed and Shafique, 2019, Napier and Kodner 2008, Poškus et al. 2021), storage conditions (duration, light exposure, temperature) and packaging material (plastic, glass) may all have a potentially adverse impact on bottled water quality (Diduch et al. 2011 and 2013, Nawrocki et al. 2002, Valavanidis 2020). Contamination of bottled water due to these factors may be (i) inorganic (e.g. heavy metals, pH, turbidity, etc.), (ii) organic (benzene, pesticides, microplastics, etc.) and (iii) microbiological (pathogenic bacteria, viruses, fungus, and parasitic protozoa).

It has been demonstrated across countries and bottled water brands that the claim "bottled water is a safer and healthier alternative to tap water" must be critically evaluated (Cha and Lee 2020, Cohen et al. 2022, Diduch et al. 2013, Valavanidis 2020, Venturini and Frazão 2015, Williams et al. 2015). However, hard evidence for and against claims of purity and safety is limited or scattered across various sources. The evidence in this review has been compiled from peer-reviewed journals on academic databases such as Google Scholar, Web of Science, and ScienceDirect and considers all aspects of bottled water quality including organic, inorganic, and microbiological. The results are summarized in Table 2 by date of publication under each contamination type.

This summary, while non-exhaustive, presents the documented evidence against the misleading perception that bottled water is an unquestionably pure and safe drinking water source. Although contamination may be occasional, similarly to tap water, it is clear that bottled water is not immune to all possible types of contaminants.

This review complements the recent report by WHO et al. (2022), showing, among others, that water quality from all source types is subject to contamination and that the risk of contamination varies considerably depending on the source. Open surface water sources and unprotected wells and springs are at the most risk, while packaged, bottled, delivered, and piped water all appear to be at the safe end of the spectrum in most surveyed countries.

Overall, there is no justification to contrapose bottled water and public drinking water supply sources on the basis of quality. Moreover, as the bottled water market grows, it is more important than ever to strengthen legislation to regulate industry quality processes and standards.

TABLE 2. Reported cases of bottled water contamination

COUNTRY	TYPE or BRAND	DESCRIPTION	REFERENCE
Inorganic contamination			
USA	103 brands	About 20% of tested brands are chemically contaminated at levels beyond the national drinking water standards.	Olson et al. 1999
USA (Alabama)	25 brands of spring water	Several contaminants exceeded national standards (e.g. As, Cd, Hg, Zn, Se).	Ikem et al. 2002
Turkey	189 brands	Some contaminants are above national and international guidelines (Na, Cl, F, Cd, Fe, Pb, Ni, Se) as well as borons and polycyclic aromatic hydrocarbons (PAHs).	Güler 2007
Egypt	14 brands	Many samples contain elements above national and international standards including Pb (exceeding 0.01 mg L^{-1} with up to 0.49 mg L^{-1} in 86% of samples), and Fe (exceeding 0.3 mg L^{-1} in 64% of samples).	Abd El-Salam et al. 2008
USA	10 brands	38 pollutants including As, bromates, chlorination by-products, and trihalomethane.	Stephenson 2009, Environmental Working Group, 2008
Malawi	12 brands	Over 82% of brands did not comply with local standards for turbidity and pH. Significant discrepancy between claimed composition on the label and the actual composition.	Chidya et al. 2019
Nigeria	Bottled and sachet water	High heavy metal contamination across the country (e.g. Cd, Ni, Cu).	Ajala et al. 2020
Organic contamination			
Argentina	Mineral water	Food additives and organic micropollutants up to 38 µg L^{-1} (e.g. butylated hydroxytoluene).	Tombesi and Freije 2002
Thailand	bottled from groundwater	Pesticides, organochlorides, surfactants, disinfection by-products, 18 µg L^{-1}.	Kruawal et al. 2005
Poland, Japan, Europe, North America	Mineral water	Carbonyl compounds from packaging material and storage (e.g. formaldehyde, acetone); levels of 0.6 to 318 µg L^{-1}.	Mutsuga et al. 2006, Nawrocki et al. 2002
China, Greece	23 brands of purified, mineral, and spring water	Haloacetic acids (e.g. dichloracetic acid, bromate, trichloroacetic acid); 0.1 to 71.8 µg L^{-1}.	Leivadara et al. 2008, Liu and Mou 2004
Spain	Mineral bottled water	Perfluorinated compounds between non-detectable to 0.9 ng L^{-1}.	Ericson et al. 2008
Mexico	Mineral water	Pesticides (e.g. DDT, endosulfan) up to 0.15 µgL^{-1}.	Díaz et al. 2009

China (Guangzhou)	21 brands of mineral water for infants	Food additives and organic micropollutants (e.g. nonylphenol in all samples) (108 to 298 ng L^{-1}), bisphenol A in 17 of 21 samples (17.6 to 324 ng L^{-1}), triclosan in 18 of 21 samples (0.6 to 9.7 ng L^{-1}).	Li et al. 2010
Mexico	6 brands	Polychlorinated biphenyls (PCB) levels between 0.035 to 0.067 µg L^{-1}.	Salinas et al. 2010
Saudi Arabia, United Arab Emirates, Kuwait, Egypt, Lebanon, Italy, Turkey, Spain, Scotland, Iceland, Greece, USA	134 brands of mineral and other bottled water types	High levels of volatile organic compounds such as Di and Trihalomethanes (e.g. bromoform, chloroform) between 0.1 to 38 mg L^{-1} (e.g. WHO guideline value for drinking water: 0.1 mg L^{-1} for bromoform and 0.3 mg L^{-1} for chloroform).	Diduch et al. 2011, 2013
Spain, Greece, Italy, Czech Republic, Honduras, Nepal, Switzerland, China, Mexico, Argentina, USA	5 to 17 brands of treated water	Alkylphenols and phthalates between non-detectable up to 9.9 µg L^{-1} (e.g. bisphenol A, triclosan).	Diduch et al. 2013
Germany, France, Italy	13 brands	72% of samples showed significant anti-estrogenicity and 89% were antiandrogenic; detection of responsible endocrine disruptor di(2-ethylhexyl) fumarate.	Wagner et al. 2013
Poland, EU, Ireland, Germany	Mineral water	Endocrine disruptor compounds from packaging materials were found in 10 to 78% of samples.	Diduch et al. 2013
China, USA, Brazil, India, Indonesia, Mexico	Unspecified	93% of samples contained microplastics and synthetic polymer particles, 10.4 particles L^{-1} (> 100 µm), and 325 particles L^{-1} (6.5 to 325 µm).	Mason et al. 2018
Germany	Mineral water in reusable and single-use plastic bottles, cartons, glass	Small microplastic fragments in every type of bottled water (returnable plastic: 118±88 particles L^{-1}, single-use plastic: 14 particles L^{-1}; 11 particles L^{-1}).	Schymanski et al. 2018
Unspecified	Unspecified	Over 90% contained fibres and particles of microplastic.	WHO 2019
Unspecified	Unspecified	4,000 microplastic particles are consumed annually via tap water and 90,000 particles per year via bottled water.	Cox et al. 2019
USA	Unspecified	Ingestion of 90,000 particles annually from bottled water.	March et al. 2020
Thailand	10 brands	140 particles of microplastic L^{-1} in single-use plastic-bottled water and 52 particles L^{-1} in glass-bottled water.	Kankanige and Babel 2020
Iran	11 brands of mineral water	Microplastic particles were detected in 80% of samples with an average concentration of 8.5 particles L^{-1}.	Makhdoumi et al. 2021
India	Unspecified	Plasticizers leach from PET into bottled water (up to 64,000 ng L^{-1}).	Mukhopadhyay et al. 2022

Microbiological contamination			
Portugal, Spain	Unspecified	Bacterial contamination leading to cholera and typhoid outbreaks.	Warburton et al. 1992, Blake et al. 1977
Canada	Unspecified bottled water	Bacterial contamination in various stages of bottled water production.	Warburton 1993
UAE, USA	23 brands of bottled water (mineral, non-carbonated)	48% of bottled water samples with bacterial contamination, and 4% with amoebas.	Nsanze et al. 1999, Penland and Wilhelmus 1999
Brazil	13 brands	15% of brands contaminated with highly infectious *Cryptosporidium* oocysts (0.2 to 0.5 oocysts L^{-1}).	Franco and Cantusio Neto 2002
Argentina	8 brands of mineral water	79% of samples with filamentous fungi contamination by *Penicillum citrium*, *Cladosporium cladosporioides*, 2.4% of samples were contaminated with fecal *Streptococci spp*.	Cabral and Pinto 2002
Ghana	Packaged water (bottles, sealed sachets, hand-filled hand-tied bags)	Number of colony-forming units (CFUs) exceeded national standards in all three types of water; fecal contamination in factory-bagged sachets (2.3%), hand-filed hand-tied bags (23%); 5% *Enterococci*.	Obiri-Danso et al. 2003
Mexico	3 brands of mineral water	Detection of human parasites *Giardia* and *Cryptosporidium* (protozoan).	Nichols et al. 2004
Germany, Italy, France,	Mineral water	Detected occurrence of antibiotic-resistant bacteria and resistant genes against several groups of antibiotics.	Messi et al. 2005, Mary et al. 2000, Massa et al. 1995, Rosenberg and Duquino 1989
Greece	Mineral water	14% of samples with inadequate microbiological quality. The most frequently detected bacterial contaminant was *P. aeruginosa*.	Venieri et al. 2006
Australia, Canada, Cuba, Germany, France, Greece, Hungary, India, Italy, Mexico, Norway, Austria, Spain, Tanzania, Turkey	68 brands of mineral water	12% of brands with confirmed bacterial *Legionella pneumophila* contamination.	Klont et al. 2006
Spain	Unspecified	Bacterial contamination with *Salmonella enterica*, causing 41 cases of infection in infants.	Palmera-Suarez et al. 2007
Greece	Unspecified	31% of samples were unsuitable for consumption according to Greek legislation; 14% contained *Pseudomonas aeruginosa* (bacteria), and 11% contained coliform bacteria.	Carr et al. 2008

Germany	Unspecified	Hospital acquired outbreak of *Pseudomonas aeruginosa* (bacteria) caused by contaminated bottled water.	Eckmanns et al. 2008
Puerto Rico	21 brands	Bacterial contamination due to high numbers of CFUs (max. 7500 CFUs mL^{-1}); Contamination by *Pseudomonas fluorescence, Aeromonas baumanni, Flavobacterium indolgenes*.	Reyes et al. 2008
Ireland	Unspecified	7% of tested samples failed to meet European microbiological standards or guidelines.	Food Safety Authority Ireland 2009
France, Portugal	Mineral bottled water	Antibiotic resistance phenotype of cultivable bacteria present in all tested bottles of three brands.	Falcone-Dias et al. 2012
Ghana (Accra)	Packaged water (Bottles, sachets)	Number of CFUs (87% of samples) and protozoa (50% of samples) for sachet and bottled water (CFUs: 10%) exceeded international standards; tap water with 40% of samples exceeding CFUs and protozoa.	Osei et al. 2013
Nigeria (South-West)	15 brands	33% of samples with CFUs within acceptable limits; 14 to 18% of samples contained another indicator organism including *Staphylococcus aureus* (bacteria).	Igbeneghu and Lamikanra 2014
Bulgaria	Unspecified	Most frequently isolated contaminant: *Pseudomonas aeruginosa* bacteria (11% of samples).	Georgieva and Dimitrova 2016
China	Unspecified	17.7% of samples did not meet national bottled water quality standards.	Pu and Fukushi 2016
Philippines	Unspecified	89% were contaminated with non-fecal coliforms and 44% with fecal coliforms.	Atienza et al. 2016
USA (Ohio)	15 brands	Contamination in bottled water from 0.01 to 4,900 CFUs mL^{-1}.	Valavanidis 2020
Nigeria	Packaged water (Bottles, sachets)	High abundance of microbiological contamination across the country (coliforms, facultative pathogens).	Ajala et al. 2020
Nepal	Domestic brands of bottled water	48% contamination with total coliform bacteria and multi-drug resistant isolates (e.g. *Pseudomonas aeruginosa*).	Gautam 2021
India	Unspecified	40% of samples were contaminated with bacteria such as *E. coli*, *V. cholerae*, *Enterobacter aerogenes*; indication of antibiotic resistance.	Reddy et al. 2022
Iraq	20 domestic brands	11% bacterial contamination (coliform bacteria) and problematic bacterial isolates with antibiotic resistance (*Klebsiella pneumonia*, *P. aeruginosa*).	Hamad et al. 2022

BOTTLED WATER AND RESOURCE DEPLETION

Like many other industries, bottled water is a high consumer of water. Besides being the obvious main product, water is used in the production processes (Nestlé 2021, Coca-Cola Company 2021). It has been estimated that Coca-Cola uses 1.95 liters of water on average to produce one liter of its final product, Unilever 3.3 liters, and Nestlé 4.1 liters (Hall 2009, Coca-Cola 2021).

