TOILETS FOR THE FUTURE

QUEST TO REDUCE GLOBAL THREAT OF INFECTIOUS DISEASE

Spotlight Series

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FII INSTITUTE
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Impact on Humanity

TOILETS FOR THE FUTURE

FIGHTING WATERBORNE DISEASES WITH INCLUSIVE SANITATION

New ways to treat human waste are desperately needed in the Global South. A solution that works at scale and doesn't require expensive water and sewerage infrastructure may soon become possible.

THE ISSUE AT STAKE

IT'S SUCH A SIMPLE IDEA – AND IT WORKS. In 1775, long before bacteria had been discovered, Scottish inventor Alexander Cumming patented a design for a flushing toilet that could be mass-produced. His ingenious innovation, an S-bend waste pipe, has saved billions of lives.[1]

Yet today more than 3 billion people – almost half the world's population – do not have access to safe sanitation systems. About 1 billion are forced to defecate outside, while another 2 billion use services in which waste is not disposed of safely.[2]

Deadly diseases, including typhoid, cholera, giardia, and trachoma, a major cause of blindness, are still prevalent in developing countries, in which half of all hospital beds are occupied by people suffering from water and sanitation-related conditions. Globally, waterborne diseases are the leading preventable causes of illness and death, and diarrheal diseases take the lives of more than half a million children under five each year.[3]

Sustainable Development Goal 6 aims to halve the number of people without access to basic sanitation by 2030. But the latest development reports show that the world is not on track to achieve this goal, and factors such as population growth, drug resistance, and global warming are increasing rates of infectious disease. To achieve SD6 would cost three times the amount of money that is currently being applied.[4]

The countries of the Global South do not have the resources to adopt the large-scale water-engineering solutions that ended cholera and typhoid outbreaks in the developed world. But perhaps they don't have to. The hope is that, just as Africa and India jumped straight to mobile telephony without the need for telegraph poles and telephone exchanges, they can adopt modern sanitation systems that won't need massive supporting water and sewage infrastructure.[5]

GLOBAL PROGRESS ON SANITATION

In 2020
3.6 BILLION PEOPLE lacked safely managed sanitation services

In 2020
115 MILLION PEOPLE
gained access to safe sanitation services at home

At this rate, by 2030
2.8 BILLION PEOPLE
will still lack safe sanitation at home

TO CLOSE THE GOBAL GAP, THE RATE OF PROGRESS MUST MOVE FOUR TIMES FASTER.

To eliminate inequalities, progress must move

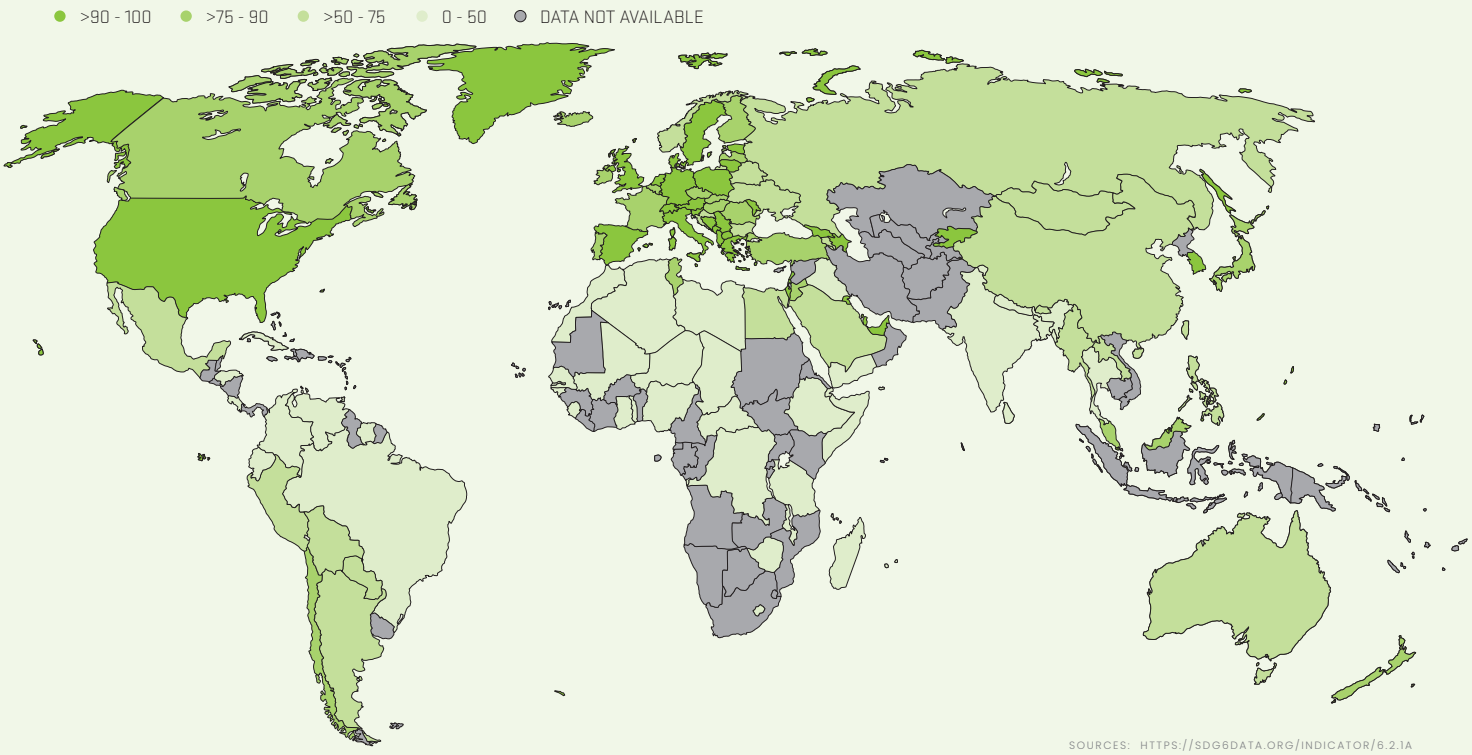
4X FASTER	5X FASTER	9X FASTER	15X FASTER
in rural areas globally	in urban areas globally	in fragile contexts	in the least developed countries

