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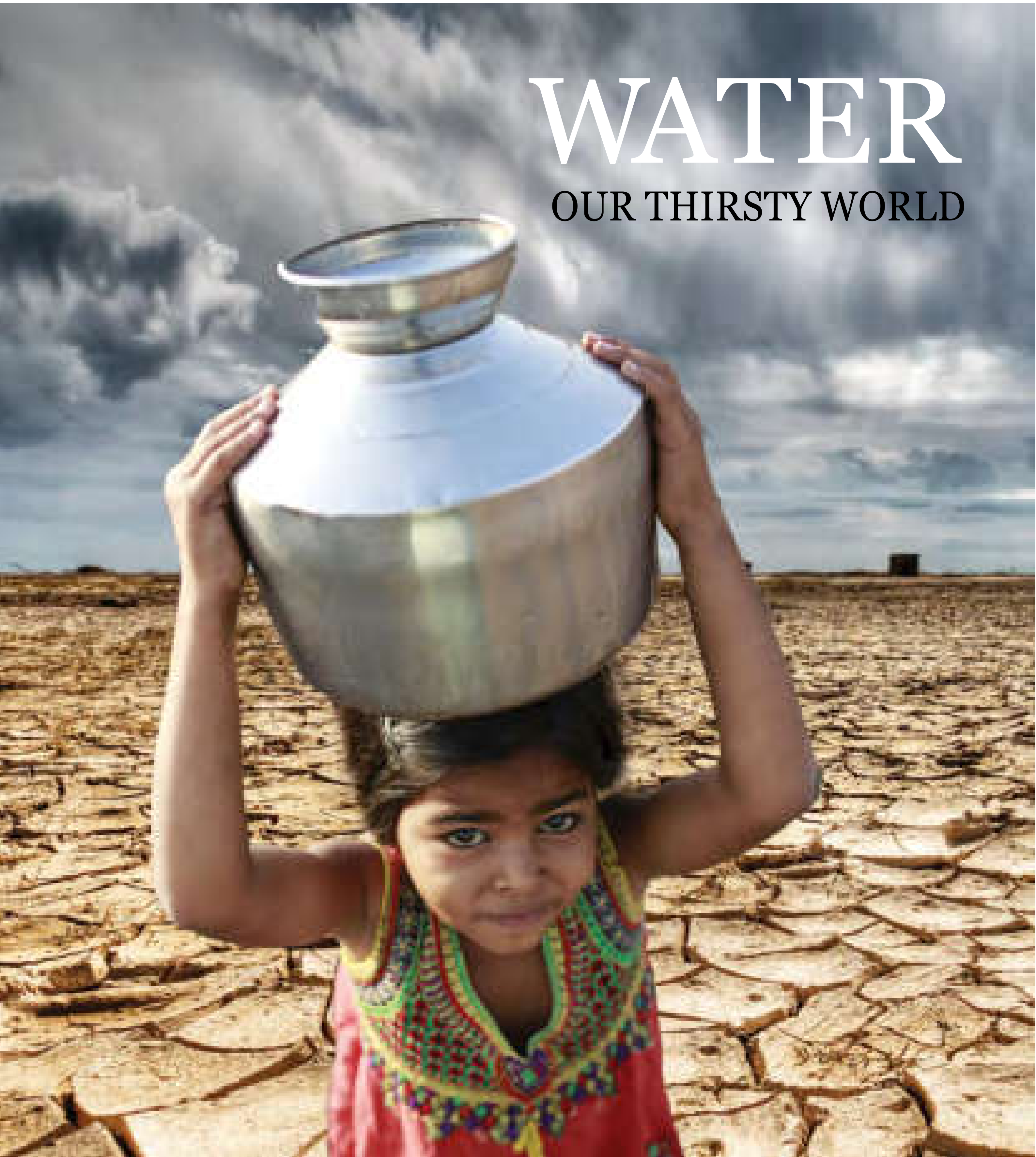
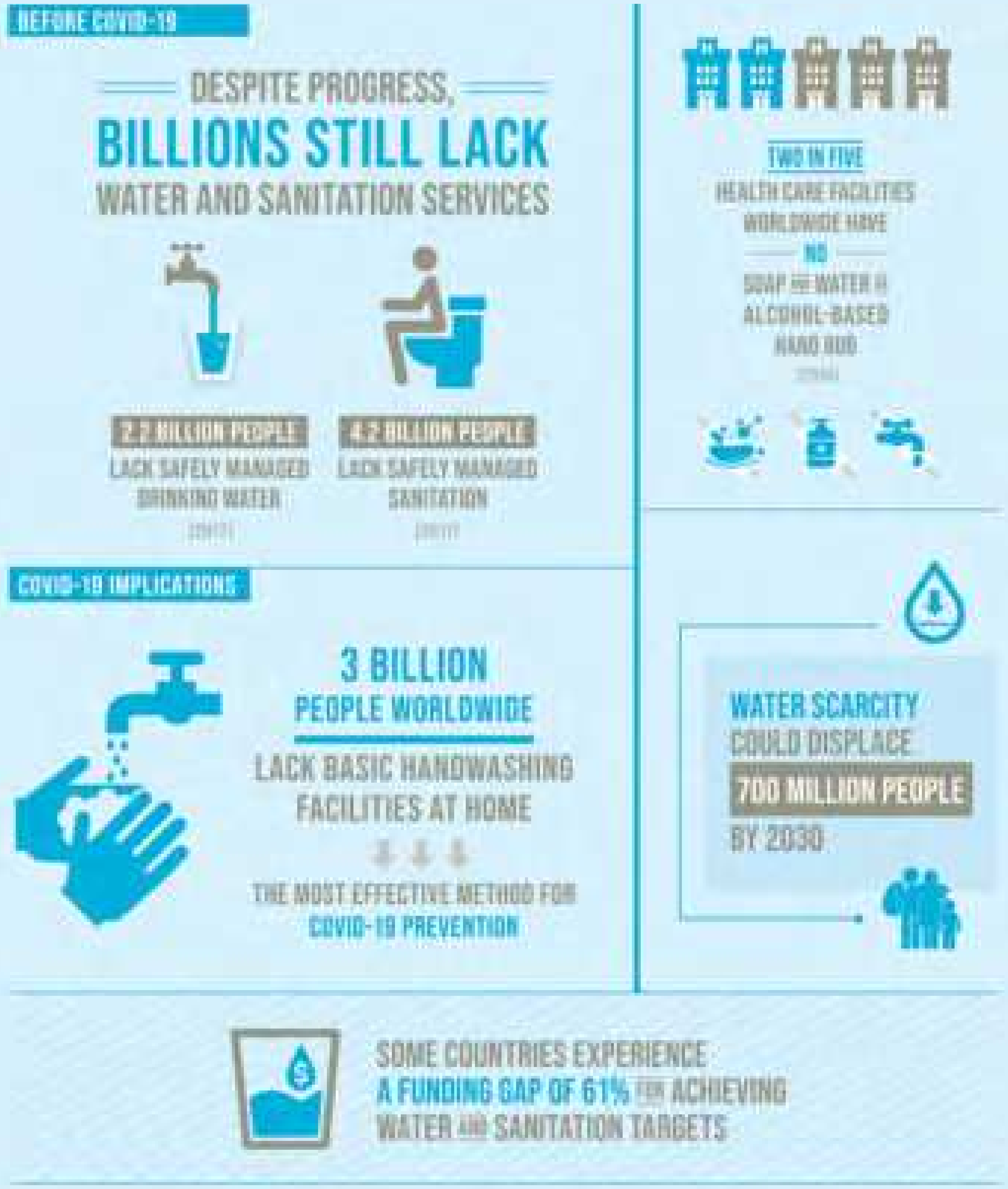


WATER

OUR THIRSTY WORLD

ENSURE AVAILABILITY AND SUSTAINABLE MANAGEMENT OF WATER AND SANITATION FOR ALL



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APRIL 2022

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SUSTAINABLE DEVELOPMENT GOAL – 6

CLEAN WATER & SANITATION

Water scarcity affects more than **40 percent of people** around the world

This is projected to increase with the rise of **global temperatures** as a result of **climate change**

In 2011, **41 countries** experienced water stress

10 countries are close to depleting their supply of renewable freshwater and must now rely on alternative sources

By 2050, it is projected that **at least one in four people** will be affected by recurring water shortages

Increasing drought and desertification is adding to the concern.

2.1 billion people have gained access to improved water sanitation since 1990

But **lack of safe drinking water** is a global concern for **every continent**

Foreword

In this edition of Organic Growth, we have 3 articles discussing the fast deteriorating crises of water supply and sanitation, in India and across the world. In the lead article, "A Bone Stuck in our Throats-Centralised Water Supply and Sanitation", Rahul Banerjee writes about the trials and travails of the centralized water management solution implemented in Indore, a city otherwise renowned for its water management.

Madhu S Thakar, in "Safe Sanitation and the Looming Water Crisis", writes about the pivotal importance of water and sanitation in every facet of human life, from health to economic, because of which water underpins almost all the SDG goals

Sunesh Sharma in "Community based water management in the Arsenic affected village of Nalbari district of Assam", outlines the effort of Centre for Microfinance and Livelihood (CML) and Tata Trusts through deploying innovative and affordable technologies are engaged in improving water quality in that region.

We hope you find the articles and other related information thought provoking to stir us into more responsible action in this area.