Across the globe, the main source of water that is bottled is groundwater. In the USA, Nestlé Waters extracts 3 million liters a day from Florida Springs. In France, Danone extracts up to 10 million liters a day from Evian-les-Bains in the French Alps. In China, the Hangzhou Wahaha Group extracts up to 12 million liters daily from Changbai Mountains springs (BlueWeave 2022). Most of China's bottled water, however, is sourced from lakes and reservoirs as over 86% of groundwater wells are unsafe for drinking (Zhang et al. 2022). In countries like Germany, Italy, the UK, Canada, and Indonesia, bottled groundwater constitutes 70–85% of all bottled water produced (BlueWeave 2022). Hence, water withdrawals by the beverage industry contribute to depleting groundwater resources, already suffering from other sectors.

Globally, over 2 billion people rely on groundwater as their primary water source (Alley et al. 2002). More than half of all irrigation water used to grow food is extracted from aquifers (Bierkens and Wada 2019, Wada et al. 2010). Estimates suggest that global groundwater depletion varied between 56 to 362 km^3 per year over the last three decades (Döll et al. 2014, Konikow 2011, Pokhrel et al. 2012, Wada et al. 2012). The amount of groundwater withdrawn in certain regions frequently exceeds natural recharge rates (Castellazzi et al. 2016, Famiglietti et al. 2011, Richey et al. 2015). Fifteen percent of all extracted groundwater is non-renewable (Döll et al. 2014).

Figure 11 illustrates estimated annual rates of groundwater depletion in some of the world's major river basins. Significant groundwater depletion has been reported in China (Famigliett 2014, Huang et al. 2015, Tang et al. 2013) India and Pakistan (Döll et al. 2014, Rodell et al. 2009) the USA (Famiglietti 2014, Richey et al. 2015) Australia (Leblanc et al. 2009, Richey et al. 2015) the Middle East and North Africa (Joodaki et al. 2014, Voss et al. 2013), Sub-Saharan Africa (Richey et al. 2015) and Central Mexico (Castellazzi et al. 2016). In some of these regions, people rely entirely on groundwater (Gleeson et al. 2010, Konikow and Kend 2005, Walton, 2015).

Women taking fresh water from open bore well in Mumbai Maharashtra India. By Bodom, Shutterstock

Globally, the major water-depleting sector is irrigated agriculture (Molden 2013). Compared to irrigation, bottled water use, both globally and within most countries is much less—at present. However, there is little data available on actual water volumes extracted by the bottled water industry, and in most cases only indirect and likely inaccurate estimates. Total water withdrawals by Coca-Cola and Nestlé in 2021 were estimated to be about 300 and 100 billion liters respectively (Nestlé 2021, The Coca-Cola Company 2021). While such withdrawals are small in absolute terms, local impacts on water resources may be significant.

A non-exhaustive summary of case studies reflecting these impacts is presented in Table 3. Some of these cases indicate that bottled water companies operate in places where communities are already suffering from drinking water shortages (Rosemann 2005, Hall and Lobina 2012). Other cases report conflicts between local communities and newly established bottled water plants and potential or perceived adverse impacts on local water resources (Jaffee and Case 2018, Rosemann 2005).

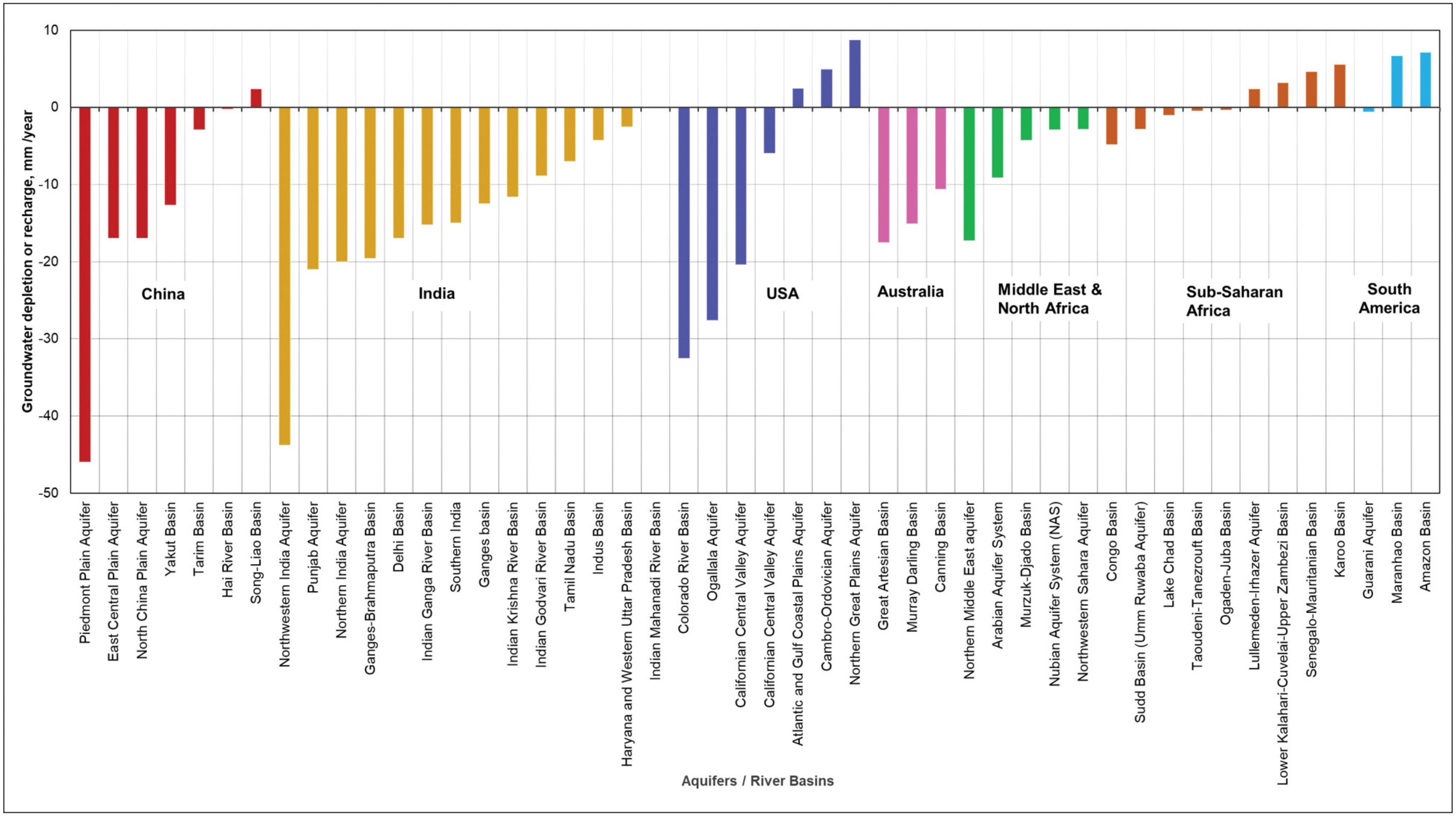

FIGURE 11. Groundwater depletion in large aquifers and river basins of the world between 2003 and 2016

Note: The unit mm/year for groundwater depletion represents the annual loss in the height of an imaginary water column per square meter.
Sources: Döll et al. 2014, Famiglietti 2014, Huang et al. 2015, Richey et al. 2015, Voss et al. 2013.

TABLE 3. Case studies on water depletion caused by bottled water companies.

Company	Location	Period	Impact	References
Coca-Cola	India: Mehdigani, Uttar Pradesh	1989–2009	Decrease in groundwater level by 7.9 m during 11 years of bottling operations.	Ghawana et al. 2011, Hall and Lobina 2012, Hassan 2016
Coca-Cola	India: Kala Dera, Rajasthan	1990 –2010	Decrease in groundwater level 10 years after bottling operation from -3.94 to -25.3 m.	Hassan 2016, Hall and Lobina 2012, Ghawana et al., 2011, Hall and Lobina, 2012, Hassan, 2016
Coca-Cola	India: Plachimada, Kerala	1999–2004	Decrease in groundwater level from 45 to 100 m. Groundwater turned brackish and milky-white due to limestone dissolution. Soil and groundwater were contaminated by heavy metals such as lead, cadmium and chrome due to bottling plants waste sludge used as 'free fertilizer' that damaged crops and caused health issues. Estimated economic loss of $48 million.	Aiyer 2007, Bijoy 2006, Carroll 2013, Ghawana et al. 2011, Hall and Lobina 2012, Ravi Raman 2010, Shree 2010, Sitisarn 2012
Coca-Cola	Mexico: Chiapas	1994–present	Coca-Cola plant owns over 30% of water resources in Chiapas using over 1 million liters of water/day (2016). Wells are drying up and local communities do not have access to safe drinking water and consume soft drinks instead resulting in an increase in diabetes and obesity.	Pliego 2019, Pskowski 2017, Vinci et al. 2018
Nestlé	Pakistan: Karachi	1998–2003	306 million liters of water are extracted annually.	Rosemann 2005
Nestlé	Pakistan: Lahore	Early 2000s	Decrease in groundwater level at an annual decline of 1.4 m/ year.	Winschewski 2017 Rosemann, 2005
Nestlé	Pakistan: Bhati Dilwan village, Southern Pakistan	2003–2016	Decrease in groundwater level from 30 to 90-120 m leading to dried springs and depriving locals of accessible groundwater sources. Locals will end up consuming Nestlé's bottled water (Pure Life) as an alternative.	Winschewski 2017 Rosemann, 2005
Nestlé	USA: Sacramento, California	2015	Extracted over 300 million liters from the aquifers in a drought year while water use restrictions were imposed on local communities.	Gumbel, 2015
Nestlé	Canada: Wellington County, Ontario	2016	Extraction of 1.6 million liters/day in addition to the 4,7 million liters/day Nestlé was already extracted in the region during the 2016 drought year.	Jaffee and Case 2018, Nestlé Waters Canada 2016
Not specified	Nepal: Jhaukhel	2003–2011	Extraction of up to 90 million liters in 2010–2011 from 12 commercial wells. Increased pumping depths from 3 to 7.6 m. Groundwater drawdown varied from 0.5 to 1.9 m/year from 2003 to 2009.	Shrestha et al. 2013

Lack of national policies and norms for groundwater management (Allen et al. 200, Hassan 2016, Packialakshmi et al. 2011, Winschewski 2017) can result in significant volumes of groundwater abstractions by bottled water companies without disclosing the volumes extracted or considering social and environmental impacts (Hall 2009, Jaffee and Newman 2013, Rooy 2002). The global expansion of the industry over the last two decades has been too fast for national legislation to be implemented effectively (Hassan 2016, Rooy 2002). This has led to the current lack of transparency and legal measures that would have compelled bottled water companies to publicly disclose the water volumes extracted and assess the environmental consequences of their activities. It would have given affected communities some leverage to hold companies accountable for adverse impacts on local groundwater resources (Ghawana et al. 2011, Packialakshmi et al. 2011). Cases have been reported where these companies used expired permits or incorrect land-use declarations which triggered public scandals (Ghawana et al. 2011, Gumbel 2015, Sitisarn 2012, Wramner 2004), or when companies faced accusations of water resources overexploitation (Brei 2018, Carroll 2013, Jaffee and Case 2018, Jithin 2016, Shree 2010, Sitisarn 2012, Wramner 2004).

Water withdrawals for bottled water affect small businesses, tourism, agriculture, and public water supply (Bierkens and Wada 2019, Konikow and Kendy 2005). Uncontrolled extraction of groundwater can disrupt local agricultural production, thereby increasing the deficit of irrigation water or leading to natural ecosystem damage (Castellazzi et al. 2016, Konikow 2011). It can also affect aquifer water quality through the remobilization of minerals and pollutants or groundwater salinization (Famiglietti 2014, Huang et al. 2015, Rooy 2002). Recharging aquifers with untreated or insufficiently treated wastewater from a bottled water plant can severely affect the suitability of groundwater as a resource for drinking water and irrigation (Hassan 2016, Packialakshmi et al. 2011, Sitisarn, 2012, Wramner 2004).

