



An Inconvenient Truth about Access to Safe Drinking Water

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Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

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ABSTRACT

The phrase inconvenient truth associated with global warming and climate change has received a great deal of publicity some years back. The objective of this article is to highlight a different kind of inconvenient truth which affects about 29% of the world population. It is about the lack of access to safe drinking water that results in over 1.2 million preventable deaths annually. The first two targets of UN sustainable development goal 6 (SDG6) aim at providing universal, affordable and sustainable access to "water, sanitation and hygiene (WASH)". Recognizing the right to safe and clean drinking water and sanitation as a basic human right, issues related to this problem as well as possible options to alleviate the problem are discussed.

Keywords: *Climate change; safe drinking water; water scarcity; water productivity; preventable deaths; UNFCC; valuing water.*

1. INTRODUCTION

'Inconvenient truth' was a widely used and publicized phrase a few years back. It was associated with global warming and climate

change, which, during the height of its publicity in 2006 ended as a documentary movie in which a former Vice President of USA made passionate presentations of the possible consequences of sea-level rises, melting of ice caps and glaciers

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and increase of green-house gases. The movie won two academy awards for best documentary feature and best original song and ranked as one of the highest box office earning movies in the US and elsewhere. In recent years, glamour of the movie and the phrase 'inconvenient truth' has faded away and the issues of climate change and global warming also have taken back seats with the emergence of the corona virus that caused a global pandemic. A lot has been written about climate change during the past decade or so, some who project the global temperatures to increase by about 2° C by the turn of the century using various types of climate models, as well as a few who take the view that the issue is blown out of proportion and that warming occurs locally or regionally and it is premature to conclude that it is a global phenomenon [1-4].

Climate change has in the recent past received much less attention because of the pandemic that is a much more serious issue. The years 2020 to 2021 have seen an unprecedented global health scare with over 241 million Covid-19 infections and over 4.9 million fatalities worldwide as of October 21, 2021, with the highest number of deaths in the United States. There appears to be a ray of hope since the beginning of this year (2021) as a result of mass vaccinations that have taken place in some countries. However, at least at the present time, access to these vaccines is restricted to rich countries although the virus does not distinguish between rich countries and poor countries. The world health organization has highlighted the lack of solidarity in combating the pandemic.

Climate change and global warming are hot topics that have attracted the attention of world leaders, scientists, and media who have portrayed it as a global issue affecting the entire world. Publicity to the issues of climate change and global warming is given mostly by developed countries and by various agencies of the United Nations. Prominent among them is the United Nations Framework Convention on Climate Change (UNFCCC or FCCC) which is an international environmental treaty produced at the United Nations Conference on Environment and Development (UNCED), also known as Earth Summit, in Rio de Janeiro, June 3-14, 1992. UNFCCC have been holding annual meetings known as the Conferences of the Parties (COP's) since 1995 of which the COP21 held in Paris during November 30 to December 11, 2015 received perhaps the most international

attention. Since the emergence of the Covid-19 pandemic, the conference of the parties that was scheduled to be held in 2019 in Glasgow has been postponed and expected to be held later in 2021.

There is no doubt that warming is taking place in some parts of the world but it is premature to conclude that it is a global phenomenon. Most of the warming is taking place in high latitude countries where some ice caps and glaciers have been melting. In equatorial regions, there is no significant warming taking place. Fortunately, no one has died so far as a direct result of climate change. Warming and emission of green-house gases are dependent on the rates of energy consumption and there is a significant difference in the per capita consumption of energy in rich and poor countries. A more important problem faced by poor countries is the lack of safe drinking water. It is more serious than climate change and perhaps more serious for such countries than the present pandemic.

The objective of this article is not to further elaborate on the issue of climate change but to highlight and bring to the attention of the world a different kind of 'inconvenient truth'. It is about the lack of safely managed drinking water to about 2.1 billion people (29% of the world population) in the world. The unfortunate inconvenient truth is that the people who are deprived of having access to safely managed drinking water live in low income countries. The World Health Organization (WHO) has concluded that water borne disease is the leading killer in the world [5]. In this context, safely managed water means water available on premises when needed, and free from contamination.