SOURCE: HTTPS://WWW.WHO.INT/IMAGES/DEFAULT-SOURCE/DEPARTMENTS/WASH/JMP21/EN_WHO_WASH_SOCIAL-MEDIA_12102021_2.JPG?SFVRSN=BE49BE8A_36

COVER: PETER DAZELEY / GETTYIMAGES

PROPORTION OF POPULATION USING SAFELY MANAGED SANITATION SERVICES

Data from 2016–2020, in percent



SOURCES: HTTPS://SDG6DATA.ORG/INDICATOR/6.2.1A

→ **REINVENTING THE TOILET**

The Bill and Melinda Gates Foundation, second-largest charitable grant giver in the world, is devoting significant resources to this issue.[6]

Using precious water resources to flush waste is unsustainable.

In 2011, noting that the use of precious water resources to flush and transport human waste is unsustainable and too expensive for developing countries, it launched a Reinvent the Toilet challenge. The aim was to revisit the 200-year-old design of the flush toilet.

To kickstart the challenge, the BMGF awarded eight universities grants of up to $400,000 to compete for a $100,000 prize. Successful designs would not require piped water, a sewerage connection, or mains electricity, and not discharge pollutants but recover energy, clean water, and nutrients. This was an acknowledgment that what is called human waste is actually a commodity from which value can be extracted as part of a circular economy. Proposed toilets should cost less than 5 cents a day in use.[7]

In 2012, the winners were announced. California Institute of Technology won first prize and $100,000 for a design using a solar-powered hydrolysis to convert waste-water into hydrogen. The UK's Loughborough University earned second place with a toilet that outputs clean water and employs combustion without oxygen, or "wet" pyrolysis, to produces biological charcoal, or biochar, that can be used as a fuel or as a fertiliser that sequesters carbon.

Canada's University of Toronto won third for a toilet that sanitizes feces and urine through dehydration, pyrolysis, and UV light to produce drinkable water. Specially commended was the Swiss Federal Institute of Aquatic Science and Technology's centralized processing facility that recycles waste to produce drinking water using gravity-driven biological membranes.[8]

In 2013, the BMGF took its Reinvent the Toilet challenge to China and India, in each →

The Generation 2 Reinvented Toilet (G2R2)was developed by the Georgia Institute of Technology.

PHOTO:

→ case awarding multiple grants and holding high-profile events.[9]

LESSONS LEARNED

It turns out that reinventing the toilet for developing countries is extremely difficult. Not one of the prizewinning designs has yet entered production at scale. Professor M. Sohail, who led Loughborough University's entry to the challenge, says: "As far as I am aware, no project has gone to the market. I have not seen anything so far that you and or I could buy. The idea was that commercialization and mass production would bring the costs down."

However, the competition has proved an excellent way to generate media interest in sanitation. In 2015, stories flashed around the world when Bill Gates drank water extracted from human waste at a plant demonstrating new technology in Seattle, where the BMGF is based.[10] Much invaluable knowledge has been gathered along the way, which has been useful to wastewater treatment generally. Lessons have been gained on technologies including ultrasound to reduce water use and enhance separation of liquid and solids, and supercritical water oxidation – a high-temperature and pressure process being developed by NASA that oxidizes waste solids in water. Promising projects have used microwaves, pyrolysis, viral agents and even insect larvae to process feces, deriving useful products, such as biochar, and syngas, a biofuel combining carbon monoxide and methane, used to generate electricity.[11]

In 2021, the BMGF selected professor Shannon Yee of the Georgia Institute of Technology to lead a team of 70 engineers, scientists, and designers and draw ideas from ten years of toilet challenges, to produce a viable "twenty-first century toilet."