While such impacts may be relatively small in global terms, at least at present, compared to other industries, local impacts can be significant. The absence or weakness of water regulations and policies in many countries, particularly in the Global South, increases the pressure on local water resources with little or no contribution to sustainable long-term drinking water provision.

BOTTLED WATER AND PLASTIC POLLUTION

Although water can be packaged in glass bottles, aluminum cans and carton boxes (Ghoshal 2019), plastic containers represent by far the most common packaging used in the industry. Every minute, over 1,000,000 bottles are sold globally (Plastics Europe 2020, UNEP 2022) and with single-use bottle disposal comes the question of plastic pollution. This leads to a major problem, as plastic materials can take up to 1,000 years to degrade (Statista 2021c).

Today, about 400 million tons of plastic waste are produced every year (UNEP 2022). The plastic used by the bottled water industry is mostly polyethylene terephthalate (PET), which makes up 5.5% of this global plastic production (OECD 2022). PET is made from a thermoplastic polymer originating from petroleum and when heated can be easily shaped into any form (Plastics Europe 2020). This contributed to the surge of single-use plastic bottle products. PET has been in use by the bottled water industry since the 1990s, when Nestlé first introduced a plastic bottle (Gleick 2010). Today, PET is the most widely used packaging material in the beverage industry (Aslani et al. 2021). Over 97% of bottled water containers are made of plastic and almost 80% of this plastic is PET (IBWA 2022a).

The amount of PET waste generated by the bottled water sector is not evident from existing public sources but can be estimated using more general data on global plastic production and use in main sectors (Johnstone and Serret 2012). In 2019, the bottled water sector used 35% of the globally produced PET bottles (Smirthers 2019, Statista 2022a). This percentage does not change significantly over time. Related estimates suggest that 85% of the total PET water bottles produced are subsequently disposed of in landfills or as unregulated waste (UNEP 2022). This suggests that around 30% (or a factor of ~0.3) can be applied to the OECD (2022) annual data on PET packaging to estimate bottled water PET waste. Figure 12 shows the result of this estimation since the beginning of the century. It appears that the annual average amount of PET water bottle waste over this period was around 18 million tons and the 2021 amount already exceeds 25 million tonnes. Figure 12 also shows some available estimates of the total number of PET bottles disposed of (Smithers 2019). The bulk of this PET waste is produced in North America, China, and Europe (OECD 2022).

Impacts

As mentioned above, about 85% of all plastic bottles sold become waste (UNEP 2022). Most of the marine plastic debris originates from inland waste, with rivers acting as major transport pathways (Plastics Europe 2020). Plastic pollution transported via rivers accounts for up to 70–80% of the plastics in the marine environment (Li et al. 2016, Ritchie 2021, Schmidt et al. 2017).

Macroplastics, of which PET makes up a part, comprise over 80% of the annual plastic pollution in the environment, around 22 million tonnes in 2019 (OECD 2022). This also contributes to sewage system blockages in cities and towns and damages tourist and landscape values due to polluted rivers, lakes, and beaches (Nikiema and Asiedu 2022). PET, as most plastics, degrades into tiny invisible pieces, referred to as microplastics. PET "share" in microplastics is significant (Lamichhane et al., 2022) and are the most abundantly documented form of plastic debris in the ocean at present (Lamichhane et al. 2022, Law and Thompson 2014).

There are other hazardous substances released from plastic bottles. These are petroleum and toxic chemical derivatives (Li et al. 2021) commonly known as persistent organic pollutants (POPs) that are resistant to environmental degradation and spread through food chains. Examples of POPs include polychlorinated biphenyls (PCBs) and dichlorodiphenyltrichloroethane (DDT), which can be transferred to animal tissues by ingesting microplastics, especially in marine environments and contaminate animal and human food chains (Rhodes 2018, Zhou et al. 2021).

Microplastics can also be vectors for other environmental pollutants such as polycyclic aromatic hydrocarbons (PAH) and heavy metals (Cd, Pb, Cu, Zn, etc.) that can all be adsorbed by a plastic surface, thus leading to the formation of plastic-pollutant mixtures in the environment (Li et al. 2021).

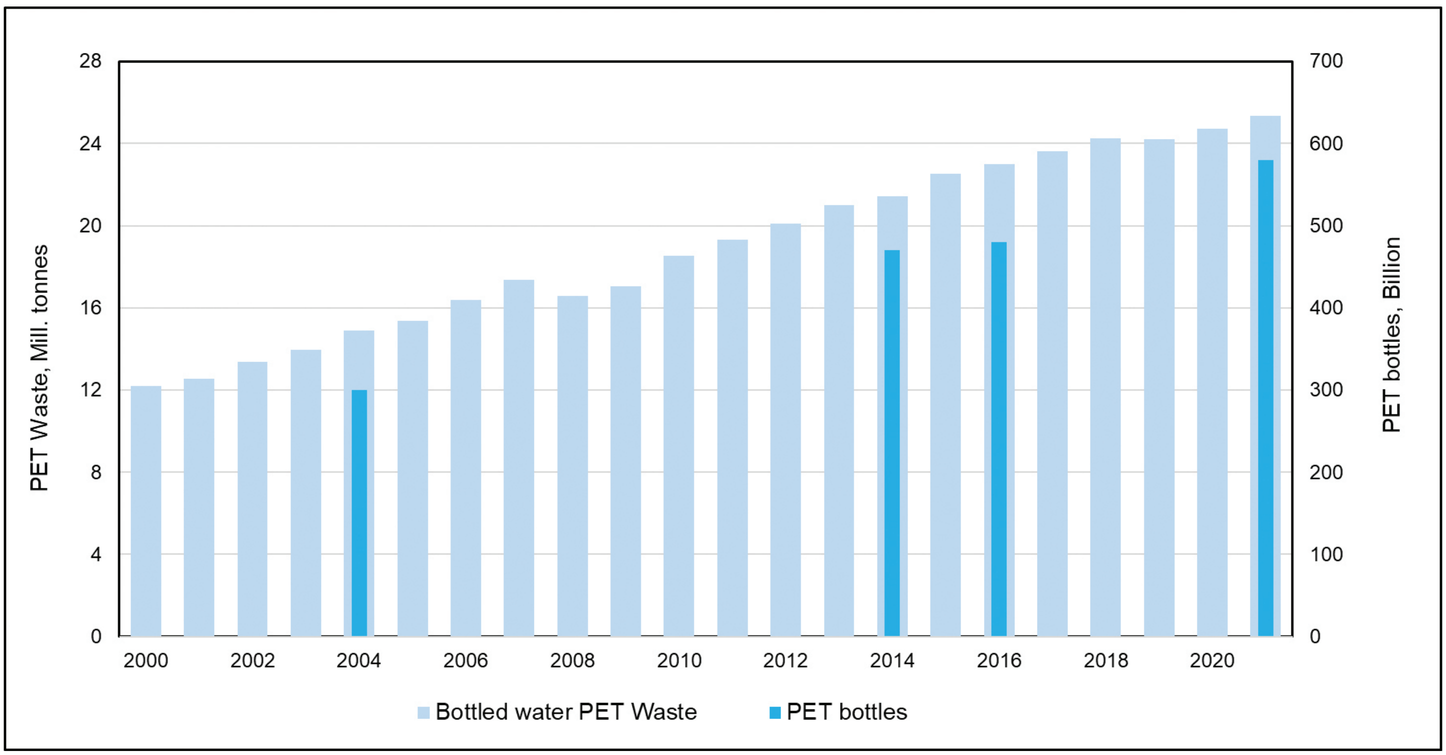

FIGURE 12. Time series of estimated global bottled water PET waste from 2000 to 2021.

Note: Dark bars show estimates of number of bottles disposed of.
Source: Smithers 2019

People are also consuming microplastics through food. It is estimated that humans ingest an amount of plastic equivalent to the size of a credit card on a weekly basis (Statista 2021c). The long-term health effects are not yet fully understood. However, concerns remain about the bioaccumulation of microplastics in the intestines and liver and a greater health risk is perceived to be associated with the presence of nanoplastics (Lim 2021). Some studies reported noticeable amounts of microplastics in bottled water (Mason et al. 2018, Schymanski et al. 2018) (see Table 2 for more examples) and there is also evidence of endocrine-disruptive chemicals in commercially available bottled water (Wagner et al. 2013). However, there is currently an overall lack of data and insufficient scientific evidence that could raise human health concerns from microplastics in drinking water (WHO 2019).

Carbon dioxide pollution is another major global environmental issue, to which the bottled water industry is contributing. In 2019, emissions from the life cycle of all plastics were 860 million tonnes of carbon dioxide worldwide. This is equivalent to the carbon dioxide emitted by 189 coal plants at full capacity. This is projected to triple by 2050 (Statista 2021c). Information on PET-specific carbon emissions at the production stage, and PET water bottle carbon emissions in particular, has not been identified due to the lack of data, although they may be in similar proportions to total plastic emissions as the proportions between plastic types themselves, i.e. much smaller. However, disposed PET, including bottled water PET, is often incinerated and can elevate carbon emissions from bottled water (OECD 2022).

Recycling

Since the 1950s, only 6.5% of all plastics produced have been recycled (Statista 2021b) and today, only 14% is recycled (World Economic Forum 2022). Most PET bottles are disposed of after the first use. To make new bottles, more crude oil is required (Gleick 2010). Data on how much water bottle plastic is recycled is elusive. Data on annual plastic production by major companies before 2017 were not readily available (Laville and Taylor 2017) but this appears to be changing. Some estimates suggest that Coca-Cola, for example, produced nearly 3 million tonnes of plastics in 2019, of which only 3% was reusable (Greenpeace 2022). Over the last decade, bottled water companies have been making efforts to increase the use of recycled PET (rPET), but their recycling rates remain low (IBWA 2021). At a country level, recycling rates differ between countries depending on their policies and regulations. For instance, strong regulations are in place for bottle recycling in Denmark, Germany, Norway, and Switzerland, where plastic recycling rates are generally over 80%. This is higher than the average European recycling rate (41%) (Eurostat 2021, Gleick 2010), while in North America, PET recycling rates were about 35% in 2019 (IBWA 2021, NAPCOR 2021).

Although plastic recycling, while environmentally friendly, could be a costly challenge for companies (OECD 2018), there is growing social awareness of the impacts of plastics on the environment and the importance of recycling. In North America, 10% more products made of rPET were consumed in 2020 compared to 2019 (NAPCOR 2021). In Mexico, the first plant for bottle-to-bottle recycling and producing rPET pellets was established by Coca-Cola in 2005 (Schwanse 2011). In Indonesia, plastic bottle recycling is an emerging industry (Kristina et al. 2018). Some countries have implemented national programs to limit the use of PET bottles and plastics (Benyathiar et al. 2022). Examples include Mexico (Schwanse 2011), Brazil (Coelho et al. 2011), and the European Union (Franz and Welle 2022).

Alternatives

There is an ongoing search for more environmentally friendly alternatives to plastic bottles. One such alternative is biodegradable bioplastics made from plants. Bioplastic was first introduced in the 1980s and it currently exists in several varieties (Ferreira-Filipe et al. 2021). For example, corn-based polylactic acid (PLA) bottles are biodegradable in principle but need specific conditions to degrade in landfills such as high temperature, high moisture, and the presence of certain micro-organisms (Gironi and Piemonte 2011). In the absence of these conditions, they can take as long as PET bottles to degrade. Additionally, if PLA bottles run off into water bodies, they can cause eutrophication (Papong et al. 2014) and can be adhered to PET, a combination that seems to be challenging to separate (Gironi and Piemonte 2011, Gleick 2010). Turning to polycyclic bottles may reduce greenhouse gas emissions, toxicity, and fossil energy demand. However, this needs careful management of bioplastic waste, including composting, incineration, and recycling (Gironi and Piemonte 2011).

Another alternative is the use of ENSO bottles. These are regular PET bottles that contain an additive that makes the bottle more enticing to the billions of micro-organisms that normally degrade plastic. Micro-organisms break down plastic bottles into biogases and inert humus leaving no toxic materials behind (Horowitz et al. 2018).

