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Editor's Note

RENU TOMAR
(Editor-in-Chief)

Dear Readers,

We all know that March is a special month for all of us. Since 1993, the 22nd of March has been celebrated as World Water Day to raise awareness about safe water. This year's theme for World Water day was Groundwater - making the invisible visible.

Groundwater is found almost everywhere under the ground surface and is an important component of the intricate hydrologic cycle that includes the ongoing movement of water on the planet. With rising populations and industrialization and a changing climate, groundwater depletion is becoming a global issue.

Groundwater is also the source of the majority of India's water woes. Because of its near-universal availability, dependability, and low capital cost, groundwater is the most desired source of water in many consumer industries in India. We are the world's largest user of groundwater and so greatly reliant on it. Our country consumes 25% of all groundwater drawn globally, ahead of the United States and China, at slightly over 260 cubic kilometers per year. Groundwater will continue to be the lifeline of India's water supplies for years to come, as it currently supplies 70% of the water used in agriculture.

The management of groundwater resources in India is a difficult task. Because of the highly unequal distribution and consumption, a single management strategy for the country as a whole is unachievable.
India's growing reliance on groundwater as a stable water source and indiscriminate extraction has occurred in numerous sections of the country, with little consideration for aquifer recharging capacity or other environmental issues.

Groundwater offers several benefits, particularly when compared to surface water, and is thus widely used for a variety of purposes across the world, including agriculture, drinking water, industries, bottling, and so on. It must, however, be properly maintained and preserved to ensure its long-term viability in terms of quantity and quality both.

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Delhi may have India's largest sewage treatment plant by December

Delhi will boast India's largest sewage treatment plant (STP), capable of pumping out 564 million liters of treated water per if all goes according to plan. The new plant being built in Okhla, together with two other STPs, will assist the national capital to avoid 1,362 MLD of unclean water from strangling the Yamuna, which is already one of the most severely polluted rivers in the world, as work progresses at a rapid rate.

"We are pushing the work very hard and all three STPs at Rithala, Kundli, and Okhla should be ready by the end of the year. So we can begin the trial runs that might take another 2–3 months. By March 2023, we should have all three up and running."

Being built at a cost of INR 665 crore, the Okhla plant with a capacity of 564 MLD is not only India's largest but is also believed to be one of the biggest sewage treatment plants in Asia. Of the other two, one at Kundli with an overall capacity of 204 MLD is being built at an overall cost of INR 239 crore, while the other at Rithala has a capacity of 182 MLD and is being built at a cost of INR 211 crore.

"Overall, Delhi will be able to treat as much as 1,362 MLD of dirty water falling into the Yamuna, which will be a big boon for the river," said Kumar, exuding confidence. "If that treated water can be put back into the river, we can improve the quality of flow as well."

The National Mission for Clean Ganga (NMCG) along with the Delhi Jal Board is now racing against time to ensure the major construction work is completed before the monsoon rains. "The work got delayed earlier because we were awaiting some tree–cutting permissions to come through. We have now readied an action plan, put additional manpower, and ordered the requisite machinery so that we are on top of it by the time monsoon starts," said Kumar, apprehending potential delay in October–November when a spike in air pollution forces the closure of all construction activities.

HP Nanda joins Grundfos as Executive Vice President & Divisional CEO, Water Utility

Grundfos has appointed HP Nanda as Executive Vice President and Divisional CEO, Water Utility. He assumed the role on 1 March 2022 and joined Grundfos' Group Management Team.

HP Nanda is a seasoned industrial executive with 23 years of experience gained at DuPont. He joins Grundfos from a role as the Vice President & General Manager of the global DuPont Water Solutions Business, where he led a ~$1.5B business which comprises a team of 2500 employees, 11 manufacturing sites, 9 technology centers and a commercial presence in most countries.

"HP brings deep knowledge about the water utility sector, many years in senior leadership and a strong and authentic leadership style. He is a true entrepreneur, and I am confident that he is the right person to lead our Water Utility Division," says Grundfos CEO Poul Due Jensen.

HP has a Bachelor of Technology in Mechanical Engineering from Sambalpur University in India and an MBA in Marketing and Finance from Xavier Institute of Management, also in India.