The Generation 2 Reinvented Toilet (G2RT) is a home-based, plug-in unit, the size of a washing machine, independent of piped water or sewers. Urine is used for flushing but also filtered to potable quality. Some feces is pasteurized and pressed into an inert, compostable solid. Remaining feces is combusted in water, by supercritical water oxidation, which produces a fertilizer and component for concrete: ash.[12]

The G2RT is set to begin field tests in South Africa, India, and China this year. →

PHOTO: FABA-PHOTOGRAHPY / GETTY IMAGES

Biogas plant in Osterholz-Scharmbeck, Germany

→ The portable high-temperature, high-pressure device has been compared to an espresso machine. But it is still too expensive. While units are set to become cheaper and smaller, the current projected price of US$450 would place them impossibly out of reach in low-income communities, where many people do not have secure, weather-proof houses.[13]

WASTE GOES OFF-GRID

Sohail says, "A more fundamental thing for me is not looking at sanitation in isolation. I think that what we need are nice, simple municipal services that can be maintained easily and work for as many people as possible." Another sanitation technology that the BMGF is backing hopes to fill this brief. It's called the omni processor. The first unit was developed by Seattle-based Janicki Bioenergy in 2013.[14]

The size of two school buses, the omni processor relies on a technology as old as the

Timeline

2011 UN five-year Drive to Sustainable Sanitation

BMGF announces Reinvent the Toilet challenge

2011 AfricaSan 3 conference, Kigali, Rwanda

2012 Reinvent the Toilet Fair in Seattle announces challenge winners

2013 Challenge is launched in China and India

Seattle's Janicki Bioenergy develops omni processor

2014 Reinvent the Toilet Fair held in Delhi

2015 Pilot operation of the omni processor in Delhi

2018 Reinvented Toilet expo in Beijing

2021 BMGF chooses Georgia Institute of Technology to develop the Generation 2 Reinvented Toilet (G2RT)

→ flush toilet – steam power. Sludge goes up a conveyor belt and is boiled and separated. Dried solids are burnt to generate steam, driving turbines that power the unit and providing electricity for sale.

Condensed, the steam becomes distilled water, safe for drinking. The three outputs – drinking water, ash and electricity – can all be sold and there is a gate fee for sludge received, so the units can be financially self-supporting. Omni processors have been successfully trialed in India and Africa, where the outputs from dispersed rural pit latrines could now find a market in urban settings and also be used to burn rubbish.[15]

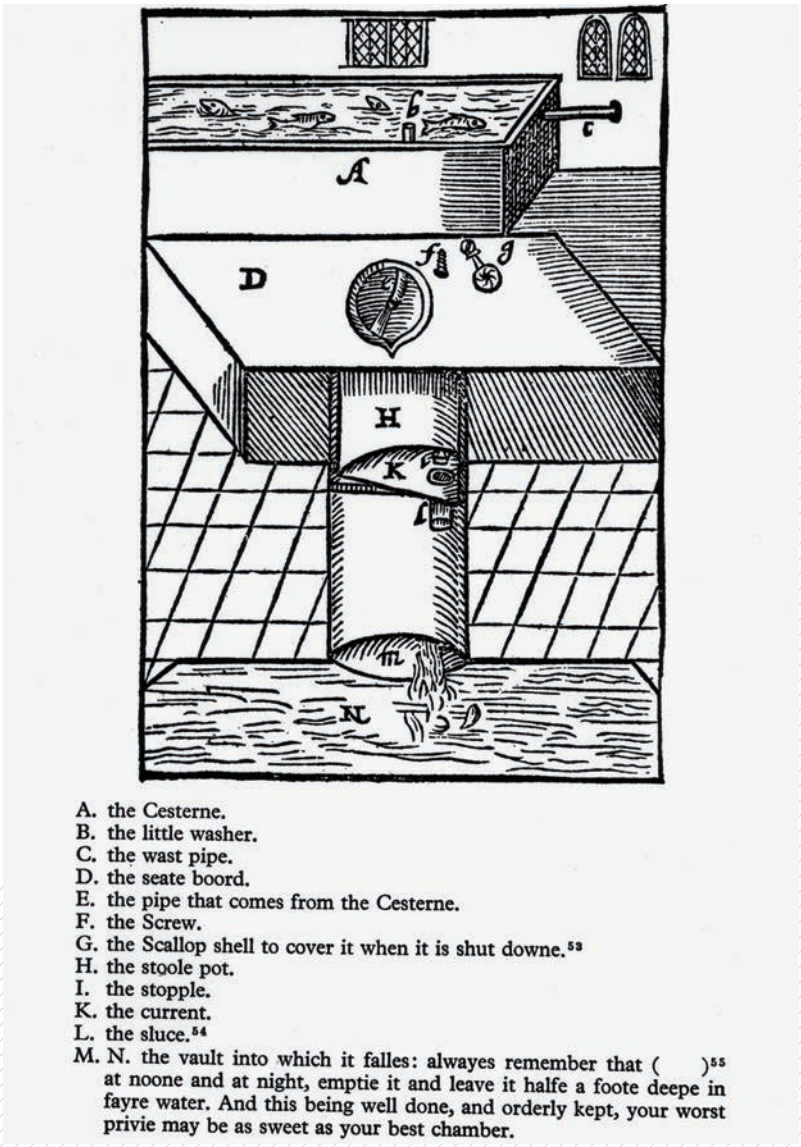
Bill Gates has established the reinvention of sanitation as a priority.