None of the available alternatives to PET are yet a breakthrough solution that could significantly reduce the environmental impacts of plastic water bottles.

BOTTLED WATER AND SUSTAINABLE DEVELOPMENT

Water reservoirs and bottles were distributed to respond to the earthquake in Les Cayes in Haiti in 2021, By UNICEF, OCHA

As may be inferred from the above sections, bottled water has links with and impacts on many Sustainable Development Goals (SDG) of the UN Agenda 2030. The withdrawal of groundwater for bottled water contributes to increasing water stress (SDG Indicator 6.4.2) in already water-depleted areas. Adoption of sustainable practices and integration of sustainability information into public reporting by bottled water companies would increase sector transparency in accordance with SDG 12 on responsible consumption and production. Increasing efforts in plastic waste recycling in the bottled water sector would also contribute to SDG 12 and SDG 14.1 by reducing marine pollution from land-generated plastic debris.

However, it is universal and equitable access to safe and affordable drinking water (SDG Target 6.1) where the impacts of bottled water are the strongest. Bottled water can hardly be considered a sustainable or affordable solution to the issue of safe and reliable drinking water provision. That it takes between two to four liters of water to produce one liter of bottled water already raises questions of sustainability and common sense (Hall 2009, The Coca-Cola 2021).

In the absence of water that meets quality standards, bottled water might provide a safe drinking water supply to a limited extent. However, it seems to have an ambiguous classification according to the JMP (Joint Monitoring Program), where it is excluded from the specifically “safely managed” drinking water services, and considered an “improved” drinking water service, meaning that it has the potential to deliver safe water while meeting the following specific criteria: accessible on premises, available when needed, and free from contamination, a category, that combines piped water, boreholes, wells, protected dug wells, protected springs, and rainwater (WHO et al. 2022). However, considering the different bottled water types described herein with regard to the water sources, and the question of quality, this categorization of bottled water could be questioned.

On the other hand, bottled water could be considered a commodity traded as a commercial product, making its affordability and accessibility of it questionable. Therefore, the strategy of relying on bottled water as a source of clean water is hardly compatible with the human right to water and does not support progress toward achieving SDG 10 on reducing inequalities. Bottling companies are by-default exercising their lucrative activities to sell bottled water for 150 to 1,000 times higher than a liter of tap water (Ferrier 2001, Jain et al. 2019, Ochungo et al. 2019). One can argue that the high price of bottled water is indeed a positive step toward reducing its waste and the high margin provides room for taxation and addressing inequalities through a transaction from the rich to the poor. However, the bottled water market is steadily growing, and plastic waste volume will not reduce in the coming decades. This ideal scenario could be applied in the presence of committed governmental tax and environmental regulations that financially frame the industry at the global scale, to benefit the population towards more equality. However, the industry remains often power-neutral, where politics, is absent from the discussion over how bottled water could be a supply to support achieving SDG6.1 (Kooy and Walter 2019)

The most straightforward linkage with regard to human rights to water and industry profitability is related to the control and exploitation of water resources (surface water and aquifers) by bottling corporations at a very low cost to meet the market's increasing demands. This could be considered as "an unfair competition" with the national population over sources of water for food and safe drinking water. While total water withdrawal volumes are not eminent in absolute global terms, the impact of resource overexploitation on local populations is often alarming and scandalous, especially when bottled water corporations use expired permits and incorrect land-use declarations. In addition, in the top three biggest markets such as the American and Indonesian markets, bottling tap water and reselling it (after a possible treatment) is a common practice (Prasetiawan et al, 2017). These activities of providing bottled water with higher prices instead of alternative cheaper options do not position bottled water as an "affordable" and "accessible" water supply for everyone, contradicting the SDG 6.1 target foundation in providing water as essential for dignity and as a human right.

It can be argued that the bottled water industry is not aligned strategically with the goal of providing universal access to drinking water or at least slows global progress in this regard, distracting development efforts and redirecting attention to a less reliable and less affordable option for many, while remaining highly profitable for producers.

The increasing market demands that bottling corporation aims to meet, is the product of complex interconnected reasons, where governments and corporations share responsibility towards the role of bottled water in SDG6. In parts of LMIC, and particularly in the biggest regional markets, such as the Asian pacific countries, the increase in the consumption of bottled water is motivated by the poor quality of safe drinking water which can be seen as a proxy indicator of the failure of public water supply systems (Foster et al. 2021, Ochungo et al. 2019, Prasetiawan et al. 2017). The weak governmental commitment to deliver safe drinking water is an unfortunate outcome of the decades of limited progress with a public water supply and its many failures. In HIC, although consumption may also be related to the concerns about the reliability and the quality of tap water, it is mostly driven by perceptions fostered by big marketing campaigns against the public water distribution systems, that promote bottled water "purity and safety" using sporadic events and repetitive advertisement over years, making an impact on the collective subconscious.

On a global scale, all countries share a common feature: weak and inadequate regulations. Poor policies framing bottled water corporations are noticed globally causing adversities at different levels. Appropriate legislation for bottled water quality control, groundwater exploitation, land use, plastic waste management, carbon emissions, finance, and transparency obligations, all need to be strengthened and adopted strategically in SDG6 national agendas. In addition, the national government should take into account other issues such as the growing population, food security, and climate change to complete the whole puzzle by including the bottled water industry, in the SDGs- and SDG6-related discussions.

The existing regulatory gaps represent suitable environments for bottling corporations to grow their business and to use the "poor public water sources" excuse to fuel their campaigns that influence perception. This could lead to a vicious cycle by discouraging public institutions from investing further in maintaining piped water quality given the low willingness to use tap water for drinking. Even if the piped water is or can be of good quality, substantial marketing efforts may now be required to restore people's trust in drinking water from a tap. A study conducted on American consumers to evaluate their attitudes and willingness to pay for improved drinking water systems has shown that consumers would support improvements in public water infrastructure for better quality (Tanellari et al.2015). Therefore, unrestricted bottled water development may, especially in LMIC, weaken or even eliminate the role of the state in providing drinking water and slow or even halt improved water infrastructure development (Bakker et al. 2008, Green 2018, Foster et al. 2021). Conversely, if good quality tap water is provided through public water systems, the bottled water industry may not be necessary at the scale and magnitude it has achieved.

Governments have powerful tools to change consumers' attitude by increasing awareness among consumers with the help of environmental activists and civil society. While there is a growing social awareness of the issues related to the bottled water industry, especially with regard to the environmental impacts of PET and microplastics, more efforts are still needed in raising awareness of these issues, especially where recycling and environmental solutions are not nationally prioritized. In addition, governments should advocate for improved public water quality standards and regulations, if applicable, while shedding light on the non-systematic safety and the possible contamination of water sold in packages.

Countries that aim to accelerate their progress toward reliable drinking water supply may need to establish how and when bottled water represents an acceptable drinking water service (Chigonda and Rusena 2019). In areas where improved water supplies are available, investments should be directed toward maintaining existing or developing

Bottled and galon water containers are very popular in Indonesia due to the deteriorated piped water quality and low public distribution coverage in the country. By Moh. Idrus, Shutterstock

new drinking water infrastructure. At the same time, bottled water may be useful or necessary in some cases, for example, in disaster situations (Cohen and Ray 2018, IBWA 2022) or during sporadic disruptions or episodes of tap water contamination (Ferrier et al. 2001).

The current total annual volume of the three main types of bottled water considered in this review is around 350 billion liters, while if all bottled water types are considered, it would be around 470 billion liters (Statista 2020, 2022a). While these numbers may seem large, they are about 50% of the annual municipal drinking water consumption in a single city like London (London City Hall 2022) or about a third of Sydney, Australia (NSW Environment Protection Authority 2022). Clearly, only around 5–10% of domestic water provided is used for drinking (DeOreo et al. 2016, Wei et al. 2021). Yet, even if drinking water were to constitute a flat 5% of the total domestic piped water supply, the global annual volume would be in the tens of trillions of liters—orders of magnitude higher than bottled water.

In 2020, 74% of the world's population used safely managed drinking water compared to 62% in 2000 (WHO et al. 2022). Despite this progress, there are wide geographical disparities and around two billion people still do not have access to safely managed drinking water. The lowest coverage of safely managed services is in the Sub-Saharan Africa region (30%). Still, no region is on track to achieve universal access to safely managed drinking water services by 2030.

The annual financing required from 2015 to 2030 to ensure safely managed, continuously available, and improved drinking water services to achieve a universal drinking water supply (SDG 6.1) was initially estimated at 114 billion US$ (Hutton and Varughese, 2016). If this estimate is compared with the global annual sales of bottled water (around 270 billion US$), one year of revenue from global bottled water sales would be sufficient to finance safely managed drinking water supply projects globally for more than two years. In other words, it takes only about half of what the world is paying for bottled water annually to finance the required annual progress in provision of clean tap water for hundreds of millions of people without it. It is not likely that such investments will happen in the eight remaining years of the SDGs. However, this comparison points to a global case of extreme social injustice, whereby billions of people worldwide do not have access to reliable water services (WHO et al. 2022) while others enjoy water luxury.

Seven years into the SDG era, the annual requirement for water financing has never yet been met. It is estimated that quadrupling the current rate of progress is needed to meet SDG Target 6.1 by 2030 (WHO et al. 2022). Achieving this in the next eight years is a colossal challenge due to significant global vulnerabilities, competing financial priorities and because business-as-usual in the water sector prevails.

However, attempts are being made to scale up financing for the SDGs and private sector support can play a major role. A recently established alliance of Global Investors for Sustainable Development (GISD) engages global business leaders from across the world to bridge the estimated annual gap of $4.3 trillion in financing all 17 SDGs. GISD has developed a unified definition of Sustainable Development Investing and SDG-aligned, sector-specific metrics that strengthen reporting and enables credible comparisons of SDG performance within and across industries. Several business sectors such as consumer staples and utilities are already exploring how to align investments with sustainable development and specific SDGs, including SDG 6. There are definitely opportunities for the bottled water sector to become an active player in this process and collaborate with the public sector on providing reliable drinking water, help boost financing and investment in water infrastructure, particularly in LMIC, and integrate sustainable development into business strategies, management, and governance processes.

CONCLUSIONS

The report attempted to review the existing information on various aspects of and perceptions of bottled water and its role in the context of sustainable development. One general observation from this experience is that information and data in the public domain are often limited, fragmented, and sometimes inconsistent, especially in the countries of the Global South. Market-related information and data for individual countries or companies are often either not available or turn out to be prohibitively expensive for a detailed independent analysis. Therefore, the report's findings and conclusions should largely be seen as preliminary.

The report shows that bottled water has developed into a major and essentially standalone economic sector in just around the past five decades. Based on the analysis of 109 countries, the study estimates that the global bottled water market, encompassing the three tap-water-like water types, is currently worth 270 billion US$ producing some 350 billion liters. This market is one of the most dynamic in the world, growing faster than any other food market, and is projected to reach and exceed 500 billion US$ by around 2025–2030. Bottled water sales and consumption are the highest in the Asia-Pacific region followed by North America and Europe. The Global South combined (Asia-Pacific, Africa, Latin America and the Caribbean) represents 60% of global sales. On a country level, the largest market is the USA with total revenue of around 64 billion US$, followed by China (almost 45 billion US$) and Indonesia (22 billion US$). These three countries combined constitute almost half of the global bottled water market. Most other national markets are small compared to the top 10–12 countries (USA, China, Indonesia, Canada, Australia, Singapore, Germany, Thailand, Mexico, Thailand, Italy, Japan) in both total sales in dollars and total consumption in liters.

Singapore and Australia are identified as the largest consumers of bottled water per capita. The USA, and particularly China, rank much lower in terms of per capita consumption (sales in liters). Most national markets, if measured in per capita terms, are much smaller.

Treated water appears to be the largest component on the market by volume, while other natural waters appear to generate the most profit. Treated and mineral bottled water types demonstrate the highest annual growth rates of over 10%. Egypt has the fastest-growing market of treated bottled water (with over 40% annual growth). In addition to Egypt, seven other countries from the Global South are in the top-ten fastest-growing markets for treated water (Algeria, Brazil, Indonesia, United Arab Emirates, India, Morocco, and Saudi Arabia). Egypt and Algeria are also among the top-ten fastest-growing markets for bottled mineral water, although the three Asia-Pacific countries (South Korea, India, and Japan) have higher growth rates in this category.