– Editor

A Bone Stuck in our Throats – Centralised Water Supply and Sanitation

– Rahul Banerjee

The prognosis is dire that by 2030 most cities in India will face severe water shortages (Niti Ayog, 2020). In what follows, these problems are detailed with reference to the city of Indore in Madhya Pradesh, which has been declared the best in India in terms of water management by the Ministry of Housing and Urban Development (Free Press, 2021) and possible solutions are discussed.

A major area of concern currently for the country is the ecological unsustainability and economic unviability of centralised water supply and sanitation (WSS) in urban areas. The supply of potable water to cater to the needs of modern urban households also increases the waste water generated. The implementation of the Swachh Bharat Mission has over and above this led to a substantial increase in the number of toilets and this has increased the faecal sludge and the wastewater load considerably along with the demand for water. Thus, while there have been substantial capital investments in recent years on centralised water supply and sanitation, there is, nevertheless, a serious lack of resources with urban local bodies (ULB) for meeting the operating expenses. The prognosis is dire that by 2030 most cities in India will face severe water shortages (Niti Ayog, 2020). In what follows, these problems are detailed with reference to the city of Indore in Madhya Pradesh, which has been declared the best in India in terms of water management by the Ministry of Housing and Urban Development (Free Press, 2021) and possible solutions are discussed.

Centralised Water Supply

The problems of centralised water supply that are there throughout urban areas are as follows –

- Local Surface Water Sources are either insufficient or are severely polluted.
- Distant sources have to be tapped and these require huge capital and operating expenditures. These sources become inadequate over time and so newer sources have to be found.
- Piped water supply leads to greater wastage as people tend to use more water since it is easily available.
- Since the centralised supply is not adequate in most cases

there is also individual ground water use which results in over extraction of ground water from the aquifers

- The water supply is unreliable and intermittent and much less than the 135 litres per capita per day (lpcd) norm for cities which is necessary in urban areas for there to be enough flow in the sewers to carry the sludge by gravity to the sewage treatment plants (STP).
- Distribution networks are plagued with leakages and contamination from sewage
- There is a high proportion of non-revenue water due to theft in collusion with the suppliers.

These problems can be better understood by studying the example of Indore city in Madhya Pradesh. The Indore Municipal Corporation (IMC) is spread over an area of 276 sq kms with a population of about 3.1 million in 2021 (IMC, 2021). The water supply is primarily from the River Narmada and the water works are at Jalud on the river bank which is at a distance of 60 kms and a height difference of 500 metres to the south of the city. There is also earlier but much smaller water supply scheme from the Yashwant Sagar dam on the Gambhir River at a distance of 30 kms to the Northwest of the city. Currently, along with some supply from an intake well in the Bilawali lake and several deep tubewells the total water supply from all sources is 400 million litres per day (MLD) and per capita supply is roughly 125 lpcd estimated by dividing the total water supply by the population but without counting the distribution losses. The installed capacity is about 600 MLD but due to unavailability of water in both surface and underground sources and supply from the Narmada source to other towns and villages, the actual average supply is less. The non-revenue water has been estimated to be 67%. There is an elaborate infrastructure of 2100 kms of supply lines, pressure pumps and mostly overhead storage tanks and two underground reservoirs for water supply to the city. The main problems are the inadequacy of supply in the summer months when the water supply reduces and tankers have to be deployed to supply water to many areas. The water supply lines and the sewer lines have leakages and so water from the two mix and lead to contamination of the water supplied.

The cost of water supply at 18.73 per kilolitre is very high in Indore because most of its water is sourced from the river Narmada, which is at a distance of 60 kms and at a height difference of 500 m. There is a huge shortfall in operating and maintenance (O&M) cost recovery of 74.7 percent. The cost recovery is done through water taxes from individual households depending on the ferrule size and from bulk users through quantitative charges on metered supply and not only are the charges low but the collection efficiency is also poor.

Centralised Sanitation

The problems with regard to centralised sanitation are two fold. One with regard to sewerage and the other with regard to sewage treatment. Sewerage problems are as follows (CPHEEO, 2013) -

- Lack of adequate water supply is the first major obstacle. Sewerage systems ideally require 135 lpcd water supply to maintain adequate flow and in no circumstances can this be less than 100 lpcd. However, this is rarely the case.
- Even where sewerage systems have been installed and are operational there are not enough house connections. Even if there are house connections these are to the septic tanks and the kitchen and bathroom wastewater which not only fail to provide adequate flow but also do not have enough faecal matter.
- The mixing of grey water from the kitchen and bathroom with the black water from the toilets unnecessarily increases the amount of waste water to be treated as black water.
- There are inadequate resources with the urban local bodies (ULB) for the operation and maintenance of the sewerage system and STPs. The sanitation charges that are levied from the users do not cover the cost of O&M of the sewerage systems and STPs.
- The cleaning of sewers which get clogged due to inadequate flow and the flushing of plastics is largely done by contractors. There is an inadequate supply of machines capable of cleaning the sewers and so this work is mostly done manually in violation of the law against manual scavenging. This frequently results in deaths of the staff employed for the purpose.
- Apart from this another anomaly is with regard to storm water management. Stormwater drains have to be designed for the highest recorded intensity of precipitation over a 25 year period. The design peak flow estimated from this is a high value that is rarely there cumulatively for more than two or three days a year. So unnecessarily big sections have to be constructed for storm water drains which rarely flow to their capacity and instead get choked with rubbish.

The sewage treatment too is not being properly done due to the following problems –

- There is a big gap between the wastewater generation and treatment. The inadequately treated and untreated wastewater is being released into water bodies causing ground and surface water contamination.
- The agencies or departments engaged in the O&M of STPs are suffering from financial crisis and lack of skilled manpower.
- The treatment and disposal of sludge from the STPs is a problem leading to a reduction of cleaning of the STPs, resulting in a drastic reduction in treating capacity. There is no attempt to generate energy and manure from the sludge and thus recover costs.
- Industrial effluents are also being mixed into the sewage coming to the STPs instead of being treated in Effluent Treatment Plants separately.
- All the STPs have a by-pass arrangement. The STPs treat only a portion of the sewage received and the rest of the sewage is discharged untreated through by-pass arrangements. During monsoons when it rains heavily, the whole flow is bypassed.
- The treated sewage of most of the STPs is not being monitored and analysed on a regular basis for the assessment of the degree of treatment as there are no dedicated laboratories in the STP campus for this purpose.
- There is no planned reuse or recycling of treated wastewater which is an important means of cost recovery.
- The treated sewage is being discharged in the nearest wastewater drain. Chlorination is not being done at the outlet of any of the STPs for control of Total and Faecal Coliforms thus contributing to contamination of surface water bodies.
- Diesel generator sets are not provided in the STPs for backup power for operation of the biological system without any interruption during power failure.

These problems of centralised sanitation manifest themselves in the city of Indore also. The Rivers Kahan and Saraswati drain the city of Indore and a considerable part of the sewage would earlier also drain into these rivers. Over the past few years, a massive programme has been undertaken to tap these open drains and

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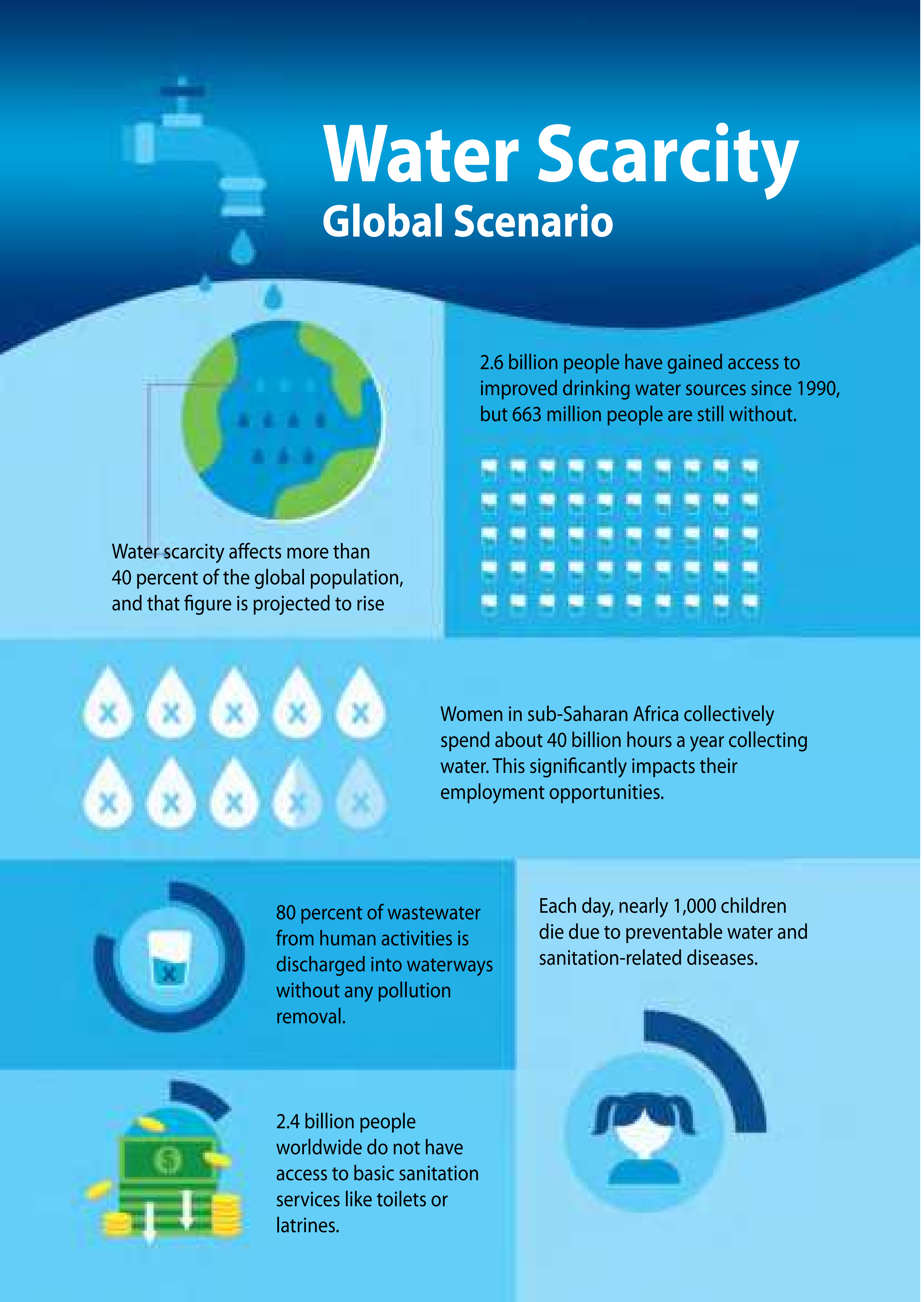