Bill Gates has established the reinvention of sanitation as a priority for his altruism, because of its life-saving potential. Since 2011, his foundation has devoted $200 million to its toilet challenges and promised, at the 2018 Reinvented Toilet Expo in Beijing. to invest the same in continuing R&D to "bring down the costs of new sanitation products for the poor and bolster market development in regions where non-sewered sanitation products can have the greatest impact."[16]

Gates revealed in Beijing that 20 reinvented toilet and omni processor technologies and products are now available for commercial licencing and production. The World Bank partnered with the BMGF for a successful trial of the omni processor in Senegal. It has found local level grants and user subsidies to be a smarter and more sustainable form of finance than top-down country-level initiatives that tend to most benefit the wealthiest.[17] At the expo, it joined the Asian and African Development Banks to announce commitments potentially unlocking $2.5 billion in finance for city-wide inclusive sanitation projects.

The Boston Consulting Group estimates that emerging economies with market readiness and national policies prioritizing sanitation improvement offer a US$3.2 billion investment opportunity.[18] It could well be that we have arrived at a tipping point, where commercial and development bank finance together with technical innovation will now facilitate sanitation projects at scale across Africa, Asia, and South America – the places where they are needed the most. ←

Sir John Harrington's design for a water closet with a raised cistern, published in 1592



Quick facts

- **One gram of feces** can contain **10 million viruses, 1 million bacteria** and **1,000 parasite cysts**
- Almost **1 billion people die** each year from **diarrhea** as a result of **unsafe drinking water and poor sanitation**
- **Sanitation-related sickness** costs an estimated **$223 billion** a year in health costs and lost productivity
- Every **$1 invested** in sanitation delivers up to **$9 in social and economic benefits,** because it increases productivity and reduces healthcare costs

SOURCES: UNICEF, WHO, BMGF

PHOTO: SCIENCE & SOCIETY PICTURE LIBRARY / KONTRIBUTOR / GETTY IMAGES

Wastewater treatment plant using sludge recirculation to produce clean water for consumption in Thailand.

PHOTO: SURIYAPONG THONGSAWANG / GETTY IMAGES

WHAT CAN WE DO?

- **Waste management** should be integrated with policies on housing, water, energy saving, and health.
- **Human waste should be disposed of** with value extracted from its constituents.
- **Grants and subsidies are best deployed locally by financial institutions,** to make sanitation improvements sustainable.
- **Charitable grants are a** great way to leapfrog old technologies while preparing new technologies for investment.

ABOUT FII INSTITUTE

THE FUTURE INVESTMENT INITIATIVE (FII) INSTITUTE is a new global nonprofit foundation with an investment arm and one agenda: Impact on Humanity.

Global, inclusive and committed to Environmental, Social and Governance (ESG) principles, we foster great minds from around the world and turn ideas into real-world solutions in five critical areas: Artificial Intelligence (AI) and Robotics, Education, Healthcare and Sustainability. We are in the right place at the right time: when decision-makers, investors and an engaged generation of youth come together in aspiration, energized and ready for change.

We harness that energy into three pillars: THINK, XCHANGE, ACT. Our THINK pillar empowers the world's brightest minds to identify technological solutions to the most pressing issues facing humanity. Our XCHANGE pillar builds inclusive platforms for international dialogue, knowledge-sharing and partnership. Our ACT pillar curates and invests directly in the technologies of the future to secure sustainable real-world solutions. Join us to own, co-create and actualize a brighter, more sustainable future for humanity. ←

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