Hand washing as a precaution against the transmission of the corona virus is promoted and encouraged by all health authorities across the world, but the big question is where is the water for 29% of the world population? Of the roughly 818 million children worldwide who lack basic hand washing facilities at school, more than one-third are in sub-Saharan Africa [6]. About 40% of the global population live without basic hand washing facilities at home [7]. The inconvenient and unfortunate truth is that the recurrent annual deaths resulting from unsafe drinking water is approximately the same as the death rate due to current Covid-19 which hopefully is not a recurrent pandemic. So the question from a consideration of saving human lives is whether addressing climate change or addressing the

problem of providing safely managed water to over 2.1 billion people in the world (29% of world population) should take priority.

2. SOME STATISTICS ON ACCESS TO DRINKING WATER

According to the key facts from WHO [8], the following statistics can be summarized:

- In 2017, 71% of the global population (5.3 billion people) had access to a safely managed drinking water service.
- 90% of the global population (6.8 billion people) used at least a basic service. Basic service in this context means an improved drinking water source within a round trip of 30 minutes to collect water.
- 785 million people lack even a basic drinking-water service. This includes 144 million people who are dependent on surface water.
- Globally, at least 2 billion people use a drinking water source contaminated with feces.
- Contaminated drinking water is estimated to cause 485,000 diarrheal deaths each year.
- By 2025, half of the world's population will be living in water-stressed areas.
- In least developed countries, 22% of health care facilities have no water service, 21% no sanitation service, and 22% no waste management service.

Furthermore, [9]

- Unsafe water is responsible for 1.2 million preventable deaths each year
- 6% of deaths in low-income countries are the results of unsafe water sources
- 666 million (9% of the world) do not have access to an improved water source
- 2.1 billion (29% of the world) do not have access to safe drinking water

2.1 Waterborne Diseases

Waterborne diseases are transmitted through contact or consumption of microbially contaminated water. Most are life-threatening. The pathway is usually fecal to oral although some diseases may be caused by contact with polluted water. Waterborne diseases may be caused by pathogens such as protozoa (e.g. amoebiasis), bacteria (e.g. cholera, dysentery,

typhoid fever), viruses (e.g. hepatitis A, polio), algae (e.g. desmodemus infection through open wounds), and parasitic worms (e.g. guinea worm disease). It is estimated that up to about 20 million people worldwide suffer from typhoid fever each year. Most of them are from poor countries. Typhoid fever is infectious and spreads through contaminated food, unsafe water and poor sanitation. Globally, in 2017, 1.2 million people died prematurely due to unsafe water which is 2.2% of global deaths. In low income countries, this percentage is about 6% [9].

2.2 Water Scarcity

Water scarcity can be arising from physical lack of water, poor quality, or due to lack of capacity for developing and maintaining a reliable supply. Arid and desert areas suffer from physical lack of water and such areas also experience pollution problems. In such situations, home-grown techniques such as rainwater harvesting and groundwater exploitation would be better appropriate technologies than conventional water supply technology. Since such areas are sparsely populated, achieving individual household self-sufficiency is more favoured and should be encouraged than traditional water distribution systems where the conveyance cost can be excessively high. It is also important to introduce low cost water filters which can be used in individual households. A dollar invested in improving access to safe drinking water is estimated to increase the GDP by \$3-14, depending on the type of investment. It is projected that by 2025, 1.8 billion people will be living in absolute water scarcity and two-thirds of world population could be living under water stressed conditions. In this context, absolute scarcity means the annual per capita water availability is less than 500 m³, water stress means when it drops below 1,700 m³, and, water scarcity means when it drops below 1000 m³. It is also projected that by 2050, 4.8 – 5.7 billion people will be living in potential water scarce areas at least one month in a year [10].

1.42 billion people including 450 million children worldwide live in areas of high water vulnerability which may be due to physical scarcity or economic inability [11]. UNICEF highlights that children can experience problems related to health, development, education, safety, employment etc. due to water scarcity. Over 90% of children in Afghanistan, Lesotho and Kenya suffer high/extremely high water vulnerability [11].