outfalls, numbering in thousands, discharging untreated wastewater into these rivers by laying sewers along their banks and then directing the wastewater to seven new STPs constructed at intervals along these rivers. Currently there are about 1100 kms of sewers in the city. There was already a group of STPs downstream of the city at Kabitkhedi along the river Kahn to treat the wastewater from the sewerage system laid in the city but they were partially treating only about 100 MLD of the total wastewater of 320 MLD or so that is generated as there were not enough sewers to carry the wastewater to them. Now, with the tapping of all the thousands of outfalls and treatment of the wastewater in the seven new STPs constructed along the rivers and greater flow to the Kabitkhedi group of STPs as a consequence of new sewers being laid, 312 MLD of wastewater is being partially treated and some of this is being reused in washing roads and in maintaining the various gardens and parks while the rest is being released into the rivers (Free Press 2021, op cit). While the improvement in water supply from the Narmada River and the treatment and reuse of wastewater has made the city best in water management in India, this has been achieved at a huge cost of thousands of crores in laying sewer lines, tapping outfalls and augmenting treatment capacity. However, the outlay on operation and maintenance of the sanitation systems too is well below the required standards and so like in the case of water supply, wastewater too is not being cleaned properly. The IMC spends only Rs 26.58 crores annually on wastewater management whereas for proper treatment it should be spending Rs 151 crores according to standard costs (CPHEEO & MoHUA, 2021). Thus, there is a huge shortfall of 82.4 percent.

Affordability Analysis of Centralised Water Supply and Sanitation Services

The foregoing financial analysis clearly shows that the IMC is not recovering the costs of the water supply and sanitation services it is providing. Let us assume that the total number of households paying the user charges for water supply will also be those that will need to pay sanitation charges for recovery of costs by the IMC and leave out other households on the grounds of equity. Thus, there were 2.01 lakh water tax payers in 2015 (IMC, 2021). However, this number needs to be increased by 20 percent to cover those that are not paying for water but should be and also by another 10 percent to account for the increase over the five years from 2015 to 2020. Thus, the total tax payer households will be 2.6 lakhs.

The total actual expenditure on water supply was Rs 273.36 crores and that required for proper wastewater management was Rs 151 crores in 2020 or a total of Rs 424.36 crores as we have seen earlier. The average per household water supply cum wastewater management charge per month required to cover the actual expenditures required for proper service delivery would then be – 424.36 crores /2.6 lakhs/12 = Rs 1360.

The Average urban per capita monthly Household Consumer Expenditure in the 68th round of the National Sample Survey Organisation survey for Madhya Pradesh in 2011-12 was Rs 1967 (NSSO, 2013). Assuming a household of five persons this gives the average monthly household consumer expenditure in 2011-12 to be – 1967 x 5 = Rs 9835.

Assuming an average annual consumer price inflation rate of 6% from 2011-12 to 2020 the average monthly household consumer expenditure in 2020 would be Rs 15675.

Thus, for recovery of costs the proportion of centralised water management to the average household consumer expenditure works out to be –

100*1360/15675 = 8.7 percent

This is an unacceptably high proportion. The proportion of households who had monthly consumer expenditure less than the average is 65 per cent of whom the bottom 30 per cent will have to be exempted as being too poor to pay. Thus, as much as 35 per cent of the population would have to spend 8.7 per cent or more of their monthly consumer expenditure on water and wastewater services which is not affordable by any means. The recovery of the huge capital expenditures over a period of time would lead to even higher user charges. The capital and operation and maintenance costs of centralised urban water management systems are very high and neither the ULBs nor the Governments are able to meet them. The affordability analysis shows that a fairly large proportion of the population will not be able to afford the required user charges for economic viability. This unworkable system was introduced by the British and is most unsuitable for this country. It has remained like a bone stuck in our throats.

An Alternative Decentralised Urban Water Management System

Thus, there is a need to explore ways in which alternative systems can make the provision of water supply and sanitation services more ecologically sustainable and economically viable. A decentralised conjunctive plan can be implemented at the household level involving –

- Rain water harvesting and recharge which will improve groundwater availability in the shallow aquifer and enable tapping of groundwater locally for water supply.
- Separate collection and treatment of grey water from the bathroom and kitchen through filtration, aeration and chlorination.
- Re-use of the treated grey water in flushing of toilets and in gardening to obviate the use of costly potable water for the same.
- The black water from the toilets to be mixed with the green waste from the kitchen in a bio-gas plant. The gas generated after being scrubbed of the hydrogen sulphide in it is to be used for heating water and also for cooking. The slurry is to be oxidised and used as manure in the garden.

This has been represented schematically in Fig. 1

The detailed features of the various components of this scheme are as follows –

- The rainwater falling on the roof of the building is

WATER SCARCITY IN INDIA

Two-thirds of India's 718 districts are affected by extreme water depletion, and the current lack of planning for water safety and security is a major concern.

India has become the **world's largest extractor of groundwater**, accounting for 25 per cent of the total

Chemical contamination of water, mainly through fluoride and arsenic, is present in **1.96 million dwellings**

Less than 50 per cent of the population in India has access to safely managed drinking water.

256 of 718 districts in India have reported 'critical' or 'over-exploited' groundwater levels

Three-fourths of India's rural families lack access to piped, drinkable water and must rely on unsafe sources

70 per cent of our water sources are contaminated and our major rivers are dying because of pollution.

Over 21% of the country's diseases are water-related. Furthermore, only **33% of the country** has access to traditional sanitation