There appears to be no obvious pattern that determines the size and rate of growth of a national market, but factors such as natural water endowment, degree of economic development, and population size may play their role. This aspect may need to receive more research attention in the future.

However, the literature review suggests that bottled water market drivers differ significantly between regions and countries. In the Global North, bottled water is often perceived as a healthier and tastier product than tap water; it is, therefore, more a luxury good than a necessity with most of the Global North countries having often reliable and good quality public drinking water supply. In the Global South, the bottled water market develops primarily due to the lack or absence of this reliable public water supply along with increasing urbanization with associated limited infrastructure for water delivery. Marketing campaigns by the bottled water industry aiming to promote the concept of bottled water "purity" and to discredit tap water for its poor quality, also played their role.

The perception that bottled water is safer than tap water needs to be challenged. Beverage corporations are adept at marketing bottled water as a "safe alternative" to tap water by drawing attention to isolated public water system failures. At the same time, bottled water rarely faces the same rigorous public health and environmental regulations as tap water. Scientific evidence backing claims of bottled water purity and safety is limited. At the same time, examples identified and summarized in this report from tens of countries from every region of the world, illustrate cases of inorganic, organic and microbiological contamination of hundreds of bottled water brands of all bottled water types. This review constitutes strong evidence against the misleading perception that bottled water is an unquestionably safe drinking water source. It clearly indicates that bottled water quality can be compromised either by the origin of water or by industrial processes that may potentially impact human health. Hence, while there are, indeed, also numerous examples of poor water quality in public domestic drinking water supply, it is hardly justifiable to claim that bottled water is any "safer". The report also shows that bottled water producers have, by and large, managed to avoid the kind of scrutiny imposed by government standards and regulations that public utilities must adhere to. As the bottled water market grows, it is probably more important than ever to strengthen legislation that regulates the industry overall and its water quality standards in particular.

Water withdrawals by the bottled water industry can lead or contribute to the depletion of groundwater resources in areas of water procurement for bottling in many parts of the world, which makes this an issue of global scale and relevance as over two billion people globally rely on groundwater as their primary water source. In certain cases, groundwater withdrawn for bottled water production may not even be replenishable. Global South, where safe drinking tap water is not always available, may be lucrative markets for future bottled water market expansion. In this context, the lack of national policies and norms for groundwater management in many such countries may promote uncontrolled groundwater withdrawal for bottling. Some case studies on water depletion caused by bottled water companies have been identified and summarized in this report. Yet, there are very few and overall little data available on water volumes extracted by the bottled water industry, again largely due to the lack of transparency and legal foundations that would have forced bottling companies to publicly disclose the extracted water volumes and assess the environmental consequences of their activities. Even if such water withdrawals are indeed small in absolute terms globally at present or compared to larger water consumers like irrigated agriculture, local impacts on water resources may be significant.

In this context, again, the absence or weakness of water regulation policies in many countries, particularly those of the Global South, together with bottled water market growth in such countries may increase the pressure on local water resources, with little or no contribution to sustainable and reliable long-term drinking water supply.

The report also examined various aspects of plastic pollution associated with bottled water and collated some scattered information from available sources. It appears that the world currently generates around 600 billion plastic bottles and containers, which converts to some 25 million tonnes of PET waste. Most of this waste is not recycled. The report, however, identifies signs of a trend toward a growing social awareness of the adverse impacts of plastics on the environment and of the importance of its recycling. It also touches on the more environmentally friendly alternatives to PET bottles but concludes that at a breakthrough solution that could radically reduce the environmental impacts of plastics does not yet exist, and hence PET pollution will likely continue in the years to come. Although PET waste from bottled water constitutes a very small percentage of the total plastic of all types generated by all industries globally, eradicating even small sources of such pollution would contribute immensely to environmental health, particularly considering that plastic waste takes a millennium to degrade. It may be argued that if the world focuses more attention on the provision of clean and safe piped water supply, bottled water production may be reduced, which, in turn will lead to the reduction of plastic waste. It is important to deal with the source of the problem rather than with its consequences.

Bottled water has clear and implicit links with several SDGs, but the strongest ones are obviously with universal access to drinking water—SDG target 6.1. The report argues that while global progress toward this target is significantly off-track, expansion of bottled water essentially works against it or at least slows this progress down, distracting attention and resources from public water supply system development. Expansion of bottled water may adversely affect investments and the role of the state in long-term public water supply infrastructure development and improvement. A comparison of estimates of global bottled water sales with the estimated needs to finance the progress to SDG 6.1 reveals that less than half of what the world pays for bottled water annually at present would pay to provide clean and long-term public water supply for hundreds of millions of people without it.

Bottled water producers have a financial incentive to expand their markets. They also have resources for marketing campaigns. To counter negative perceptions of tap water, civil society groups and NGOs should be encouraged and financially supported to run advocacy campaigns. Private companies can be expected to resist attempts to implement any measures that would increase their costs, but they will respond to consumer demands. Advocacy campaigns can point to water quality and resource depletion issues. They can also highlight cases of successful provision of high-quality tap water and point to the positive actions of companies such as steps to improve the transparency of operations, access to data or actions to enhance plastic recycling.

Finally, there are currently some high-level initiatives, like an alliance of Global Investors for Sustainable Development, that aim to scale up finance for the SDGs, including water-related ones. Such an initiative is an opportunity for the bottled water sector to become an active player in this process and help accelerate progress toward reliable water supply, particularly in the Global South.

ACKNOWLEDGEMENTS

This research was supported by funds received by UNU INWEH through a long-term agreement with Global Affairs Canada. The authors thank Morgane Bouvet (The University of Edinburgh), Ethan Danielli, Amanda Giancola, and Muhammad Anwer (McMaster University) for their research contribution, and Manzoor Qadir (UNU INWEH) for providing his valuable insights in reviewing the manuscript. The authors also gratefully acknowledge the comments and edits by Terry Clayton.

REFERENCES

Abd El-Salam, M. M., El-Ghitany, E. M., and Kassem, M. M. (2008). Quality of bottled water brands in Egypt part I: Physico-chemical analyses. *J. Egypt Public Health Assoc* **83**, 369-388.

Ahmed, A., and Shafique, I. (2019). Perception of household in regards to water pollution: an empirical evidence from Pakistan. *Environmental Science and Pollution Research* **26**, 8543-8551.

Aiyer, A. (2007). The allure of the transnational: notes on some aspects of the political economy of water in India. *Cultural Anthropology* **22**, 640-658.

Ajala, O. J., Ighalo, J. O., Adeniyi, A. G., Ogunniyi, S., and Adeyanju, C. A. (2020). Contamination issues in sachet and bottled water in Nigeria: a mini-review. *Sustainable Water Resources Management* **6**, 1-10.

Allen, A., Dávila, J. D., and Hofmann, P. (2006). The peri-urban water poor: citizens or consumers? *Environment and Urbanization* **18**, 333-351.

Alley, W. M., Healy, R. W., LaBaugh, J. W., and Reilly, T. E. (2002). Flow and storage in groundwater systems. *science* **296**, 1985-1990.

Aquastat, F. (2016). Water withdrawal by sector, around 2006. *Update november*.

Aslani, H., Pashmtab, P., Shaghaghi, A., Mohammadpoorasl, A., Taghipour, H., and Zarei, M. (2021). Tendencies towards bottled drinking water consumption: Challenges ahead of polyethylene terephthalate (PET) waste management. *Health Promotion Perspectives* **11**, 60.

Atienza, B. A., Jalover, A., Sepe, E. M., and Tabanag, K. (2016). Microbiological Profile Of Bottled And Tap Drinking Water In Brgy. San Miguel, Iligan City. *GSTF Journal of Nursing and Health Care (JNHC)* **3**.

Bakker, K., Kooy, M., Shofiani, N. E., & Martijn, E. J. (2008). Governance failure: Rethinking the institutional dimensions of urban water supply to poor households. *World Development*, **36**(10), 1891-1915.

Benyathiar, P., Kumar, P., Carpenter, G., Brace, J., and Mishra, D. K. (2022). Polyethylene Terephthalate (PET) Bottle-to-Bottle Recycling for the Beverage Industry: A Review. *Polymers* **14**, 2366.

Bierkens, M. F., and Wada, Y. (2019). Non-renewable groundwater use and groundwater depletion: a review. *Environmental Research Letters* **14**, 063002.

Bijoy, C. R. (2006). Kerala's Plachimada struggle: a narrative on water and governance rights. *Economic and Political Weekly*, 4332-4339.

Blake, P. A., Rosengerg, M. L., Costa, J. B., Ferreria, P. S., and Guimaraes, C. L. G., Eugene J (1977). Cholera in Portugal, 1974: I. Modes of transmission. *American journal of epidemiology* **105**, 337-343.

BlueWeave (2022). Global bottled Water Market : Forecast to 2030. Report. *BlueWeave Consulting*, 222.

Brei, V., and Tadajewski, M. (2015). Crafting the market for bottled water: a social praxeology approach. *European Journal of Marketing* **49**, 327-349.

Brei, V. A. (2018). How is a bottled water market created? *WIREs Water* **5**, 14p.

Cabral, D., and Pinto, V. E. F. (2002). Fungal spoilage of bottled mineral water. *International journal of food microbiology* **72**, 73-76.

Carr, G., Neary, P. J., Hodgson, K., Richards, R., Baker, S., Zalewski, M., and Wagner, I. (2008). Water Quality for Ecosystem and Human Health. *United Nations Environment Programme, Global Environment Monitoring System/Water Programme* **2**, 130p.

Carroll, A. (2013). Have a Coke and a Smile: Is the Aqueduct Alliance Coca-Cola's Solution to Escape Future Liability for Groundwater Depletion. *Pac. McGeorge Global Bus. & Dev. LJ* **26**, 475.

Castellazzi, P., Martel, R., Rivera, A., Huang, J., Pavlic, G., Calderhead, A. I., Chaussard, E., Garfias, J., and Salas, J. (2016). Groundwater depletion in Central Mexico: Use of GRACE and InSAR to support water resources management. *Water resources research* **52**, 5985-6003.

Cha, J., and Lee, J.-Y. (2020). Qualities of groundwater source used for production of commercial bottled waters in Korea. 지질학회지 **56**, 789-802.

Chidya, R. C., Singano, L., Chitedze, I., and Mourad, K. A. (2019). Standards compliance and health implications of bottled water in Malawi. *International Journal of Environmental Research and Public Health* **16**, 951.

Chigonda, T., and Rusena, T. (2019). Bottlemania: the bottled drinking water boom in Zimbabwe with a special focus on Harare. *European Journal of Social Sciences Studies*.

Clarke, T. (2007). Inside the bottle: an exposé of the bottled water industry. *Canadian Ctr for Policy, Ottawa: Polaris Institute*, Revised edition. 216p.

Coelho, T. M., Castro, R., and Gobbo Jr, J. (2011). PET containers in Brazil: Opportunities and challenges of a logistics model for post-consumer waste recycling. *Resources, conservation and recycling* **55**, 291-299.

Cohen, A., Rasheduzzaman, M., Darling, A., Krometis, L.-A., Edwards, M., Brown, T., Ahmed, T., Wettstone, E., Pholwat, S., and Taniuchi, M. (2022). Bottled and Well Water Quality in a Small Central Appalachian Community: Household-Level Analysis of Enteric Pathogens, Inorganic Chemicals, and Health Outcomes in Rural Southwest Virginia. *International Journal of Environmental Research and Public Health* **19**, 8610.

Cohen, A., and Ray, I. (2018). The global risks of increasing reliance on bottled water. *Nature Sustainability* **1**, 327-329.

Cox, K. D., Covernton, G. A., Davies, H. L., Dower, J. F., Juanes, F., and Dudas, S. E. (2019). Human consumption of microplastics. *Environmental science & technology* **53**, 7068-7074.

DeOreo, W. B., Mayer, P., Dziegielewski, B., and Kiefer, J. (2016). Residential end uses of water. *Water Research Foundation*, Version 2. Denver, Colorado.

Díaz, G., Ortiz, R., Schettino, B., Vega, S., and Gutiérrez, R. (2009). Organochlorine pesticides residues in bottled drinking water from Mexico City. *Bulletin of environmental contamination and toxicology* **82**, 701-704.

Diduch, M., Polkowska, Ż., and Namieśnik, J. (2011). Chemical quality of bottled waters: a review. *Journal of food science* **76**, R178-R196.