2.3 Water Productivity

The productivity of water in agriculture is generally quantified using the crop water productivity (CWP) which varies with the crop type, evapo-transpiration as well as with climatic condition, soil type and several other factors. The main crops which end up as staple food in the world are rice, wheat and maize which are all cereals. Of these, rice consumes more water than other cereals and thus the water productivity of rice is significantly lower than those of other cereals. Rice has a worldwide average growing season of 136 days from crop emergence to harvest including mountain and lowland rice. Reported values of CWP vary from region to region and from source to source too. Based on data for the period 1998-2008, a global average value of CWP for rice is reported to be 0.98 kg/m³ [12] whereas a high value of 2.2 kg/m³ has been reported for rice crop in the Zhangye irrigation system in China [13] as cited by [12]. The lowest CWP is in sub-Saharan Africa with values ranging between 0.10 – 0.25 kg/m³. In USA values range from 0.9 to 1.9 kg/m³ with higher values in the north than in the south and the highest in the north-western regions [14]. The projected values of water productivity and water use for the period 2021-2025 for rice in developing countries have been reported to be 0.53 kg/m³ and 8445 m³/ha. The corresponding figures in developed countries are 0.57 kg/m³ and 9730 m³/ha respectively [14].

Other indicators of water productivity in agriculture include the yield per unit area and the water consumption per unit area. In sub-Saharan Africa, which have the lowest values in the world, the average yield for rice is 1.4 tons/ha and the water consumption is close to 9500 m³/ha. In the developed world, the yield and water consumption for rice are 4.7 tons/ha and 10,000 m³/ha respectively whereas in the developing world the corresponding figures are 3.3 tons/ha and 8,600 m³/ha [14].

In a study by Cai and Rosegrant [14], the projected values of three indicators (basin efficiency, water withdrawals and irrigation consumptive use) for the period 2021- 2025 under different scenarios (baseline, high efficiency and high efficiency with low water withdrawal) have been reported. Of these, the basin efficiencies in developing countries are 0.59 as baseline, 0.77 for high basin efficiency and 0.77 with high basin efficiency and low water withdrawal respectively whereas the

corresponding figures in developed countries are 0.69, 0.81 and 0.81 respectively. The water withdrawals in developing countries are 3486 km³, 3347 km³ and 3043 km³ respectively as baseline, high basin efficiency and with high basin efficiency and low water withdrawal respectively whereas the corresponding figures in developed countries are 1277 km³, 1228 km³ and 1183 km³ respectively. The irrigation consumptive use in developing countries are 1214 km³, 1135 km³ and 283 km³ respectively whereas in developed countries, the corresponding figures are 274 km³, 250 km³ and 227 km³ respectively [14].

The challenge therefore is to increase the water productivity in food production. Any saving in the water needs for food production could be used for other water needs. It is reported by FAO that a 1% increase in water productivity in food production generates a potential of water use of 24 liters/capita/day. Increasing the water productivity in the agriculture sector appears to be the best way of freeing water for other purposes. This can be achieved by minimizing the outflow from paddy fields, re-use of any outflows and drainage from fields, adopting aerobic irrigation in place of flooded irrigation, reducing evaporation from bare soil, and reducing seepage and percolation. Aerobic irrigation reduces the yield but is compensated by less water requirement compared with flooded irrigation. Wet seeding is another method of increasing the water productivity. In this method, farmers soak the rice seeds for 24 hours and then sow them in puddled or muddy fields. By this method which is popular in parts of Thailand, Vietnam and the Philippines, the water requirements are about 20-25% less than for traditional methods. Intermittent irrigation, where the fields are flooded and allowed to dry and flooded again is a practice adopted in China where the per capita freshwater availability is among the lowest in Asia. Land leveling where the slopes are reduced to improve uniform field conditions thereby requiring less water to flood is another approach.

Using pricing policies to increase water productivity requires governmental intervention and even so it does not seem feasible at least in the Asian context as it would be difficult to recover the true cost of providing water for agriculture. In the Indian subcontinent, it has been suggested that the charge required to affect demand significantly would be about ten times the cost of operation and maintenance of

irrigation systems. It is also not feasible to charge agricultural water users on a volumetric basis because of the high cost of installing water meters as well as maintaining them. This applies to surface waters as well as groundwater which require energy for pumping.

In some regions, crop substitution has been used as a means of increasing water productivity. Farmers tend to grow crops that require less water but have higher market values such as flowers and vegetables which can also be exported. Such practices can conflict with national policies which aim at self-sufficiency in staple foods. Aiming at long-term sustainability of water and food security should be the way forward.

2.4 International Initiatives

The first International Decade for Clean Drinking Water, 1981-1990, was set up at the 1977 United Nations 'Water Conference' at Mar del Plata with the aim of making access to clean drinking water available across the world.