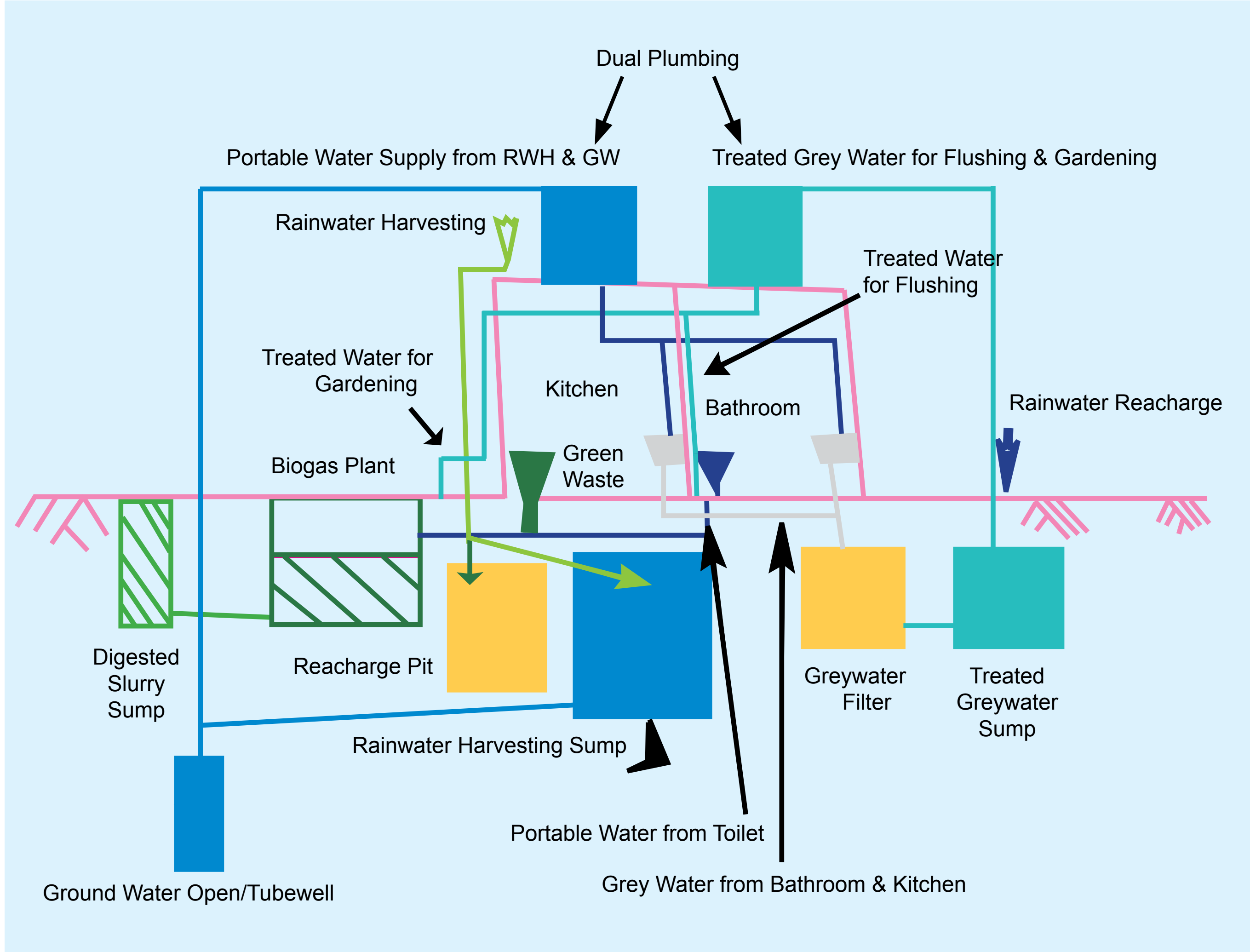

Fig. 1: Schematic Diagram of Decentralised Conjunctive Water Management

either harvested or recharged. Harvesting is more costly as it involves the construction of an underground sump to collect the water. Currently the cost is about Rs 8 per litre as a reinforced concrete tank has to be constructed. Thus, an optimisation has to be done as to how much of the rainfall is to be harvested and how much recharged depending on the availability of groundwater as recharging is much cheaper. In hard rock areas with poor water availability in summer, water harvesting can be done to take care of the water demand in the summer months if the groundwater dries up. However, if there is water recharging done on a mass scale throughout the urban area then most areas in the country will have adequate water in the confined aquifer. In alluvial plains like in the Mahanadi basin of Chhattisgarh even the shallow aquifer will have adequate water in summer if water recharging is done. That is why in the diagram two options have been provided and there is also a recharge pit alongside the harvesting sump. This pit is filled with a mixture of gravel and sand and is designed to be of a size to absorb the flow of rainwater coming to it from the roof. The rainwater falling on the ground too will be recharged either directly through the soil if there is a garden or the water falling on the paved area will be directed to the recharge pit. The rain water falling on the roof is filtered through a mixture of gravel and sand before being collected in the harvesting sump. The first one or two showers are bypassed to the recharge pit as the water is dirty with dust gathered on the roof so about 80 percent of the rainfall can be collected if so required but usually to optimise collection costs less is collected.

- The harvested rainwater and the groundwater provide the potable water supply for drinking, washing and bathing uses and there is a separate plumbing system for these under the dual plumbing system as the water demand for flushing and gardening is to be met from treated grey waste water.
- The grey water from the bathroom and that from the

kitchen, which latter has to first pass through an oil and grit trap, are directed to a filtration tank consisting of gravel, sand and charcoal. After filtration the water is collected in a sump where it is aerated and chlorinated to clean it further. This water is then used for flushing of toilets and gardening through a separate plumbing system. In this way the use of potable water for these uses is obviated which is a considerable saving because as per the CPHEEO norms (CPHEEO, 2005), of the 135 lpcd of water supply as much as 25 lpcd is for gardening and 40 lpcd for flushing of toilets. Since the black water does not have to be carried in sewers, the quantity of water needed for flushing is greatly reduced and special toilets can be installed that require less water. Sensors have to be placed in the sump and the overhead tank to automatically regulate the pumping of water from the former to the latter so as to prevent over flow in the former.

◗ The black water from the toilets and the green waste from the kitchen are sent to a biogas plant. The gas generated from this plant contains mainly methane and some hydrogen sulphide also. The latter being harmful, has to be removed through a scrubber. The gas generated can be used for cooking and for heating water in a gas geyser. In case of four storeyed or higher buildings, the gas produced can be used to generate electricity which can be reused in the aerators of grey and black water treatment. The digested slurry is collected in a two chambered sump in which one chamber is alternatively filled up and the sludge further digested by anaerobic decomposition to be turned into manure that can be used in the garden while the other chamber fills up much like a two-pit latrine but with the water not leaching into the ground but drying up slowly in the chamber that has filled up as an aerator runs in it to both oxidise the slurry and dry it up. The energy required for this is much less than that needed to run the heavy blowers in large sized STPs of centralised systems.

There are some households in slums that do not have enough area for implementing the wastewater treatment part of this scheme and for them a community wastewater system called DeWATS (Decentralised Water Treatment Systems) has to be implemented as shown in Fig 2 below.

The principles are the same as in the household model but in this case the reuse of treated wastewater, gas and compost will require some more investment and involvement at the community level. These community systems will have to be implemented by the ULBs but the investments and operating expenses required will be similar as for the household model.

The most important positive aspects of the decentralised model are as follows –

◗ When implemented at a household level in standalone houses of up to four storeys it requires only minimal energy for wastewater treatment for aeration of the greywater after filtration which is more than compensated by the generation of gas from the black water and green waste. So, the overall wastewater treatment system is energy and carbon positive. The amount of net energy generated and carbon emission reduced depends on the quantity of waste water treated. This is much better than having sewer lines and STPs for community housing layouts because then the capital cost, operating cost and energy use increases exponentially with the size of the layout. In case of high-rise buildings, however, there have to be community STPs of the second type but even in those, the separation of grey and black water will reduce the energy consumption which will be required only for aerating the grey water. The energy required for this can be met by generating electricity from the biogas produced by digestion of the black water and green waste.

◗ The problem of disposal of the green kitchen waste which is a major expense for ULBs is also solved very efficiently by directing it to the biogas plant and generating energy and manure from it. The huge expense and carbon emissions involved in transporting the green waste to trenching grounds will also be obviated.

◗ Potable water is sourced in situ and in most areas of the country the amount of rain water recharged will be more than the amount of water drawn from the ground for water supply and so the water availability in both the confined and unconfined aquifers will increase if this scheme is implemented over the whole urban area. This too results in savings in energy costs for pumping of water because the water level is much higher and there is consequent reduction of carbon emission. Even greater are the savings in energy and costs at the urban level because as we have seen even in cities like Raipur and Kolkata which are situated near perennial rivers, the water supply cost is so high that it is not met by user charges. In the case of cities like Indore and Bengaluru which have to rely on distant water sources these savings will be huge and considerably improve the financial health of the ULBs.

◗ A persistent problem facing ULBs is that of non-revenue water. A considerable amount of the water is lost through leakages and theft. The leakages and theft are difficult to control because this requires more capital and operating expenditure which are difficult to come by given the precarious financial situation of the ULBs. This is a Catch 22 situation wherein losses and theft take place because of lack of resources with ULBs and these then aggravate the financial situation of the ULBs even further and they are more unable to remedy the situation. This is where the decentralised systems will make a major impact. With the need for centralised supply completely obviated there will not

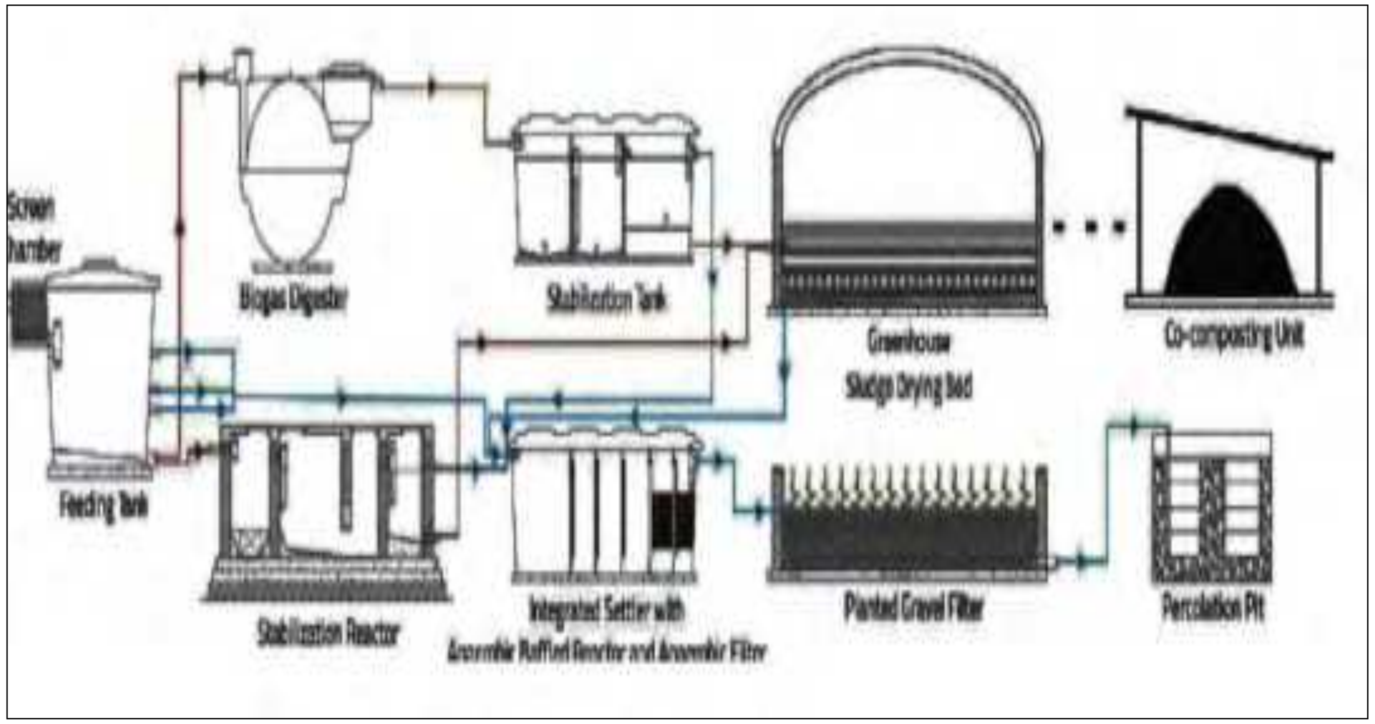

Fig. 2: Schematic Diagram of a DeWATs System (Source: CDD 2020)

be lengthy supply lines which can be breached or stolen from.