Diduch, M., Polkowska, Ż., and Namieśnik, J. (2013). Factors affecting the quality of bottled water. *Journal of exposure science & environmental epidemiology* **23**, 111-119.

Dindarloo, K., Ghaffari, H. R., Kheradpisheh, Z., Alipour, V., Ghanbarnejad, A., Fakhri, Y., and Goodarzi, B. (2016). Drinking water quality: comparative study of tap water, drinking bottled water and point of use (PoU) treated water in Bandar-e-Abbas, Iran. *Desalination and water treatment* **57**, 4487-4493.

Döll, P., Müller Schmied, H., Schuh, C., Portmann, F. T., and Eicker, A. (2014). Global-scale assessment of groundwater depletion and related groundwater abstractions: Combining hydrological modeling with information from well observations and GRACE satellites. *Water Resources Research* **50**, 5698-5720.

DWRF (2022). The Drinking Water Research Foundation- Regulations *The Drinking Water Research Foundation*, accessed 05.04.2022 at https://thefactsaboutwater.org/

Eckmanns, T., Oppert, M., Martin, M., Amorosa, R., Zuschneid, I., Frei, U., Rüden, H., and Weist, K. (2008). An outbreak of hospital-acquired *Pseudomonas aeruginosa* infection caused by contaminated bottled water in intensive care units. *Clinical Microbiology and Infection* **14**, 454-458.

Environmental Working Group (2008). Bottled Water Quality Investigation: 10 Major Brands, 38 Pollutants. *Environmental Working Group*.

Ericson, I., Nadal, M., van Bavel, B., Lindström, G., and Domingo, J. L. (2008). Levels of perfluorochemicals in water samples from Catalonia, Spain: is drinking water a significant contribution to human exposure? *Environmental Science and Pollution Research* **15**, 614-619.

Eurostat (2021). EU recycled 41% of plastic packaging waste in 2019. *Eurostat*, accessed 14.12.2022 at https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20211027-2

Falcone-Dias, M. F., Vaz-Moreira, I., and Manaia, C. M. (2012). Bottled mineral water as a potential source of antibiotic resistant bacteria. *Water research* **46**, 3612-3622.

Famiglietti, J. S. (2014). The global groundwater crisis. *Nature Climate Change* **4**, 945-948.

Famiglietti, J. S., Lo, M., Ho, S. L., Bethune, J., Anderson, K., Syed, T. H., Swenson, S. C., de Linage, C. R., and Rodell, M. (2011). Satellites measure recent rates of groundwater depletion in California's Central Valley. *Geophysical Research Letters* **38**.

FAO/WHO (2007). "Codex Alimentarius - Waters," Food & Agriculture Org., Rome.

Ferreira-Filipe, D. A., Paço, A., Duarte, A. C., Rocha-Santos, T., and Patrício Silva, A. L. (2021). Are biobased plastics green alternatives?—A critical review. *International Journal of Environmental Research and Public Health* **18**, 7729.

Ferrier, C. (2001). Bottled water: understanding a social phenomenon. *AMBIO: A journal of the Human Environment* **30**, 118-119.

Foltz, F. (1999). Science, pollution, and clean drinking water: choosing between tap water, bottled water, and home purification. *Bulletin of Science, Technology & Society* **19**, 300-309.

Food Safety Authority Ireland (2009). The consumption of bottled water containing certain bacteria or groups of bacteria and the implications for public health. Report.. *Food Safety Authority Ireland Report*, Dublin. 20p.

Foster, T., Priadi, C., Kotra, K. K., Odagiri, M., Rand, E. C., and Willetts, J. (2021). Self-supplied drinking water in low-and middle-income countries in the Asia-Pacific. *NPJ Clean Water* **4**, 1-10.

Francisco, J. P. S. (2014). Why households buy bottled water: a survey of household perceptions in the P hilippines. *International Journal of Consumer Studies* **38**, 98-103.

Franco, R., and Cantusio Neto, R. (2002). Occurrence of cryptosporidial oocysts and giardia cysts in bottled mineral water commercialized in the city of Campinas, State of São Paulo, Brazil. *Memórias do Instituto Oswaldo Cruz* **97**, 205-207.

Franz, R., and Welle, F. (2022). Recycling of post-consumer packaging materials into new food packaging applications—critical review of the european approach and future perspectives. *Sustainability* **14**, 824.

Gautam, B. (2021). Microbiological quality assessment (including antibiogram and threat assessment) of bottled water. *Food Science & Nutrition* **9**, 1980-1988.

Geerts, R., Vandermoere, F., Van Winckel, T., Halet, D., Joos, P., Van Den Steen, K., Van Meenen, E., Blust, R., Borregán-Ochando, E., and Vlaeminck, S. E. (2020). Bottle or tap? Toward an integrated approach to water type consumption. *Water research* **173**, 115578.

Georgieva, V., and Dimitrova, Y. (2016). Study of the microbiological quality of Bulgarian bottled water in terms of its contamination with *Pseudomonas aeruginosa*. *Central European Journal of Public Health* **24**, 326-330.

Ghana Statistical Service (2009). Ghana statistical service (GSS), Ghana health service (GHS), and ICF macro. *Accra: Ghana Demogr Health Surv* 2008, 79-96.

Ghana Statistical Service (2013). 2010 population & housing census: National analytical report.

Ghawana, T., Hespanha, J. P., Zevenbergen, J., and Van Oosterom, P. (2011). Spatial dimensions of land administration and user rights over groundwater: Case study of Kerala, India vs. Coca Cola. *In* "Proceedings of the FIG Working Week 2011" Bridging the Gap between Cultures" & 6th National Congress of ONIGT, Marrakech, Morocco, 18-22 May 2011". International Federation of Surveyors (FIG), Ordre National des Ingénieurs.

Ghoshal, G. (2019). Recent development in beverage packaging material and its adaptation strategy. *Trends in Beverage Packaging*, 21-50.

Gironi, F., and Piemonte, V. (2011). Bioplastics and petroleum-based plastics: strengths and weaknesses. *Energy sources, part a: recovery, utilization, and environmental effects* **33**, 1949-1959.

Gleeson, T., VanderSteen, J., Sophocleous, A., Taniguchi, M., Alley, W., Allen, D., and Zhou, Y. (2010). Commentary: Groundwater sustainability strategies. *Nature Geoscience* **3**, 378–379.

Gleick, P. H. (2010). Bottled and sold: The story behind our obsession with bottled water. Vol. 119(5): A224, pp. 288p. Island Press.

Grand View Research (2022). Bottled Water Market Size, Share & Trends Analysis Report By Product (Spring Water, Purified Water, Mineral Water, Sparkling Water), By Distribution Channel (On-trade, Off-trade), By Region, And Segment Forecasts, 2022 – 2030. Historical Range-2017-2020. Accessed 04.07.2022 https://www.grandviewresearch.com/industry-analysis/bottled-water-market

Greene, J. (2018). Bottled water in Mexico: The rise of a new access to water paradigm. *Wiley Interdisciplinary Reviews: Water* **5**, e1286.

Greene, J. C. (2014). What happens when water is commodified? Case study Mexico: dominant movements and alternative discourses in the access to water landscape, Univ. Genève.

Greenpeace (2022). How to refill and reuse at home. accessed 8.12.2022 at https://www.greenpeace.org/africa/en/blogs/50705/how-to-refill-and-reuse-at-home/

Güler, C. (2007). Evaluation of maximum contaminant levels in Turkish bottled drinking waters utilizing parameters reported on manufacturer's labeling and government-issued production licenses. *Journal of Food Composition and Analysis* **20**, 262-272.

Gumbel, A. (2015). California drought spurs protest over'unconscionable'bottled water business. *The Guardian* **19**.

Hall, D., and Lobina, E. (2012). Conflicts, companies, human rights and water—A critical review of local corporate practices and global corporate initiatives. *In* "Report prepared for the 6th World Water Forum, Marseilles, France. Public Services International, University of Greenwich Business School, London".

Hall, N. D. (2009). Protecting freshwater resources in the era of global water markets: Lessons learned from bottled water. *U. Denv. Water L. Rev.* **13**, 1.

Hamad, A. A., Sharaf, M., Hamza, M. A., Selim, S., Hetta, H. F., and El-Kazzaz, W. (2022). Investigation of the Bacterial Contamination and Antibiotic Susceptibility Profile of Bacteria Isolated from Bottled Drinking Water. *Microbiology Spectrum* **10**, e01516-21.

Hassan, N. (2016). Ground Water Depletion Due To Water Mining–A Threat. *Journal of Environmental Science, Computer Science and Engineering & Technology* **5**, 129-136.

Hawkins, G. (2017). The impacts of bottled water: An analysis of bottled water markets and their interactions with tap water provision. *Wiley Interdisciplinary Reviews: Water* **4**, 10.

Hawkins, G., Potter, E., and Race, K. (2015). Plastic water: The social and material life of bottled water. *MIT Press*, Accessed 14.10.2022 at http://www.jstor.org/stable/j.ctt16wd0bv

Horowitz, N., Frago, J., and Mu, D. (2018). Life cycle assessment of bottled water: A case study of Green2O products. *Waste Management* **76**, 734-743.

Howell, R., Sinha, K. M., Wagner, N., Doorn, N., and van Beers, C. (2020). Consumption of bottled water at the bottom of the pyramid: Who purchases first? *Journal of Macromarketing* **40**, 31-50.

Huang, Z., Pan, Y., Gong, H., Yeh, P. J. F., Li, X., Zhou, D., and Zhao, W. (2015). Subregional-scale groundwater depletion detected by GRACE for both shallow and deep aquifers in North China Plain. *Geophysical research letters* **42**, 1791-1799.

Hutton, G., and Varughese, M. (2016). The Costs of Meeting the 2030 Sustainable Development Goal Targets on Drinking Water, Sanitation, and Hygiene. *World Bank*, Washington, DC. © World Bank. https://openknowledge.worldbank.org/handle/10986/23681 License: CC BY 3.0 IGO.

IBWA, I. B. W. A. (2021). Recycled Rpet Facts. *International Bottled Water Association*, accessed 27.10.2022 at https://bottledwater.org/rpet-facts/

IBWA, I. B. W. A. (2022a). Packaging. *International Bottled Water Association*, accessed 27.10.2022 https://bottledwater.org/packaging/

IBWA, I. B. W. A. (2022b). Water Types. *International Bottled Water Association*, accessed 07.04.2022 https://bottledwater.org/types-of-water/

ICBWA (2022). Links for international bottled water associations. *Council of Bottled Water Associations*, accessed 10.04.2022 at https://www1.icbwa.org/links/

Igbeneghu, O. A., and Lamikanra, A. (2014). The bacteriological quality of different brands of bottled water available to consumers in Ile-Ife, south-western Nigeria. *BMC research notes* **7**, 1-6.

Ikem, A., Odueyungbo, S., Egiebor, N. O., and Nyavor, K. (2002). Chemical quality of bottled waters from three cities in eastern Alabama. *Science of the total environment* **285**, 165-175.

Jaffee, D., and Case, R. A. (2018). Draining us dry: Scarcity discourses in contention over bottled water extraction. *Local Environment* **23**, 485-501.

Jaffee, D., and Newman, S. (2013). A more perfect commodity: Bottled water, global accumulation, and local contestation. *Rural Sociology* **78**, 1-28.

Jain, B., Singh, A., and Susan Md, A. (2019). Bottled and packaged water. *The World Around Bottled Water*, 39p.

Jithin, V. (2016). Legal impediments of groundwater conservation and water law reforms in India. *Int J Econ Soc-Legal Sci* **2**, 1-21.

Johnstone, N., and Serret, Y. (2012). Determinants of bottled and purified water consumption: results based on an OECD survey *Water Policy* 668-679.

Joodaki, G., Wahr, J., and Swenson, S. (2014). Estimating the human contribution to groundwater depletion in the Middle East, from GRACE data, land surface models, and well observations. *Water Resources Research* **50**, 2679-2692.

Kankanige, D., and Babel, S. (2020). Smaller-sized micro-plastics (MPs) contamination in single-use PET-bottled water in Thailand. *Science of the total environment* **717**, 137232.

Klont, R. R., Rijs, A. J., Warris, A., Sturm, P. D., Melchers, W. J., and Verweij, P. E. (2006). *Legionella pneumophila* in commercial bottled mineral water. *FEMS Immunology & Medical Microbiology* **47**, 42-44.