HP, who is Indian/American, assumed his role on 1 March 2022 and will be based in Houston, Texas, United States.

President Launches "Jal Shakti Abhiyan: Catch the Rain' Campaign

The President of India has launched Jal Shakti Abhiyan–Catch the Rain Campaign–2022 on 29th March 2022. This is the 3rd year that the country is, in mission mode, organizing a Jan Andolan to conserve rainwater and recharge groundwater.

Led and inspired by the Prime Minister of India Shri Narendra Modi, the Jal Shakti Abhiyan was launched for the first launch in the year 2019 with the vision to involve everybody in preparing for the rains so that we can

store and use as much of the rainwater as possible and replenish our groundwater reserves.

Groundwater is sometimes called the invisible resource. Everybody uses it. It is mostly free, available to those with access and the means to extract it. It sustains critical ecosystems, such as lakes, wetlands, and woods.
India is the largest user of groundwater in the world, using more than a quarter of the available global resources. Groundwater has played an important role in ensuring the food security of the country for several decades. It was a major driver in ensuring the success of the 'Green Revolution' through millions of energized tube wells. This finite resource currently caters to more than 60 percent of irrigated agriculture, 85 percent of rural drinking water supplies, and more than 50% of the urban water supplies.

Increasing and unsustainable extraction of groundwater has resulted in significant depletion of this valuable resource. From the large–scale loss of livelihoods to health issues related to the lack of availability of safe drinking water to people migrating, the impact of water scarcity is severe. This is compounded by climate change, which makes precipitation patterns erratic and therefore affects the predictability of groundwater recharge. At present, groundwater resources in nearly one–third of the country are under different levels of stress. Small and marginal farmers, women, and weaker sections of society, disproportionately bear the brunt of groundwater depletion and contamination.

IBM and the Nature Conservancy India Jointly to Monitor Chennai Lake in Real–Time

IBM and The Nature Conservancy India have collaborated on a project designed to provide real–time monitoring of the water quality and level of Lake Sembakkam, which has long suffered from sewage disposal, untreated solid waste dumping, and excessive accumulated silt as a result of climate change, in Chennai.

According to The Nature Conservancy India, over time, this has severely damaged the quality of the watersheds and the wildlife that benefits from it, in addition to threatening the future of sustainable development in the region, reports ZDNet.

The Nature Conservancy India said it uses a metric –– dissolved organic carbon (DOC) – to measure the organic pollution of water and wastewater. Safe levels hover around 0–10mg/l. Lake Sembakkam's is in the range of 3–70mg/l (mean 24.70 mg/l), making it unportable and unsurvivable for wildlife.

IBM worked with The Nature Conservancy India to deploy a network of Internet of Things (IoT) monitors to check the health of the lake and offer experts real–time data to help their efforts to conserve it, the report said.

Manoj Balachandran, head of CSR at IBM India and South Asia, told ZDNet that the IBM volunteer team was mobilized for approximately three months of direct work with The Nature Conservancy India.

That period followed a planning period of over eight months when The Nature Conservancy and IBM co–created a project plan based on a review of needs specific to Lake Sembakkam and prior IBM IoT deployments for water conservation, including The Jefferson Project at Lake George, NY.

IBM has done five other IBM Service Corps deployments in support of water–related work with TNC since 2016, including projects focused on Brazil, Peru, Colombia, and Kenya.

The Principal Scientific Adviser India and Director IIT Madras Inaugurates the AquaMAP Water Management and Policy Centre

The Principal Scientific Adviser to the Government of India has launched the new water management and policy center, AquaMAP, at IIT Madras and launched its website – https://aquamap.iitm.ac.in/ on March 19, 2022. Joining him at the launch were Prof. V. Kamakoti, Director, IIT Madras, Prof. Ligy Philip, Faculty Coordinator of AquaMAP, and Dr. P. Balasubramanian, CEO, Theme Work Analytics and Krishnan Narayanan, President, Research and Digital, IIT Madras Alumni Association.