◗ Rain water harvesting and recharging also means that there is no stormwater exiting from the house premises. This will considerably reduce the stormwater load during monsoons. If the storm water falling on roads is also recharged along the sides of the roads through appropriately designed recharge trenches instead of the stormwater drains that are now there, then there will be no water logging during monsoons at all and instead the water availability in the aquifer will increase substantially, further reducing energy costs for water supply.

◗ The average additional capital cost of implementing this system of water management at the household level is about Rs 1500 per square metre which is about 10 percent of the prevailing cost of building construction of standard specifications of 15000 per square metre. In case all the rain water is recharged then the capital cost comes down to Rs 750 per square meter or 5 percent of total cost of construction. Most of the buildings in an urban area belong to either the Government, commercial establishments or middle, upper middleclass or upper-class people who can easily undertake this extra cost given that in the long run they will recover this initial outlay from reduced user charges to be paid to the ULB for water supply and waste management. Not only do these decentralised systems need to be made the norm in new building construction but should also be retrofitted in already constructed buildings which occupy most of the space in cities. Thus, the ULBs will be left only with the responsibility of supplying potable water to and collecting and treating the waste water and green waste from the poorer households who are not able to incur these expenses. However, since this too will be done in a decentralised manner in the localities in which the resource poor live, the huge expenses involved in constructing and running centralised water supply and wastewater management systems will be obviated.

◗ The ULBs can also free themselves from the onerous and expensive task of collecting the non-biodegradable waste since

All the STPs have a by-pass arrangement. The STPs treat only a portion of the sewage received and the rest of the sewage is discharged untreated through by-pass arrangements. During monsoons when it rains heavily, the whole flow is bypassed.

of leakages and thefts in water supply. This problem will become non-existent with decentralised systems as all the waste water will be properly treated and reused in situ. The associated problem of cleaning the sewers, which results frequently in the death of workers who are deployed for this purpose will also be solved.

◗ The CPHEEO manual on sewerage and sewage treatment lays considerable stress on reuse of treated wastewater from STPs and energy generation from sludge and its use as manure. However, in reality this is difficult because STPs are located at distance and down stream from the reuse areas. Therefore, pipelines have to be laid back to the city from the STPs and the treated water has to be pumped back. This is a huge capital expenditure and the operating cost of running the reuse system is also quite high making it uneconomical to reuse. However, with decentralised systems since the reuse is in situ it is much less costly and it also reduces the potable water demand by taking care of the two biggest water uses – toilet flushing and gardening. Moreover, energy generation and the extraction of manure from the sludge is also much easier and adds to revenue reducing the cost.

◗ There is a considerable reduction in carbon emissions also as not only is the fossil fuel energy use reduced and most of the energy is recouped from digestion of the waste in decentralised systems but also the huge energy involved in transportation of water, wastewater and green waste is also obviated. In this way decentralised systems are carbon positive as opposed to centralised systems which are highly carbon negative. This is an important consideration given the need for mitigating climate change.

◗ The biggest problem is the inequity in provision of water supply and wastewater management services by ULBs due to the financial crunch that they are in. Invariably, the well

IMPACT OF WATER SCARCITY ON CHILDREN

CHILDREN IN **100** MILLION HOMES IN THE COUNTRY LACK WATER

CHILDREN OFTEN BEAR THE BURDEN OF WALKING MILES EACH DAY TO FIND WATER IN STREAMS AND PONDS

SCHOOL ATTENDANCE IN INDIA DECREASES WHEN CHILDREN ARE REQUIRED TO SPEND HOURS COLLECTING WATER

22% INCREASE IN SCHOOL DROPOUT RATES HAS BEEN REPORTED IN DROUGHT AFFECTED STATES

54% OF RURAL WOMEN – AS WELL AS SOME ADOLESCENT GIRLS – SPEND AN ESTIMATED 35 MINUTES GETTING WATER EVERY DAY, EQUIVALENT TO THE LOSS OF 27 DAYS' WAGES OVER A YEAR

All children have the right to clean water and basic sanitation, as stated in the Convention on the Rights of a Child. The ultimate aim of UNICEF's work in water, sanitation and hygiene (WASH) is to ensure that all children fulfill this right, and that no child is left behind.

to do are provided with much better water supply and waste management services than the economically weaker sections of the urban areas. Often the latter have to pay exorbitant rates for tanker supply in the summer months when there are acute water shortages.
The decentralised system will put the onus of water supply and wastewater management for most of the urban areas on the well to do residents, commercial establishments and the government offices thus freeing the ULBs of a major responsibility. They can then concentrate on facilitating decentralised water supply and wastewater management to the economically weaker sections at a much lower cost than in centralised systems.
There are a few examples of the successful implementation of such decentralised water management systems across the country, most notably that implemented by the Dhas Gramin Vikas Kendra in Indore over the past two decades (Pillai, 2012).

Comparison of Costs of Centralised and Decentralised Water Management Systems

We have seen earlier that the centralised water supply cost in Indore is Rs 18.73 per kilolitre for a supply of 125 lpcd. The corresponding cost of water supply through decentralised systems can be calculated as follows –
Out of the norm of 135 lpcd water supply, 65 lpcd or roughly half the total requirement. The other half will come from either the rain water harvesting sump or from an open/bore well. Assuming a 1 HP pump supplying at 50 litres per minute, the electrical energy required for pumping 1000 litres of water will be 0.750 kilowatts *1000/(50*60) hours = 0.25 Kwh or units. Assuming a domestic tariff of Rs 6 per unit the cost of energy per kilolitre comes to Rs 1.5. If we add another Rs 0.5 for maintenance of rainwater harvesting and recharging expenses, then the cost of 1 kilolitre of water from a decentralised system comes to only Rs 2 which is only 10.6 percent of the cost of water from the prevailing centralised system.
The cost of centralised wastewater treatment in Indore currently is much lower than it should be and so the national average cost has to be taken which is Rs 12.3 per kilolitre (CPHEEO & MoHUA, 2021). The main cost in decentralised waste water treatment is in aeration of the

The cost of centralised wastewater treatment in Indore currently is much lower than it should be and so the national average cost has to be taken which is Rs 12.3 per kilolitre water and the slurry. A 0.5 HP air pump can aerate the combined grey water and the slurry volume of 1 kiloliter by running 3 hours at night when there is little or no flow. Thus, the energy expended will be 0.375 kilowatts*3 hours = 1.13 Kwh or units of electricity. However, the energy produced from the biogas plant by digesting the black water and green waste is 6 Kwh per m3 at standard temperature and pressure (Energypedia, 2021). Assuming that 0.1 m^3 of gas are produced we get 0.6 Kwh of energy from the digested biogas. Therefore, the net electricity requirement is only 0.53 units which at Rs 6 per unit comes to a cost per kilolitre of wastewater of Rs 3.2. If we add another Rs 0.3 for maintenance costs then the total cost is only Rs 3.5 per kilolitre of wastewater which is only 28 percent of the cost of treatment in a centralised system. Moreover, the cost of transportation of green waste is obviated and the dry waste is recycled by cooperatives of waste collectors at no operating cost to the ULBs. The per household cost of solid waste management from collection to disposal averaging across various sizes of towns is Rs 360 per capita per annum (DTE, 2016). This will also be saved. This comparative cost analysis makes it clear that it is extremely important to cut down on costs of water management by switching to a decentralised system because ULBs in India just do not have the resources for implementing a centralised system. Extrapolating from a study on municipal finances in India (MGI, 2010) the average annual per capita revenue expenditure in Tier 1 Indian cities in 2019-20 was Rs 11,500. Whereas, the equivalent expenditure in purchasing power parity terms in the United Kingdom was Rs 100,000. Similarly, the average annual per capita capital expenditure in Tier 1 cities in 2019-20 was Rs 9000 whereas in the United Kingdom it was Rs 50,000. Properly constructed and operated centralised urban services require huge funds which are not available in any of the Indian cities unlike in the United Kingdom from whom we have inherited them as a colonial legacy.