In the 1980's, of the 1.8 billion people living in the rural areas of developing countries, only one in five had access to clean water. Over half a billion of the children under 15 years old did not have clean water. In developing countries, one hospital patient in four suffered from an illness caused by polluted water. Although the decade focused on safe water and sanitation for all by 1990, only 1.2 billion people were fortunate to have access to safe drinking water and about 770 million to safe sanitation by the end of the decade. In 2017, at least 1.2 billion people worldwide were estimated to drink water contaminated with feces and over 2 billion people did not have access to basic sanitation facilities such as toilets or latrines.

As a follow-up, the United Nations General Assembly adopted a draft resolution proclaiming 2005 to 2015 as the "International Decade for Action - Water for Life" with the aim of halving by 2015 the proportion of people who are unable to reach or afford safe drinking water and who do not have access to basic sanitation with emphasis on the participation of women in water-related development efforts. From 1990 to 2015, 2.1 billion people gained access to a latrine, flush toilet or other improved sanitation facilities. While the team of the United Nations Office to Support the International Decade for Action "Water for Life" 2005-2015 have received

accolades for their efforts to collect and disseminate water-related information, over 663 million people still drew water from an unimproved source in 2015. An unimproved drinking water source in this context means a source that does not protect against contamination.

One of the key Sustainable Development Goals (SDG's) is SDG6 on safe drinking water and sanitation. It involves health, dignity, environmental sustainability and the survival of the planet and requires efforts at regional, national and international levels. Universal, affordable and sustainable access to "Water, sanitation and hygiene" (WASH) is the focus of the first two targets of SGD6. On July 28, 2010, the UN General Assembly adopted a resolution recognizing "the right to safe and clean drinking water and sanitation as a human right that is essential for the full enjoyment and all human rights". Regions and nations therefore have an obligation to work towards achieving universal access to safe drinking water and sanitation for all human beings without any discrimination while prioritizing those most in need.

The SDG6 also defines accessibility to safe managed drinking water as water available at the premises when needed that is not contaminated by fecal and chemical matter. In terms of access, there is no legal standard for physical accessibility, but a maximum of 30 minute round trip travel time to a location of managed water supply is considered as a norm. For basic sanitation, the facilities should not be shared and available at the premises. On the affordability issue, while it is not a human right to expect free access to safe and clean water, disconnection of water services due to lack of means is considered as a violation of human rights. Sometimes water rights may impinge on human rights. Water right is a legal issue and can be taken away from an individual but human rights cannot be taken away from an individual.

The sustainable development goals (SDGs) were set in 2015 by the United Nations General Assembly and are intended to be achieved by the year 2030. This has been replaced by the SDG6 Global Acceleration Framework in partnership with over 30 UN entities and 40 international organizations as a contribution to deliver the goals by 2030. However, as highlighted in the introduction, it is unlikely that these goals will be achieved during this time frame.

2.4.1 Disparity in preventable deaths due to unsafe water and sanitation

Table 1 illustrates the disparity in preventable deaths due to unsafe water and sanitation across some selected low income and high income countries. In low income countries, the deaths due to unsafe water as a percentage of the total deaths range from about 5.75% to 14.45% whereas in high income countries the corresponding range is from about 0% to 0.04%. The world-wide average is about 2.2%. Based on these figures, there is a 1000-fold difference in death rates between developing (low income) countries and developed (high income) countries. Similar trends can be seen in the death rates due to unsafe or lack of proper sanitation. In developing countries, it is in the range of 3.32% to 11.25% whereas in developed countries the corresponding range is 0% to 0.02% with a world average of about 1.38%. i.e. greater than a 1000-fold difference. As shown in Table 1, the percentage of population with access to improved sanitation ranges from a high of 100% to a low of about 6.7% (South Sudan) in 2017. Improved sanitation in this context means having access to a piped sewer system, septic tanks, ventilated improved pit (VIP) latrines, pit latrines with slab and composting toilets, limited service means improved facility shared with other households, unimproved facility means facilities which do not separate excreta from human contact, and no service means open defecation. In terms of numbers, deaths due to unsafe drinking water worldwide are about 1.2 million per year and due to unsafe sanitation worldwide are about 775,000 per year which are approximately 2.2 % and 1.4% respectively of global deaths. In low income countries they are about 6% and 5% respectively [9,15].