Providing a context in which AquaMAP has been established, Prof. VijayRaghavan said, "Our world faces the consequences of climate change and the pressure on biodiversity. Thus, renewing our air, water,

and land and pressing sustainable development to become important." Prof. Kamakoti added, "Water consumption in the agriculture sector is the maximum among all the needs, and therefore focus on improving the agricultural water use efficiency is one of the major focuses of AquaMAP."

AquaMAP aims at providing solutions for complex and challenging water problems by designing and evolving smart and optimal water management practices and implementing them in the field, at different locations across the country, as a scalable model by leveraging best practices in management and innovative technologies. AquaMAP is a national water center and IIT Madras is collaborating with IIT Dharwad around the broad theme of 'Data Science for Water Security and Agriculture Sustenance'.

The key activities of AquaMAP include (i) Field (in villages and towns) implementation of water technologies and management practices, (ii) Identifying grand challenges in water/wastewater management for focused attention, and (iii) Setting up a state–of–the–art Hydro–Informatics Laboratory.

SKion and Meinhardt Collaborate to Build Water Infra in India

Meinhardt Group (a Singapore–based company) has partnered with Germany's SKion Water to build net–zero water infrastructure and harness carbon from water in markets such as India where large–scale environmental management projects are being implemented, the two companies said here on Tuesday.

Announcing the partnership, Meinhardt Group CEO Omar Shahzad said: "We are excited about working with SKion Water to develop the utility infrastructure that will enable cities to decarbonize and transform. It will be a big step towards building a resilient and circular economy."

Citing challenges of managing water resources, he pointed out that India has 16 percent of the world's population but only four percent of the world's freshwater resources.

SKion and Meinhardt are exploring opportunities in markets to be able to capture carbon from water and translate it to various other uses including calcium carbonate ($CaCO_3$), a crucial component of the cement industry.

SKion Water CEO Dr. Reinhard Hübner said the company is committed to ambitious sustainability targets and is piloting and acquiring innovative water technologies and solutions to help accelerate the net–zero water and carbon transition.

JICA Extends Loan Worth INR 2,391 crore for Water Supply, Sewage Treatment Facilities in Bengaluru

The Japan International Cooperation Agency (JICA) has signed a loan agreement with the Government of India to provide Japanese Official Development Assistance (ODA) loan amounting to INR 2,391 crore for the construction of water supply and sewerage facilities under a Bengaluru Water Supply and Sewerage Board (BWSSB) Project (Phase 3).

The project aims to provide safe and stable water supply and sewerage services by carrying out the construction of water treatment and sewage treatment plants and related facilities for the residents in Bruhat Bengaluru Mahanagara Palike (BBMP) areas, including the recently–added 110 villages in the municipal limit, where approximately 3.5 million people are expected to be benefitted from the project.

JICA has been supporting the construction of water supply and sewage facilities and services in the core city and surrounding Urban Local Body areas of Bengaluru under the Bangalore Water Supply and Sewerage Board (BWSSB) since 1996 under phases 1 and 2.

The loan agreement was signed between Rajat Kumar Mishra, Additional Secretary, Department of Economic Affairs, Ministry of Finance, and SAITO Mitsunori, Chief Representative, JICA, India.

Speaking on this occasion, Mitsunori said, "The installation of the water supply and sewerage facilities had been significantly promoted in the core city of Bengaluru but there were no such facilities in the 110 villages of BBMP. With the rapid growth of the population and the economy, we are hopeful that the project will provide a safe and reliable water supply to BBMP areas by constructing a water treatment plant and sewage treatment plants together with related facilities. In addition, it will provide an opportunity for BWSSB to review and develop a new business plan for ensuring sustainability."

JICA in its statement stated that non–existent water supply and sewerage facilities in 110 villages encompass an urgent need for development in order to provide safe drinking water to the residents and to maintain the hygienic environment of Bengaluru suburb areas.

Centre to Monetize Treated Sewage, Dirty Water Removed from Ganga

The government of India is looking at ways to monetize treated sewage and dirty water that is removed from the Ganga river and will soon start selling it to the Indian Oil Corporation Limited (IOCL), a senior official said.

Approximately 12,000 million liters per day (MLD) of sewage is generated in the Ganga basin.

Director General (DG) of the National Mission for Clean Ganga (NMCG) Asok Kumar said the agency will start selling treated water to the IOCL.