Konikow, L. F. (2011). Contribution of global groundwater depletion since 1900 to sea-level rise. *Geophysical Research Letters* **38**.

Konikow, L. F., and Kendy, E. (2005). Groundwater depletion: A global problem. *Hydrogeology Journal* **13**, 317-320.

Kooy, M., & Walter, C. T. (2019). Towards a situated urban political ecology analysis of packaged drinking water supply. *Water*, **11**(2), 225.

Kristina, H. J., Christiani, A., and Jobiliong, E. (2018). The prospects and challenges of plastic bottle waste recycling in Indonesia. *In* "IOP Conference Series: Earth and Environmental Science", Vol. 195, pp. 012027. IOP Publishing.

Kruawal, K., Sacher, F., Werner, A., Müller, J., and Knepper, T. P. (2005). Chemical water quality in Thailand and its impacts on the drinking water production in Thailand. *Science of the total environment* **340**, 57-70.

Lamichhane, G., Acharya, A., Marahatha, R., Modi, B., Paudel, R., Adhikari, A., Raut, B., Aryal, S., and Parajuli, N. (2022). Microplastics in environment: global concern, challenges, and controlling measures. *International Journal of Environmental Science and Technology*, 1-22.

Laville, S., and Taylor, M. (2017). A million bottles a minute: world's plastic binge 'as dangerous as climate change'. *The Guardian* **28**, 2017.

Law, K. L., and Thompson, R. C. (2014). Microplastics in the seas. *Science* **345**, 144-145.

Leblanc, M. J., Tregoning, P., Ramillien, G., Tweed, S. O., and Fakes, A. (2009). Basin-scale, integrated observations of the early 21st century multiyear drought in southeast Australia. *Water resources research* **45**, 10.

Leivadara, S. V., Nikolaou, A. D., and Lekkas, T. D. (2008). Determination of organic compounds in bottled waters. *Food chemistry* **108**, 277-286.

Li, P., Wang, X., Su, M., Zou, X., Duan, L., and Zhang, H. (2021). Characteristics of plastic pollution in the environment: a review. *Bulletin of environmental contamination and toxicology* **107**, 577-584.

Li, W. C., Tse, H., and Fok, L. (2016). Plastic waste in the marine environment: A review of sources, occurrence and effects. *Science of the total environment* **566**, 333-349.

Li, X., Ying, G.-G., Su, H.-C., Yang, X.-B., and Wang, L. (2010). Simultaneous determination and assessment of 4-nonylphenol, bisphenol A and triclosan in tap water, bottled water and baby bottles. *Environment international* **36**, 557-562.

Lim, X. (2021). Microplastics are everywhere—but are they harmful? Nature Publishing Group.

Liu, Y., and Mou, S. (2004). Determination of bromate and chlorinated haloacetic acids in bottled drinking water with chromatographic methods. *Chemosphere* **55**, 1253-1258.

London City Hall (2022). Water. *In* "Programmes and Strategies, Climate Change". Accessed: 20.06.2022 at https://www.london.gov.uk/what-we-do/environment/climate-change/water#:~:text=In%20London%20we%20use%20more,Hall%2026%20times%20every%20day.

Makhdoumi, P., Amin, A. A., Karimi, H., Pirsaheb, M., Kim, H., and Hossini, H. (2021). Occurrence of microplastic particles in the most popular Iranian bottled mineral water brands and an assessment of human exposure. *Journal of Water Process Engineering* **39**, 101708.

March, H., Garcia, X., Domene, E., and Sauri, D. (2020). Tap water, bottled water or in-home water treatment systems: Insights on household perceptions and choices. *Water* **12**, 1310.

Marty, N. (2005). Perrier, c'est nous!: histoire de la source Perrier et de son personnel. *2 Editions de l'Atelier*, Book. 254p.

Mary, P., Defives, C., and Hornez, J. (2000). Occurrence and multiple antibiotic resistance profiles of non-fermentative Gram-negative microflora in five brands of non-carbonated French bottled spring water. *Microbial ecology* **39**, 322-329.

Mason, S. A., Welch, V. G., and Neratko, J. (2018). Synthetic polymer contamination in bottled water. *Frontiers in chemistry*, 407.

Massa, S., Petruccioli, M., Fanelli, M., and Gori, L. (1995). Drug resistant bacteria in non carbonated mineral waters. *Microbiological research* **150**, 403-408.

McLennan, J. D. (2015). Choosing bottled over tapped: drinking water in the Dominican Republic. *Journal of Water, Sanitation and Hygiene for Development* **5**, 9-16.

Messi, P., Guerrieri, E., and Bondi, M. (2005). Antibiotic resistance and antibacterial activity in heterotrophic bacteria of mineral water origin. *Science of the total environment* **346**, 213-219.

Mihayo, I., and Mkoma, S. (2012). Chemical water quality of bottled drinking water brands marketed in Mwanza city, Tanzania. *Research Journal of Chemical Sciences* **2231**, 606.

Molden, D. (2013). Water for food water for life: A comprehensive assessment of water management in agriculture. *International Water Management Institute*, 48.

Morinville, C. (2017). Sachet water: Regulation and implications for access and equity in Accra, Ghana. *Wiley Interdisciplinary Reviews: Water* **4**, e1244.

Mukhopadhyay, M., Jalal, M., Vignesh, G., Ziauddin, M., Sampath, S., Bharat, G. K., Nizzetto, L., and Chakraborty, P. (2022). Migration of plasticizers from polyethylene terephthalate and low-density polyethylene casing into bottled water: a case study from India. *Bulletin of Environmental Contamination and Toxicology*, 1-7.

Mutsuga, M., Kawamura, Y., Sugita-Konishi, Y., Hara-Kudo, Y., Takatori, K., and Tanamoto, K. (2006). Migration of formaldehyde and acetaldehyde into mineral water in polyethylene terephthalate (PET) bottles. *Food additives and contaminants* **23**, 212-218.

NAPCOR (2021). NAPCOR's 2020 pet recycling report reveals an 800 million pound increase of recycled pet for end market use over the past decade. *National Association for PET Container Resources*, accessed 27.10.2022 at https://napcor.com/news/napcors-2020-pet-recycling-report-reveals-an-800-million-pound-increase-of-recycled-pet-for-end-market-use-over-the-past-decade/

Napier, G. L., and Kodner, C. M. (2008). Health risks and benefits of bottled water. *Primary Care: Clinics in Office Practice* **35**, 789-802.

National Population Commission (2013). Nigeria demographic and health survey 2013. *National Population Commission, ICF International*, 565p.

Nawrocki, J., Dąbrowska, A., and Borcz, A. (2002). Investigation of carbonyl compounds in bottled waters from Poland. *Water Research* **36**, 4893-4901.

Nestlé (2021). Creating Shared Value and Sustainability Report 2021. 59p.

Nestlé Waters Canada (2016). Nestlé in Canada. *Nestlé*, accessed 30.05.202 at https://www.corporate.nestle.ca/en/ask-nestle/documents/nestle%20-%20fact%20sheet%20(sept.%202016).pdf

Nikiema, J., and Asiedu, Z. (2022). A review of the cost and effectiveness of solutions to address plastic pollution. *Environmental Science and Pollution Research*, 1-27.

NMWE (2021). Natural mineral and spring waters - a gift of nature. *Natural Mineral Waters Europe*, accessed 12.12.2022 at https://naturalmineralwaterseurope.org/water/

Nsanze, H., Babarinde, Z., and Al Kohaly, H. (1999). Microbiological quality of bottled drinking water in the UAE and the effect of storage at different temperatures. *Environment international* **25**, 53-57.

NSW Environment Protection Authority, S. o. E. (2022). Urban Water Supply: A high-quality and secure water supply is essential to sustain communities and support economic growth. Accessed 19.06.2022 at https://www.soe.epa.nsw.gov.au/all-themes/human-settlement/urban-water-supply

Obiri-Danso, K., Okore-Hanson, A., and Jones, K. (2003). The microbiological quality of drinking water sold on the streets in Kumasi, Ghana. *Letters in Applied Microbiology* **37**, 334-339.

Ochungo, E., Ouma, G., Obiero, J., and Odero, N. (2019). The implication of unreliable urban water supply service: The case of vendor water cost in Langata Sub County, Nairobi City, Kenya. *Journal of Water Resource and Protection* **11**, 896.

OECD (2018). The circular economy -improving plastics recycling. *Meeting of the OECD council at ministerial level, Paris, 30-31 May 2018*, ccessed 09.09.2021 at https://www.oecd.org/mcm/2018/documents/ENV-EPOC-2018-REV1-EN.pdf

OECD (2022). Global Plastics Outlook: Economic Drivers, Environmental Impacts and Policy Options. pp. https://doi.org/10.1787/de747aef-en OECD Publishing Paris, France.

Olson, E. D., Poling, D., and Solomon, G. (1999). Bottled water: pure drink or pure hype? Book. *National Resources Defense Council*, 133.

Olukoju, A. (2007). Provision and management of water services in Lagos, Nigeria, 1915–2000. *Environmental History of Water: Global Views on Community Water Supply and Sanitation. London: IWA Publishing*, 343-354.

Opel, A. (1999). Constructing purity: Bottled water and the commodification of nature. *The Journal of American Culture* **22**, 67.

Osei, A. S., Newman, M. J., Mingle, J., Ayeh-Kumi, P. F., and Kwasi, M. O. (2013). Microbiological quality of packaged water sold in Accra, Ghana. *Food Control* **31**, 172-175.

Pacheco-Vega, R. (2019). Human right to water and bottled water consumption: Governing at the intersection of water justice, rights and ethics. *In* “Water politics”, pp. 113-128. Routledge.

Packialakshmi, S., K Ambujam, N., and Nelliyat, P. (2011). Groundwater market and its implications on water resources and agriculture in the southern peri-urban interface, Chennai, India. *Environment, development and sustainability* **13**, 423-438.

Palmera-Suarez, R., García, P., García, A., Barrasa, A., and Herrera, D. (2007). *Salmonella Kottbus* outbreak in infants in Gran Canaria (Spain), caused by bottled water, August–November 2006. *Weekly releases (1997–2007)* **12**, 3235.

Pandal, N. (2020). Birth of the Bottled Water Industry. *BCC Research*, accessed 24.07.2022 at https://blog.bccresearch.com/birth-of-the-bottled-water-industry

Papong, S., Malakul, P., Trungkavashirakun, R., Wenunun, P., Chom-in, T., Nithitanakul, M., and Sarobol, E. (2014). Comparative assessment of the environmental profile of PLA and PET drinking water bottles from a life cycle perspective. *Journal of Cleaner Production* **65**, 539-550.

Parag, Y., and Opher, T. (2011). Bottled drinking water. *Water And Health,© Encyclopedia of Life Support Systems (EOLSS)*.

Penland, R. L., and Wilhelmus, K. R. (1999). Microbiologic analysis of bottled water: is it safe for use with contact lenses? *Ophthalmology* **106**, 1500-1503.

Plastics Europe (2020). Plastics - the facts 2020. *Plastics Europe*, accessed 27.10.2022 https://plasticseurope.org/knowledge-hub/plastics-the-facts-2020/

Pliego, J. T. P. (2019). Sweet extermination: Soda and beer, as trigger cause and complications in diabetics, among high land mayans of Chiapas, Mexico. *Social Medicine* **12**, 79-83.

Pokhrel, Y. N., Hanasaki, N., Yeh, P. J., Yamada, T. J., Kanae, S., and Oki, T. (2012). Model estimates of sea-level change due to anthropogenic impacts on terrestrial water storage. *Nature Geoscience* **5**, 389-392.

Poškus, M. S., Balundė, A., Jovarauskaitė, L., Kaniušonytė, G., and Žukauskienė, R. (2021). The Effect of Potentially Groundwater-Contaminating Ecological Disaster on Adolescents’ Bottled Water Consumption and Perceived Risk to Use Tap Water. *Sustainability* **13**, 5811.

Prasetiawan, T., Nastiti, A., and Muntalif, B. S. (2017). ‘Bad’piped water and other perceptual drivers of bottled water consumption in Indonesia. *Wiley Interdisciplinary Reviews: Water* **4**, e1219.