The health of a nation depends upon the level of cleanliness of the domestic water supply. It is a problem that is often ignored or sidelined by the developed countries as it is only a problem of the poor and the developing countries. Coupled with the accompanying sanitation problem, the situation if allowed to continue can be disastrous. Unlike a major flood or an earthquake which affect a small region with high population density, the effect of the lack of safe drinking water is spread over vast areas with relatively low population densities. From the media point of view, such widespread and prolonged suffering receives much less attention compared with that received for high impact type of disasters such as earthquakes and major floods.

Although the numbers of people with access to improved water sources have increased in recent years, over 666 million people still did not have access to improved water sources by 2015. South and East Asia and sub-Saharan regions are among the worst affected. In this context, having access to an improved water source does not necessarily guarantee that the water is free from contamination.

Access to improved water sources is highly correlated with the income levels in any region (Table 2). Although the per capita GDP is an indicator of the income level in a country, it may sometimes give a distorted image particularly when the income is concentrated in a small fraction of the overall population with a high degree of inequality in income distribution.

2.5 Valuing Water

Water, which has no substitute, is a basic human need as there is no life without water and access to water and sanitation is a basic human right. In addition to drinking water, food production also depends on water which can be thought of as the blood of the earth. The value of water is unquantifiable in monetary terms. It is also important to realize that the value of water is much more than its price.

The cost of providing safe water include financial, social, environmental and health components. Benefits include economic, social, environmental, food security, health etc. some of which cannot be easily converted into monetary terms. For example, lives saved by providing clean water cannot be assigned a monetary value in a traditional cost-benefit analysis. It is also important to take into account the possible costs that may be incurred if projects to provide safe drinking water are not carried out. As illustrated in Table 1, the cost of not providing safe water would be preventable deaths. In this context, instead of the traditional cost-benefit analysis, an approach in which the cost-effectiveness which takes into account the lives saved and people served would be more appropriate.

As highlighted in World Water Development Report 2021 which was released on the World Water Day (March 22), valuing water involves valuing the water sources and ecosystems, valuing water infrastructure for water storage, use, reuse or supply augmentation, valuing water services which include drinking water, sanitation

and related human health aspects, valuing water as an input to production and socio-economic activities such as food production, energy and industry, business and employment, and other socio-cultural values of water, including recreational, cultural and spiritual attributes. Good governance plays a crucial part in valuing water infrastructure. Traditional approaches of valuing water are based on cost-benefit analysis in which there is a tendency to over-estimate benefits and under-estimate costs. In particular, the value of water assigned to food production is low compared to other uses and also, the values attached to staple food production are much lower than the corresponding values attached to high-value crops such as flowers.

Even the rich countries which hitherto have not experienced the lack of safe drinking water would have realized the importance of safe water during the recent water shortages in Texas where over 1.4 million Texans faced water disruptions due to winter storm 2021, Flint in Michigan where the water has been contaminated with lead and possibly *Legionella* bacteria during 2014 – 2019 [16]. Based on a study carried out [17] McGill University Newsroom reports that rural Alaskan homes without piped water use only 5.7 liters per capita per day compared to the WHO standard of 20 liters per capita per day and far below the average consumption of 110 liters per capita per day in some parts of Canada.

2.6 Water Crises and GDP

It has been reported that securing water for all by 2030 will cost just over 1% of global GDP [18] and that the economic benefits outweigh the costs. The share of population with access to improved water ranges from about 65% in low income countries to about 99% in high income countries with a world average of about 90% (Table 2). It is also reported that failing to implement better water management policies would result in regional GDP losses from 2 – 10 % by 2050 [18]. More than 10% of the global population who live mostly in low income countries will need more than 8% of their annual GDP to deliver sustainable water management. This can be achieved only with assistance from financial institutions and governments of high income countries. Since water crises cascade beyond national boundaries, the governments around the world should pay attention to and invest in water

security regardless of national or political boundaries.

2.7 What can and Should be Done

There are no insurmountable technical problems in implementing solutions to the world's water crises. The problem is finding money to implement the solutions. This requires political will as well as seeing it not as a burden but as an opportunity. Economic losses due to lack of water and sanitation in Africa is estimated to be about 5% of GDP [24]. It is an inconvenient and sad truth that many of the people who most need water filters are those who are least able to afford them. It is difficult to expect the high income countries to solve a problem of low income countries but from a humanitarian point of view, the former can offer a helping hand to the latter. WHO also has highlighted the importance of solidarity in the context of fighting the corona virus. High tech and expensive water filters which such people cannot afford will not solve the problem. Therefore, attempts should be made to introduce low tech inexpensive filters which can be constructed with minimum instructions and with locally available materials. Nature-based solutions need to be promoted. Some possible options are given below:

2.7.1 Rainwater harvesting

Rainwater harvesting has been practiced in both developed and developing countries to augment their supplies of fresh water for domestic use. However, the quality of harvested rainwater is not always clean as one would expect because of the possible contamination enroute to the storage tank and within the storage tank. Contaminants may include bird droppings, insects, wind-blown dirt etc. Rainwater is slightly acidic and therefore can dissolve metallic substances from metallic roofs and storage container surfaces. Typical heavy metal contaminants include lead and zinc which are harmful to human health. Microbial contamination can be significantly reduced if harvesting is done after the initial flush of rainwater. Storage containers should be covered to prevent mosquito breeding and to prevent sunlight reaching the water that can promote algal growth. Harvested rainwater can be used as a non-potable source for domestic use and also as a potable source after some treatment. Ideally, the harvested rainwater can be used as the raw water in mini slow sand filters.

Table 1. Death rates due to unsafe water and sanitation in some selected countries in 2017 (extracted from (<https://ourworldindata.org/water-access#unsafe-water-is-a-leading-risk-factor-for-death>))

Country	No. of deaths due to unsafe water (per 100,000)	Percentage of deaths due to unsafe water sources	Percentage of population with access to improved water source	No. of deaths due to unsafe sanitation	Percentage of deaths due to unsafe sanitation	Percentage of population with access to improved sanitation
Chad	130.5	14.45	50.8	16,517	11.25	12.1
South Sudan	118.42	9.86	58.7	7,514	7.73	6.7
Madagascar	96.05	10.57	51.5	15,674	8.47	12.0
Niger	93.74	10.73	58.2	14,624	8.45	10.9
Angola	83.06	7.94	49.0	9,616	5.21	51.6
Somalia	75.1	6.06	31.7	6,792	4.66	23.5
India	67.46	5.75	94.1	328,720	3.32	39.6
China	0.32	0.04	95.5	2,405	0.02	76.5
Japan	0.11	0.03	100	104	0.01	100
USA	0.05	0.01	99.2	577	0.02	100
Luxembourg	0.04	0.01	100	< 1	0.01	97.6
UK	0.03	0.01	100	6	0	99.2
Italy	0.02	0.01	100	26	0	99.5
Netherlands	0.02	0.01	100	5	0	97.7
Ireland	0.01	0.0	97.9	2	0.01	90.5
World average	16.97	2.2	90.95	774,241	1.38	67.53

Table 2. Share of the population with access to improved drinking water vs. annual GDP per capita, 2015: (Source: extracted from <https://ourworldindata.org/grapher/improved-drinking-water-vs-gdp-per-capita?tab=table>)

Region	Share of population with access to improved water	Annual per capita GDP (US\$)
Low income countries	65.64%	1,844
Low middle income countries	89.19%	6,054
Middle income countries	92.15%	10,300
Upper middle income countries	95.49%	15,126
High income countries	99.54%	41,901
World average	90.95%	14,778

2.7.2 Slow sand filtration

Slow sand filters operate with the combined action of sedimentation, adsorption, straining, and, biological and microbial filtration. They not only remove suspended matter in water but also remove harmful bacteria present in water once the filter has ripened which is achieved when a gelatinous layer of bacteria, algae, fungi and higher organisms known as a *Schmutzdecke* grows over the filter. Construction of mini slow sand filters can be carried out without much skill and would be ideal in remote sparsely populated areas. With some initial guidance on the construction and maintenance, slow sand filters can be installed in individual houses.

2.7.3 Xylem filters

A more recent low-cost filtration technique practiced in India makes use of plant xylem. Xylem is the porous tissue that conducts fluid in plants with pore sizes in the nanoscale (typically a few nanometers to about 500 nanometers depending on the plant species). Based on a study carried out by MIT scientists [19,20], it has been demonstrated that filters made of pine sapwood removed E-coli bacteria from polluted water. E-coli have typical diameters of the order of 1 μm . The process begins with cutting cross sectional discs from tree branches after removing the bark, soaking them in hot water, drying, and dipping in room temperature water. The discs are then soaked in ethanol to keep the xylem membranes from sucking and sticking together when drying. After drying, the discs are placed in cylindrical filtration devices. The filtration process is then similar to that of a slow sand filter. Tests carried out in India have shown that the xylem filters remove over 99% of E-coli and rotovirus from contaminated water. Flow rates however are low of about 4 liters/cm²/day at a pressure of about 34.4 kPa which is sufficient to meet the drinking water needs of one person. Since raw materials are widely available, fabrication process is simple once the initial instructions are given to individual users. Xylem filters are able to effectively reject particles with diameters larger than 100 nanometers. The principle of the xylem filter is based on the mechanism that transports water from the root system to the plant cells. Further research and development of xylem filters could lead to their widespread use in developing countries thereby greatly reducing the incidence of waterborne infectious diseases.