Policy Recommendations for Implementation of Decentralised Urban Water Management

The foregoing discussion has clearly established the economic unviability, ecological unsustainability and lack of socio-economic equity of centralised urban water management. Nevertheless, the legacy of colonial policies is so well entrenched that it is difficult to replace it with the

RIGHT TO WATER

One of the most important recent milestones has been the recognition in July 2010 by the United Nations General Assembly of the human right to water and sanitation. The Assembly recognized the right of every human being to have access to enough water for personal and domestic uses, meaning between 50 and 100 litres of water per person per day. The water must be safe, acceptable and affordable. The water costs should not exceed 3 per cent of household income. Moreover, the water source has to be within 1,000 metres of the home and collection time should not exceed 30 minutes.

785 MILLION PEOPLE REMAIN WITHOUT EVEN **BASIC DRINKING WATER** SERVICE (2017)

2 OUT OF 5 PEOPLE WORLDWIDE **DO NOT HAVE** A BASIC HANDWASHING FACILITY WITH SOAP AND WATER AT HOME (2017)

1 OUT OF 4 HEALTH-CARE FACILITIES WORLDWIDE LACK BASIC DRINKING WATER SERVICES (2016)

BY 2030, **700 MILLION** PEOPLE COULD BE DISPLACED BY **INTENSE** WATER SCARCITY

673 MILLION PEOPLE (9% OF THE GLOBAL POPULATION) STILL PRACTISE OPEN DEFECATION (2017)

THE MAJORITY OF THEM ARE IN SOUTHERN ASIA

2 BILLION PEOPLE LIVE IN COUNTRIES EXPERIENCING HIGH WATER STRESS

much more suitable decentralised system of water management. Therefore, some strong policy measures are required to bring about the switch from centralised to decentralised urban water management as follows –

1. First and foremost, the public health and environmental engineering technocracy, including both the engineers in the field involved in design and implementation and the academics who teach and research in universities and colleges, must be made to acknowledge the superiority of decentralised urban water management in Indian conditions and this should be adopted as the norm in future in both teaching and implementation. The guidelines of the Government of India for Urban Water Conservation and Decentralised Wastewater Management must be well publicised and strictly implemented to make this possible. The CPHEEO in collaboration with the State Public Health Engineering Departments and the local engineering colleges, must come up with detailed plans for decentralised water management specific to each ecological zone of the country.

2. Urban planners too must be made aware of the need to implement decentralised water management systems and plan urban development with this as the centrepiece. Urban planning rules and regulations are already in place to make this possible but they are followed only in the breach currently. Strict implementation of Building Byelaws and Planning Rules must be done as mentioned in the Guidelines after first explaining the reason behind these laws and rules. There is currently a woeful lack of awareness among both city planners and citizens about the need for these rules.

◗ Architects must be sensitised to the need for incorporating decentralised water management in their designs of houses as there will be a big shift of responsibility in this regard from ULBs to individual households and residential colonies.

◗ The Union and State Governments must set out clear guidelines to ULBs to implement decentralised water management and the grants which are now going to shore up the unsustainable centralised water management systems must be instead directed towards promotion of decentralised water management with Government offices taking the lead in this regard.

◗ The laws and rules with regard to prevention of water pollution must be strictly enforced. The pollution control boards must be empowered to be able to take prompt action against offenders who violate rules. All industrial and commercial outlets that are generating wastewater must have effluent treatment plants installed and operational.

◗ Currently there is no ecosystem for the implementation of decentralised urban water management. Therefore, individuals and NGOs are trying to implement it on their own with marginal impact (Biome Environmental Trust, 2021). People will adopt decentralised systems only if there are trained architects, engineers, plumbers, masons, manufacturers of components in large numbers and an easily accessible maintenance and repair facility. This will be possible only if the Governments take the lead in making decentralised urban water management the norm rather than the exception as it is now by both strictly enforcing the rules and also providing subsidies where necessary.

◗ Property taxes must be enhanced and the tax base must be completely identified by using geographical information systems as this is the most progressive way to improve the finances of ULBs without which it will not be possible to provide for the economically weaker sections of the urban population. Currently, own tax revenue mobilisation by ULBs is abysmally low.

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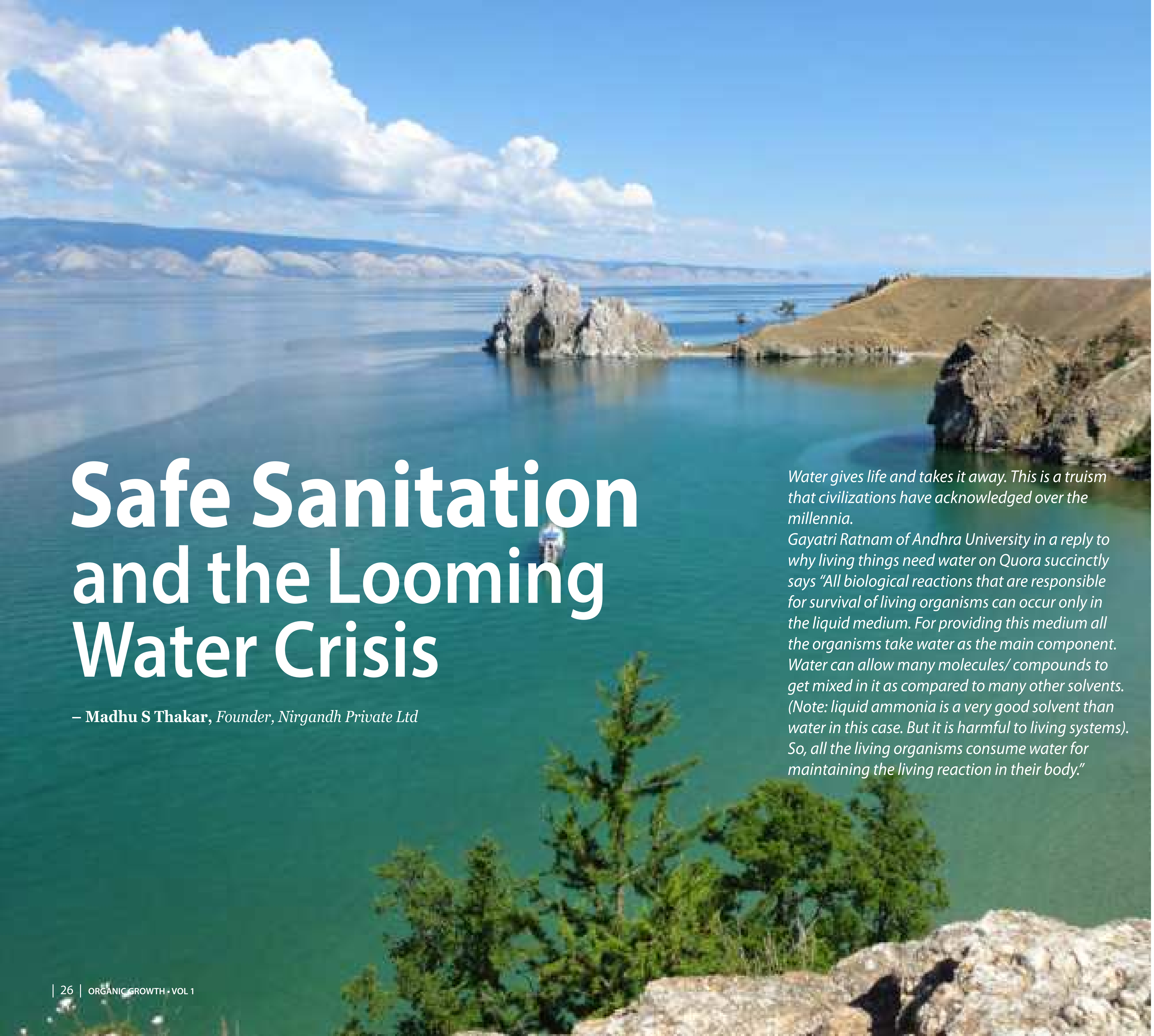

Safe Sanitation and the Looming Water Crisis

– **Madhu S Thakar,** *Founder, Nirgandh Private Ltd*

Water gives life and takes it away. This is a truism that civilizations have acknowledged over the millennia.
Gayatri Ratnam of Andhra University in a reply to why living things need water on Quora succinctly says "All biological reactions that are responsible for survival of living organisms can occur only in the liquid medium. For providing this medium all the organisms take water as the main component. Water can allow many molecules/ compounds to get mixed in it as compared to many other solvents. (Note: liquid ammonia is a very good solvent than water in this case. But it is harmful to living systems). So, all the living organisms consume water for maintaining the living reaction in their body."

It is little wonder that even in space research the main thrust is to locate water either in the atmosphere or in the soil of different planets. That alone will enable us to populate these planets with human, animal, and plant life.
As per a report in October 2021 by World Meteorological Organization based in Geneva, 3.6 billion people lacked safely managed sanitation services, 2.3 billion lacked basic hygiene services and more than 2 billion live in water-stressed countries with lack of access to safe drinking water. 75 countries reported water efficiency levels below average, including 10 with extremely low levels as recently as in 2020. The alarming scene is illustrated in the graphic in the adjoining page.

UN's Sustainability Goals

It is estimated that 70% of the earth's freshwater resources are consumed by agriculture and as much as 22% by industry. Water used by human, animal and plant life takes up the remaining 8%. With increasing human population from 7.87b at present to 10.87 b[1] in 2099 and rising aspirations for a comfortable life, the demand for water for use by humans is rising rapidly. Day-by-day demand keeps growing, further draining water sources, from great rivers to underground aquifers. The rate of groundwater depletion has doubled since 1960.
This requires more efficient use of water by agriculturists and industrialists. Additionally human beings need to use water wisely and reclaim water that has been contaminated and polluted.