Pskowski, M. (2017). Coca-Cola sucks wells dry in Chiapas, forcing residents to buy water. *Truthout*, Accesses 9.12.2022 at https://truthout.org/articles/coca-cola-sucks-wells-dry-in-chiapas-forcing-residents-to-buy-water/

Pu, J., and Fukushi, K. (2016). Bacterial water quality and risk evaluation of bottled drinking water in China. *International Journal of Food Safety, Nutrition and Public Health* **6**, 1-13.

Quansah, F., Okoe, A., and Angenu, B. (2015). Factors affecting Ghanaian consumers' purchasing decision of bottled water. *International Journal of Marketing Studies* **7**, 76.

Ravi Raman, K. (2010). Transverse solidarity: Water, power, and resistance. *Review of Radical Political Economics* **42**, 251-268.

Reddy, M. K., Priyadarshini, N. P., Singh, V., and Suresh Reddy, K. (2022). A study on drinking water quality in different income groups of Vizianagaram region of India. *Journal of Water and Health* **20**, 1445-1456.

Reyes, M. I., Pérez, C. M., and Negrón, E. L. (2008). Microbiological assessment of house and imported bottled water by comparison of bacterial endotoxin concentration, heterotrophic plate count, and fecal coliform count. *Puerto Rico Health Sciences Journal* **27**.

Rhodes, C. J. (2018). Plastic pollution and potential solutions. *Science progress* **101**, 207-260.

Richey, A. S., Thomas, B. F., Lo, M. H., Famiglietti, J. S., Swenson, S., and Rodell, M. (2015). Uncertainty in global groundwater storage estimates in a total groundwater stress framework. *Water resources research* **51**, 5198-5216.

Ritchie, H. (2021). Where does the plastic in our oceans come from. *Our World in Data* **1**, Accessed 15.12.2022 at https://ourworldindata.org/ocean-plastics#:~:text=Most%20of%20the%20plastic%20in,%2C%20ropes%2C%20and%20abandoned%20vessels

Rodell, M., Velicogna, I., and Famiglietti, J. S. (2009). Satellite-based estimates of groundwater depletion in India. *Nature* **460**, 999-1002.

Rodwan, J. J. (2018). Significant but slower, growth for bottled water in 2018. Market Report. *International Bottled Water Association* **1**, 9.

Rooy, T. B.-V. (2002). Bottling up our natural resources: the fight over bottled water extraction in the United States. *J. Land Use & Envtl. L.* **18**, 267.

Rosemann, N. (2005). Drinking water crisis in Pakistan and the issue of bottled water: the case of Nestlé's 'Pure Life.'. *Actionaid Pakistan* **4**, 37.

Rosenberg, F., and Duquino, H. H. (1989). Antibiotic resistance of *Pseudomonas* from German mineral waters. *Toxicity Assessment* **4**, 281-294.

Ross, G. (2021). Global Plastic Product & Packaging Manufacturing. *IBIS World*, 39p.

Salinas, R. O., Bermudez, B. S., Tolentino, R. G., and Gonzalez, G. D. (2010). Presence of polychlorinated biphenyls (PCBs) in bottled drinking water in Mexico City. *Bulletin of environmental contamination and toxicology* **85**, 372-376.

Schmidt, C., Krauth, T., and Wagner, S. (2017). Export of plastic debris by rivers into the sea. *Environmental science & technology* **51**, 12246-12253.

Schwanse, E. (2011). Recycling policies and programmes for PET drink bottles in Mexico. *Waste management & research* **29**, 973-981.

Schymanski, D., Goldbeck, C., Humpf, H.-U., and Fürst, P. (2018). Analysis of microplastics in water by micro-Raman spectroscopy: release of plastic particles from different packaging into mineral water. *Water research* **129**, 154-162.

Shree, R. (2010). Water as a natural resource: right versus need debate. *Rajagiri journal of social development* **2**, 2-30.

Shrestha, A., Karki, K., Shukla, A., and Sada, R. (2013). Groundwater extraction: implications on local water security of peri-urban, Kathmandu, Nepal. *Peri Urban Water Security Discussion Paper Series* **7**, 8.

Sitisarn, S. (2012). Political Ecology of the soft drink and bottled water business in India; a case study of Plachimada. *Degree of Master of Science; Lund University*, 33p.

Smirthers *in* Statisa (2019). Distribution of polyethylene terephthalate (PET) packaging consumption worldwide in 2019, by end-use sector. *Statista*, accessed: 15.11.2022 at https://www.statista.com/statistics/858624/global-polyethylene-terephthalate-consumption-distribution-by-end-use/

Spar, D. a. B., K. (2008). Profitable springs : the rise, sources, and structure of the bottled water business.. *Entreprises et histoire* **1**, 100-118.

Statista (2020). Bottled water worldwide. *Statista Dossier on the bottled water market worldwide*, 32p.

Statista (2021a). Food Report *Statista Consumer Market Outlook, 2022*, 294p.

Statista (2021b). The life cycle of plastics, Statista Dossier on the global impact of plastics throughout production,use, and disposal. 37p.

Statista (2021c). Plastic industry worldwide. *Statista Dossier on the global plastic industry*, 39p.

Statista (2022a). Bottled Water Report 2022. *Statista Consumer Market Outlook. Segment Report* 38p.

Statista (2022b). Non-Alcoholic Drinks Report 2022. *Statista Consumer Market Outlook, Market Report*, 103p.

Stephenson, J. B. (2009). Bottled water: FDA safety and consumer protections are often less stringent than comparable EPA protections for tap water. DIANE Publishing. pp. 56.

Stoler, J. (2017). From curiosity to commodity: a review of the evolution of sachet drinking water in West Africa. *Wiley Interdisciplinary Reviews: Water* **4**, e1206.

Stoler, J., Weeks, J. R., and Appiah Otoo, R. (2013). Drinking water in transition: a multilevel cross-sectional analysis of sachet water consumption in Accra. *PloS one* **8**, e67257.

Tang, Q., Zhang, X., and Tang, Y. (2013). Anthropogenic impacts on mass change in North China. *Geophysical Research Letters* **40**, 3924-3928.

Tanellari, E., Bosch, D., Boyle, K., & Mykerezi, E. (2015). On consumers' attitudes and willingness to pay for improved drinking water quality and infrastructure. *Water Resources Research*, **51**(1), 47-57.

The Coca-Cola Company (2021). 2021 business and ESG report. *The Coca-Cola company*, 86p.

Tombesi, N. B., and Freije, H. (2002). Application of solid-phase microextraction combined with gas chromatography–mass spectrometry to the determination of butylated hydroxytoluene in bottled drinking water. *Journal of Chromatography A* **963**, 179-183.

UN Comtrade (2021). Free access to detailed global trade data. *The United Nations Comtrade database*, accessed : 12.12.2022 at https://comtradeplus.un.org/TradeFlow?Frequency=A&Flows=X&CommodityCodes=2201&Partners=0&Re-porters=all&period=2021&AggregateBy=none&BreakdownMode=plus

UN Stats (2021). Sustainable Development Goals Progress Chart 2021, Technical note. *United Nations Reports*, accessed 28.07.2022 at https://unstats.un.org/sdgs/report/2021/Progress_Chart_2021_Technical_note.pdf

UNEP (2022). Visual feature: Beat plastic pollution. UNEP. *UN Environment Programme* accessed on : 07.09.2022 at https://www.unep.org/interactives/beat-plastic-pollution/

Valavanidis, A. (2020). Tap Drinking Water versus Bottled Water. *Scientific review. National and Kapodistrian University of Athens*, 36p.

Venieri, D., Vantarakis, A., Komninou, G., and Papapetropoulou, M. (2006). Microbiological evaluation of bottled non-carbonated ("still") water from domestic brands in Greece. *International journal of food microbiology* **107**, 68-72.

Venturini, C. Q., and Frazão, P. (2015). Fluoride concentration in bottled water: a systematic review. *Cadernos Saúde Coletiva* **23**, 460-467.

Vieux, F., Maillot, M., Rehm, C. D., Barrios, P., and Drewnowski, A. (2020). Trends in tap and bottled water consumption among children and adults in the United States: analyses of NHANES 2011–16 data. *Nutrition Journal* **19**, 1-14.

Vinci, G., Rapa, M., and Roscioli, F. (2018). Sustainable development in rural areas of Mexico through beekeeping. *International Journal of Science and Engineering Invention* **4**, 01 to 07.

Voss, K. A., Famiglietti, J. S., Lo, M., De Linage, C., Rodell, M., and Swenson, S. C. (2013). Groundwater depletion in the Middle East from GRACE with implications for transboundary water management in the Tigris-Euphrates-Western Iran region. *Water resources research* **49**, 904-914.

Wada, Y., van Beek, L. P., and Bierkens, M. F. (2012). Nonsustainable groundwater sustaining irrigation: A global assessment. *Water Resources Research* **48**.

Wada, Y., Van Beek, L. P., Van Kempen, C. M., Reckman, J. W., Vasak, S., and Bierkens, M. F. (2010). Global depletion of groundwater resources. *Geophysical research letters* **37**.

Wagner, M., Schlüsener, M. P., Ternes, T. A., and Oehlmann, J. (2013). Identification of putative steroid receptor antagonists in bottled water: combining bioassays and high-resolution mass spectrometry. *PloS one* **8**, e72472.

Walton, B. (2015). Groundwater Depletion Stresses Majority of World's Largest Aquifers. *Circle of Blue*.

Warburton, D. W. (1993). A review of the microbiological quality of bottled water sold in Canada. Part 2. The need for more stringent standards and regulations. *Canadian journal of microbiology* **39**, 158-168.

Warburton, D. W., Dodds, K. L., Burke, R., Johnston, M. A., and Laffey, P. J. (1992). A review of the microbiological quality of bottled water sold in Canada between 1981 and 1989. *Canadian Journal of Microbiology* **38**, 12-19.

Wei, J., Guo, X., Yan, Q., Wang, A., and Bian, H. (2021). Analysis of China's domestic water prediction. *In* "IOP Conference Series: Earth and Environmental Science", Vol. 631, pp. 012046. IOP Publishing.

WHO (2019). Microplastics in drinking-water. *World Health Organization* ISBN 978-92-4-151619-8, Licence: CC BY-NC-SA 3.0 IGO. Geneva

WHO/UNICEF (2021). Joint monitoring programme for water supply, sanitation and hygiene – data tables. *WASH Data*, Accessed: 07.11.2022 at https://washdata.org/data/household#!/table

WHO, World. Bank Group and UNICEF (2022). State of the World's Drinking Water. *World Health Organization*, Geneva. Licence: CC BY-NC-SA 3.0 IGO.

Wilk, R. (2006). Bottled water: the pure commodity in the age of branding. *journal of Consumer Culture* **6**, 303-325.

Williams, A. R., Bain, R. E., Fisher, M. B., Cronk, R., Kelly, E. R., and Bartram, J. (2015). A systematic review and meta-analysis of fecal contamination and inadequate treatment of packaged water. *PloS one* **10**, e0140899.

Winschewski, J. (2017). Putting a price tag on human rights. An anthropological perspective on Nestle's drinking water Privatisation in Pakistan. *Prace Etnograficzne* 2017, 175-195.

World Economic Forum (2022). Why is black plastic packaging so hard to recycle? *World Economic Forum*, accesses 27.10.2022 at https://www.weforum.org/agenda/2019/12/black-plastic-recycling-supermarkets-waste/

Wramner, E. (2004). Fighting Cocacolanisation in Plachimada: Water, soft drinks and a tragedy of the commons in an Indian village. *Unpublished Master's Thesis. Lund, Sweden: Lund University*.

Wright, J., Dzodzomenyo, M., Wardrop, N. A., Johnston, R., Hill, A., Aryeetey, G., and Adanu, R. (2016). Effects of sachet water consumption on exposure to microbe-contaminated drinking water: household survey evidence from Ghana. *International journal of environmental research and public health* **13**, 303.

Zhang, Y., Deng, J., Qin, B., Zhu, G., Zhang, Y., Jeppesen, E., and Tong, Y. (2022). Importance and vulnerability of lakes and reservoirs supporting drinking water in China. *Fundamental Research, In press*, https://doi.org/10.1016/j.fmre.2022.01.035

Zhou, X.-j., Wang, J., Li, H.-y., Zhang, H.-m., and Zhang, D. L. (2021). Microplastic pollution of bottled water in China. *Journal of Water Process Engineering* **40**, 101884.

204-175 Longwood Road South,
Hamilton, Ontario, Canada, L8P 0A1

Tel: +905 667-5511
Fax: +905 667 5510

UNU INWEH