2.7.4 Solar evaporation

Water purification by evaporation using solar energy is a possible solution to an increasing demand for clean water, but the downside is that the production rate is small. Still, in remote areas it is an option for producing potable water for individual houses.

2.7.5 Bioinspired hydrogel

A new technique that does not require evaporation has been recently tested [21,22] using solar absorber gel (or, SAG) that is inspired by the pufferfish's (sometimes called blowfish) ability to inflate and deflate itself with water in response to dangers from predators. In the context of water purification, the process is equivalent to absorbing contaminated water and spitting out clean water. The purifier consists of a macroporous heat-responsive hydrogel coated with polydopamine (PDA) and sodium alginate which helps to repel salts. A hydrogel is a three dimensional network of hydrophilic polymers that can expand and hold large amounts of water while maintaining their physical structure due to cross linking of individual polymer chains. When immersed in contaminated water, the SAG absorbs large quantities of water while repelling contaminants such as salts, bacteria, and other pollutants. When exposed to sunlight, the gel gets heated releasing clean water. The SAG expels the clean water by a phase change at a lower critical solution temperature without having to go through the evaporation process. Thus its energy efficiency is much higher than that in the evaporation process.

2.7.6 Diverting military spending to provide safe drinking water

The military spending as a percentage of the GDP ranges from 1.2% in low income countries, 1.9% in middle income countries and, 2.4% in high income countries to a high value of 20.9% in Eritrea [23]. Military spending is also promoted by arms traders in high income countries. Rather than selling hardware to kill people, it would be a noble practice if at least part of the resources in arms trade can be diverted to selling equipments and methods to save lives.

3. CONCLUDING REMARKS

The inconvenient truth highlighted in this paper is that about 29% of the world population who live in low income countries (or regions) do not have

access to safely managed drinking water. The result of this sad inconvenient truth is about 1.2 million preventable deaths per year worldwide. It is a problem that receives little or no attention compared with that for climate change which so far has not caused a single death directly resulting from climate change. The objective of this article is to highlight this anomaly to researchers, economists, financiers, politicians, international organizations and the world at large. Even in USA, the American Society of Civil Engineers (ASCE) infrastructure report card for drinking water received a grade of C- in 2021 while that for waste water it has been D+!.

Addressing this problem requires no high tech solutions. Nature-based infrastructure which preserves ecosystems and where the traditional cost-benefit analysis is replaced with cost effectiveness needs to be promoted as it is difficult if not impossible to quantify in monetary terms the losses or savings of human lives. Research and development can enhance the provision of fair and equitable share of water to all human beings as well as increasing the productivity of water. In addition to research and development, other means of educating the general public on the importance and sustainability of water taking into account cultural and religious practices as well as the value of water which may differ from region to region and even from person to person need be adopted. It is also ironical to note the suggestion that wealthier lenders should provide financial support to the most vulnerable countries on condition that the money is used to increase climate resilience when 29% of the world population do not have access to safe drinking water.

COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

1. IPCC. Climate Change 2007: Synthesis Report, Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. IPCC: 104;2007.
2. Jayawardena AW. Climate Change - Is it the cause or the effect? KSCE Journal of Civil Engineering Management. 2015;19:359-365.
3. Jayawardena AW. Climate change: Myths, realities and prospects of a global deal to curb climate change, 6th World Conference on Climate Change, Berlin, Germany;2019.
4. Jayawardena AW. Climate Change and Impediments to the Implementation of COP21 Paris Agreement. J Earth Science and Climate Change. 2020;11: 530.
5. Berman J. WHO – Waterborne-disease-worlds-leading-killer, VOA news; 2009. Available:<https://www.voanews.com/archive/who-waterborne-disease-worlds-leading-killer>
6. UNICEF and WHO. Progress on drinking water, sanitation and hygiene in schools: Special focus on COVID-19. New York: United Nations Children’s Fund (UNICEF) and World Health Organization (WHO), 2020;87. Available:<https://news.un.org/en/story/2020/08/1070072>
7. Kisaakye P, Ndagurwa P, Mushomi J. An assessment of availability of handwashing facilities in households from four East African countries, Journal of Water, Sanitation and Hygiene for Development. 2021;11 (1):75–90. Available:<https://doi.org/10.2166/washdev.2020.129>.
8. WHO. Drinking-water, World Health Organization;2019. Available: <https://www.who.int/news-room/fact-sheets/detail/drinking-water>
9. Ritchie H, Roser M. Clean Water and Sanitation. Published online at OurWorldInData.org;2021a. Available: '<https://ourworldindata.org/clean-water-sanitation>' [Online Resource]
10. Burek P, Satoh Y, Fischer G, Kahil MT, Scherzer A, Tramberend S, Nava LF, Wada Y, et. al. *Water Futures and Solution - Fast Track Initiative (Final Report)*. IIASA Working Paper. IIASA, Luxembourg, Austria: WP-16-006;20160
11. UNICEF. Water scarcity for all, Reimagining WASH, United Nations Children’s Fund, Report (March 2021) 2021;19. ([water-security-for-all.pdf](https://www.unicef.org/wash/files/2021/03/water-security-for-all.pdf) (unicef.org))
12. Bastiaanssen WGM, Steduto P. The water productivity score (WPS) at global and regional level: Methodology and first results from remote sensing measurements of wheat, rice and maize, Science of the Total Environment;2016.

- Available:<http://dx.doi.org/10.1016/j.scitotenv.2016.09.032>
13. Dong B, Loeve R, Li YH, Chen CD, Deng L, Molden D. Water productivity in the Zhangye Irrigation System: issue of scale. In: Barker, et al. (Eds.), Water Saving for Rice, pp. 97–115 Proceedings of an international workshop held in Wuhan, China; 2001.
 14. Cai X, Rosegrant MW. World Water Productivity: Current Situation and Future Options, CAB International. Water Productivity in Agriculture: Limits and Opportunities for Improvement (eds J.W. Kijne, R. Barker and D. Molden). 2003;163-178.
 15. Ritchie H, Roser M. Clean water, Published:OurWorldInData.org;2021b. Available: <https://ourworldindata.org/water-access#unsafe-water-is-a-leading-risk-factor-for-death>
 16. Masten SJ, Davies SH, McElmurry SP. Flint Water Crisis: What Happened and Why?, Journal of the American Water Works Association; 2016. Available:<https://doi.org/10.5942/jawwa.2016.108.0195>
 17. Sohns A, Ford JD, Adamowski J, Robinson BE. Participatory Modeling of Water Vulnerability in Remote Alaskan Households Using Causal Loop Diagrams, Environmental Management; 2021.
 18. Strong C, Kuzma S. It Could Only Cost 1% of GDP to Solve Global Water Crises, World Resources Institute, Washington DC;2020.
 19. Lee J, Boutilier MSH, Chambers V, Venkatesh V, Karnik R. Water filtration using plant xylem, arXiv:1310.4814 [physics.flu-dyn]. 2013;11.
 20. Boutilier MSH, Lee J, Chambers V, Venkatesh V, Karnik R. Water Filtration Using Plant Xylem. PLoS ONE. 2014;9(2): e89934. Available:<https://doi.org/10.1371/journal.pone.0089934>
 21. Xu X, Ozden S, Bizmark N, Arnold CB, Datta SS, Priestley RD. A Bioinspired Elastic Hydrogel for Solar-Driven Water Purification, Advanced Materials, Wiley Online library;2021. Available:<https://doi.org/10.1002/adma.202007833>.
 22. Corless V. Inspired by the pufferfish, this hydrogel purifies water using nothing but sunlight, Advanced Science News, Environment, food and water; 2021. Available:<https://www.advancedsciencenews.com/inspired-by-the-pufferfish-this-hydrogel-purifies-water-using-nothing-but-sunlight/>
 23. The World Bank. Military expenditure (% GDP);2020.Available:<https://data.worldbank.org/indicator/MS.MIL.XPND.GD.ZS?view=chart>
 24. UNESCO World Water Assessment Programme [440]. The United Nations world water development report 2021: valuing water. 2021;187. ISBN: 978-92-3-100434-6

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