The United National General Assembly has recognized "the right to safe and clean drinking water and sanitation as a human right that is essential for the full enjoyment of life and all human rights." Making that right become a universal reality and providing each person on the planet with affordable access to the 20 to 50 liters of daily water required to sustain life, is a clear goal for the decades ahead[2].

Water underpins almost all the SDG goals.

There is overwhelming evidence that water will dominate the discourse on sustainability goals as shown in the infographic below published by Waterscan[3],

Well known effects of poor sanitation, worth repeating

Poor Sanitation and lack of water has grave deleterious consequences on mankind. Millions of children die due to preventable diseases like diarrhea, cholera, and dysentery. These diseases make them incapable of absorbing even nutritious food, should it be available, in their households. Many children become blind. A considerable number have stunted intellectual and physical growth. Women, who must find a safe spot for open defecation, suffer from urinary tract infections and stave off snakes, insects and vermin including the humankind. Girls in rural areas do not attend, for several days each month, the few schools that are available to them due to inadequate menstrual hygiene management. Both men and women waste time in fetching water from afar or walk a long distance for open defecation due to lack of piped water and sewage lines. This leads to contraction of up to 15-25% of available time for educational, economic, and recreational opportunities. The vicious cycle of poverty remains unresolved. In many cases it leads to trauma and mental health issues. Some of it results in unacceptable behavior and violence.

Management of resources is essential

Integrated Water Resources Management (IWRM) is vital to achieving long-term social, economic and environmental well-being. But, although most countries have advanced their level of IWRM implementation, 107 countries remain off track to hit the goal of sustainably managing their water resources by 2030 (UN SDG 6)[4].

This would require management of both the demand and supply side of water resources. It is imperative that we reduce the consumption and wastage of water significantly. Additionally, we must contaminate and pollute the water less so that it can be reclaimed for reuse at an affordable cost.

Both these require technical interventions and behavioral change.

Sustainable sanitation is a significant component of this endeavor.

In the developed world toilets constitute nearly 24% of the very large per capita consumption of water[5]. A family consumes almost 90 liters of water in toilets alone. Expensive sewage systems and sewage treatment systems are affordable only by rich countries. For the developing world cheaper, faster, and better (low energy) systems are required. The obvious ones are pit latrines linked to septic tanks with several variations for collection and transportation of the sludge.

Bio digester toilets are a recent development in design of toilets though the anaerobic bacterial treatment of feces has been known of since many years.

Circular sanitation economy makes it sustainable

There is a strong case for Biodigester toilet systems keeping in mind Clean Development Mechanism and Circular Toilet Economy as part of Sustainable Sanitation Systems in achieving SDG 6 (Clean Water and Sanitation).

Many factors in traditional toilet design make the initial capital cost go up. The affordability of toilets appears to be a deterrent. A new approach thus becomes necessary, and the toilet needs to be redesigned to make the "waste" as an economic resource.

Urine has many uses. It is rich in nitrogen and phosphorus. It can be separated easily and put to many uses in fertilizing agriculture and horticulture, in safety match making, in beauty treatment products and even in production of electricity.

Likewise, the fecal waste can be turned into bio char, a fertilizer. The output water from bio digester toilets can be reused as irrigation water rich in nutrients for higher yields of citrus fruits, vegetables, and bamboos.

Anaerobic Bio Digester Systems are versatile

Anaerobic bio digester toilets are very versatile in their design and implementation. These can be used in a variety of terrains i.e., from rocky, sandy to flood plains. The anaerobic bacteria can operate over a very wide temperature range of $-50^{\circ}C$ to $50^{\circ}C$.The output water has a low pathogen count and is helminth free.

Anaerobic bio digester toilets can be "No Flush" Toilets thereby reducing water consumption to only that is required for self-cleansing, which is about half a liter per person as opposed to 8-10 liters per person per use in Flush type toilets. Saving just 5 liters per person per day would save 10 billion liters of treated water every day if all 2 billion underserved persons switched to this technology!

There is practically no sludge left in the bio digester tank and it does not need emptying for 5-7 years unlike septic tanks and pit latrines. Manual scavenging is eliminated.

The output water can be reclaimed without much energy and chemicals to a level fit for horticulture and even to potable standards at a low cost.
However, care must be taken to ensure that bacteria is not washed away with the output water. This can be done by using a retention matrix in the bio digester tank below the toilet cabin. In addition, it must be ensured that detergents and chemicals like Phenyl are not poured into the tank as that will destroy the bacteria inoculum.

Fecal Sludge management with Anaerobic Bio Digester Technology

Likewise in areas where there is preponderance of septic tanks and pit latrines, Several pit latrines could easily be linked to decentralized fecal sludge treatment by anaerobic bacteria as an effective option.
These are quicker to implement by local labor at a low initial cost and cheap and easy O&M by unskilled personnel. The output water is relatively pathogen free and after a reed bed treatment good for irrigation and recreational use.

Mitigating GHG emissions with Bio Digester Toilets

Anaerobic Fecal Sludge treatment is the best for mitigating Climate Change.
Winrock International India[6], a US based agency in its research has made a comparison of emission of Green House Gases (GHG) between Open Defecation (OD), Leach Pit Toilets (LPT) and Toilet linked Bio gas plants (TLB) The GHG emission from Open Defecation to Leach Pit Toilets goes down to 43% and to only 15% when using Toilet Linked Biogas plants. For every one 100 million persons who stop open defecation the annual GHG emissions drop by nearly 1.9 million tons of Carbon Di Oxide equivalent when opting for Leach Pit Latrines to 2.8 million tons of Carbon Di Oxide equivalent when using Bio Digester Toilets.
Unfortunately, the leachate from septic tanks and pit latrines is the biggest polluter of underground water resources such as wells and hand water pump reservoirs. Harmful pathogens which cause intestinal diseases can travel 20 m vertically down and 50 m across from the source through cracks and crevices in the soil.

Bio Digester Toilets and Covid Testing

Covid has dominated our lives for the last two years. New

York Times has highlighted surveillance of Covid by analyzing data from sewage water in its issues of January 20 and 21,2022. Amy Kirby, the program lead for the National Wastewater Surveillance System in USA has said that "Wastewater surveillance is a really powerful tool, and we are seeing a good example of that with Omicron."

"It's a type of data that we are creating, naturally, organically when we are using the restroom," said Marianna Matus the CEO and Co-Founder of Biobot Analytics. Rockefeller Foundation funds wastewater surveillance around the world. Mr. Samuel Scarpeno, the managing director of pathogen surveillance at Rockefeller Foundation said that wastewater analysis revealed that the Omicron variant was present in multiple cities but did not appear to be widespread.

An unintended benefit of bio digester treatment of feces leading to its degradation into water and methane is that the output water can be tested directly for Covid viral load. These inexpensive tests give results in under half an hour. Such decentralized Virus monitoring and surveillance can identify emerging variants quickly. One can find out the geographical spread, the variant and duration of existence for a faster, targeted response.

Viruses are not going anywhere soon, and this method of sewage water surveillance would be "helpful to monitor the full trajectory of a surge," said Amy Kirby. Wastewater Analysis will yield clues to future waves of the virus.

Conclusion

It would be fair to acknowledge that water scarcity for human needs is looming large over planet earth. Relocating to other planets is several centuries away if not impossible in the next few decades.

Safe and sustainable sanitation is an important component in curbing its demand and recycling of sewage and fecal sludge for reuse to overcome supply constraints. Anaerobic bio digestion is a viable technology for achieving this objective economically, at scale and in a short period of time.

Adoption needs concerted effort on the part of all stakeholders in creating a very large number of pilot toilets and plants for fecal sludge management in a widely spread geography. Data should be collected at these spots in the short run of 1-2 months to verify water conservation and 3-6 months for societal benefits in terms of self-esteem, health parameters and water reclamation.

A major push must be given to bring about behavioral change by a carrot and stick policy. Financial outlays need to be mandated at the earliest at international fora, at individual Government level and at corporate level in their respective spheres of influence.

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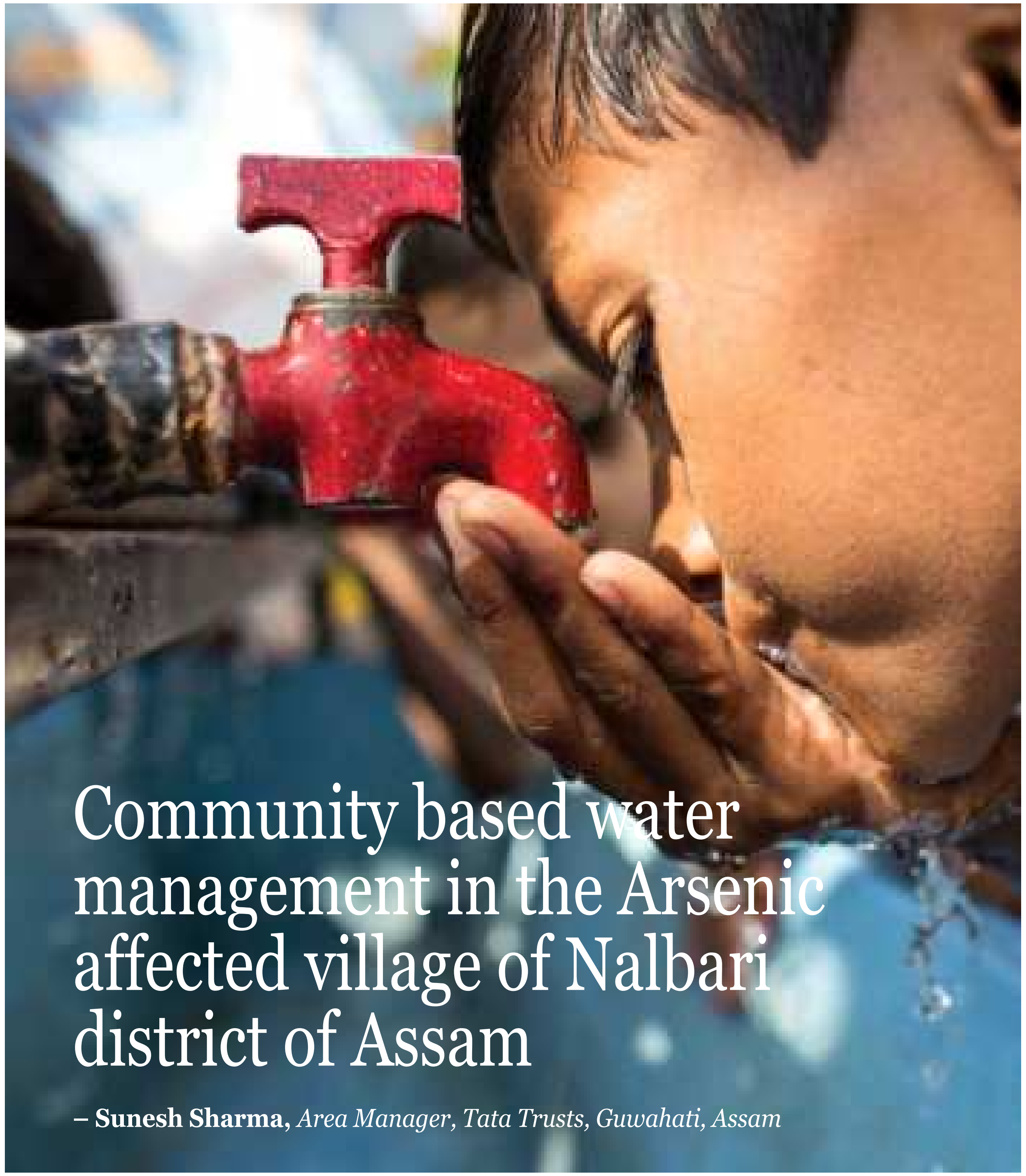


Community based water management in the Arsenic affected village of Nalbari district of Assam

– **Sunesh Sharma,** *Area Manager, Tata Trusts, Guwahati, Assam*

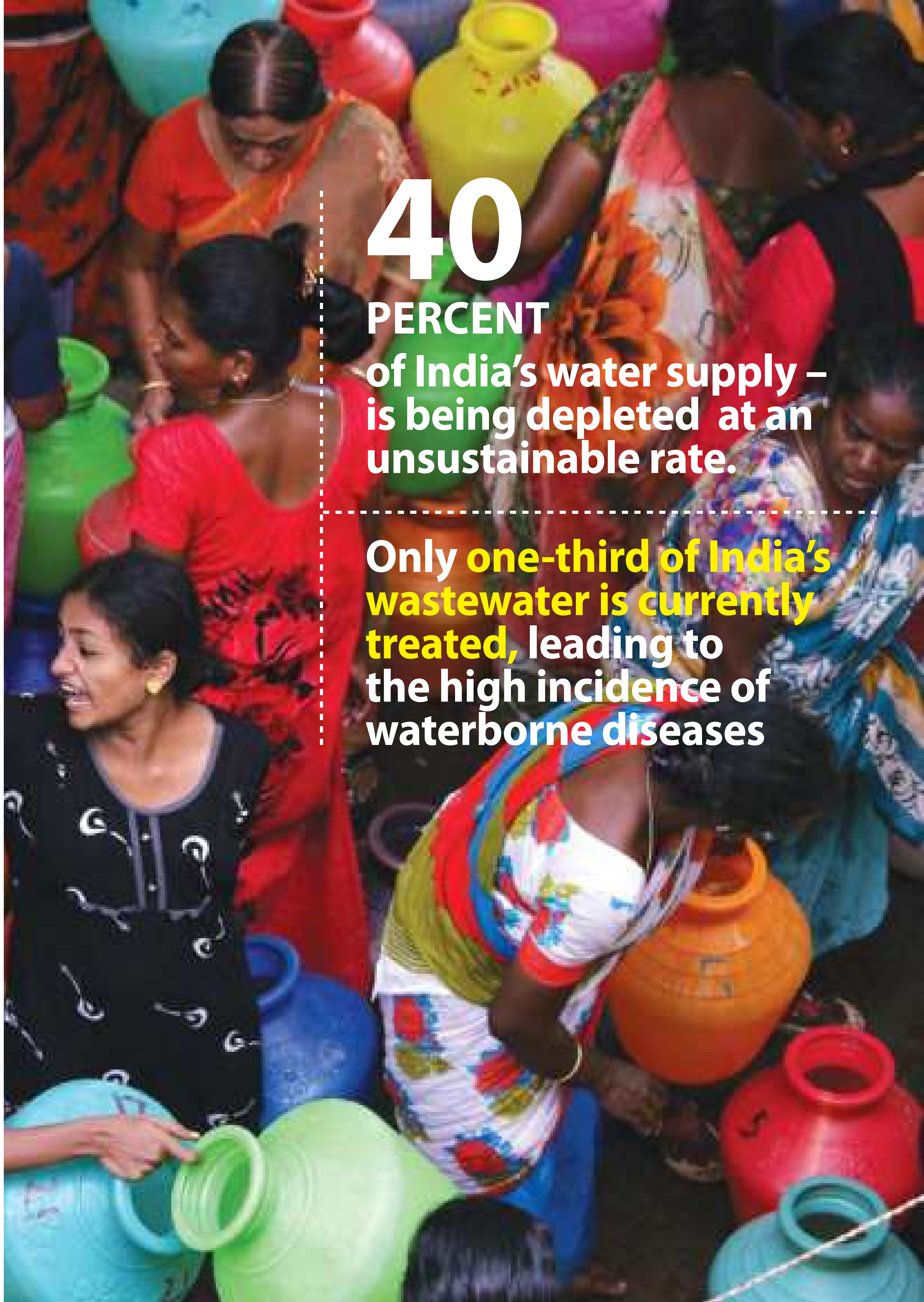
Arsenic has been considered as a target contaminant because of its potential health and regulatory concerns. Reportedly, 300 million people worldwide are affected by the consumption of arsenic contaminated groundwater. The use of arsenic contaminated drinking water is the major cause for skin, lung, bladder, kidney cancer as well as other adverse health effects such as skin manifestations, gastrointestinal disorders, neurological effects, hormone disruption and infertility, posing global health concerns.

The presence of Arsenic in ground water may be as a result of mineral dissolution and industrial discharges containing Arsenic or by the application of Arsenic based pesticides used for agricultural purposes. Minerals containing arsenic found naturally in rocks of underground aquifers will dissolve more and leach more arsenic under unsaturated conditions. Aquifers essentially constitute rocks and water, surrounded by microbes and organic matter.

Higher concentration of arsenic (As) in groundwater in the north eastern states of India has become a major cause of concern in recent years. Arsenic (As) in ground water has been reported from a few parts of Assam and adjoining areas. 18 of the 34 districts in Assam are affected by arsenic contamination. These areas mostly fall in the vast river side tracts of the Brahmaputra River.

World Health Organisation (WHO) states that a maximum of 10 ppb (part per billion) or 0.01 mg/litre of arsenic in drinking water is safe. Tata Trusts along with its associate organisation Centre for Microfinance and Livelihood (CML) deploy innovative and affordable technologies, including artificial intelligence, for strengthening access to safe drinking water, setting up water purification systems and augmenting water resources. With the help of global expertise and partnerships, the Trusts are engaged in improving water quality by installing water purification systems in areas affected by the presence of iron and arsenic, online chlorination of water is also being implemented. Adsorption, ion-exchange, and reverse osmosis (RO) are considered the most effective processes to remove arsenic from water. The presence of iron in the Northeast water is an advantage. Iron is one of the natural adsorbents of arsenic. If the groundwater contains 20 times more iron than arsenic, then we may be able to design affordable arsenic removal processes.

Kothora village in Nalbari district is known for community based water management. Groundwater in Kothora village is affected by arsenic. The CML/Tata Trusts has supported a hybrid anion exchanger technology-based village and community level water purification system in the arsenic-affected village. The unit produces about 8000 litres of arsenic-free drinking water every day. Arsenic removal unit benefitted around 400 households of Kothora village. Each household gets a 'Water ATM' card to 'withdraw' 20 litres of water. The villagers pay Rs 210 per month to get 20 litres of water a day. Monthly salary of operator and annual maintenance has been managed through collected money. There are a few economically challenged families in the village and getting free water from the plants. CML-Tata Trusts has initiated an awareness programme and helped the community for O&M of the plant. CML's volunteers sensitized and organized the water users to form a water management committee to effectively manage the treatment system and other management decisions.



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