"We are starting it with Mathura, a project for 20 MLD of treated water to be given to the IOCL. There is an oil refinery there and the treated water from the Mathura STP will be given as per the requirement of the IOCL.

In one month or so we will be able to get that project and it will be the first time in the country that an oil refinery will be taking treated water," Kumar said.

The sewage water collected from the Ganga will be treated in sewage treatment plants (STPs) and then it can be sold to industries as it is suitable for them, he said.

"The treated water, which is of good bathing standard, can be used by industries. It will also help in reducing the usage of good water from rivers," he added.

Kumar said earlier that less treated water was generated for sale to industries as very few STPs were functional.

The NMCG DG said the agency is also in talks with the Ayush ministry on how medicinal plants can be grown on river beds as part of natural farming.

SPML Infra Receives INR 1157.08 Crore Order of Isarda Water Supply Project in Rajasthan Under Jal Jeevan Mission

160 MLD Water Treatment Plant, Dhannaser, Rajasthan

SPML Infra Limited has received a new bulk water supply project order (Isarda Water Supply Project to provide safe drinking water in Dausa and Sawai Madhopur districts) from the Public Health Engineering Department, Tonk, Rajasthan under the flagship scheme of Jal Jeevan Mission. The ambitious Isarda Water Supply Project of Govt. of Rajasthan envisages providing safe drinking water facilities to almost 25 lakh rural and urban populations that will benefit 1079 villages and 5 towns in Dausa and 177 villages and 1 town in Sawai Madhopur districts in Rajasthan. The order valued at INR 1157.08 Crore (USD 151.6 Million) is awarded to SPML Infra Limited, which is the largest single order received by the company to execute an important water supply project in Rajasthan.

The scope of work includes:

- 341 Kilometres of 150 mm–1900 mm dia MS & DI Raw Water and Clear Water Transmission Pipeline
- 225 MLD Water Treatment Plant (WTP) at Isarda, Dausa
- 2 Pumping Stations (including civil work, pumping machinery, related piping, electromechanical, instrumentation works), one at WTP and another at Bagri
- 2 Clear Water Reservoirs: 24.50 Million Litres at WTP and 21.50 Million Litres at Bagri
- Construction of 33 kV Power Substation at Intake Pumping Station
- Other civil works, offices, residential buildings, crossing at National Highways, Railways, Petroleum/Gas pipelines, etc.

The work is to be completed in 2 years' time along with 1 year of defect liability period and 10 years of operation and maintenance post–post–commissioning.

Commenting on the new project order, Subhash Sethi, Chairman, SPML Infra Limited said, "We are very delighted that our experience of executing several hundred water supply projects has helped us in winning this large project in Rajasthan.

SPML Infra has an excellent track record of executing water supply projects in the state and we are sure that the trust placed on us by our esteemed client will be fulfilled in an exemplary manner. We are fully committed to the cause of water and this project under the ambitious scheme of Jal Jeevan Mission will certainly help our client to provide clean drinking water to a large number of rural households in the state.

It will be our endeavor to develop a robust and sustainable infrastructure for providing valuable water for drinking to realize the idea of 'Har Ghar Jal" and making a good contribution towards the development of the state."

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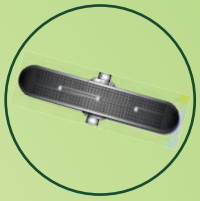

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Shakti Pumps Introduces 4–Inch Plug & Play Submersible Pumps

Shakti Pumps (India) Limited has launched another innovative solution to its product portfolio with launch of a 4–inch Plug and Play Submersible Pumps. The product, designed for achieving higher efficiency with lower operational cost can be operated without the need for a control box. The Pumps' 2–Wire Motor is an integral wire motor that offers customers ease of operation and protection against overload and under–voltage operations.

The 4–inch Plug and Play Submersible Pump is designed to work with Range of 1HP, 1.5HP, 2HP and 3HP. This product has been built for 100 mm (4 inches) or larger borewells with cooling jacket; the series motors used in the 4–inch Plug and Play Submersible Pump are pre–loaded, pre–tested and come with a free cable.

Shakti Pumps with its immense understanding of India's irrigation and pumping requirements is invested in ongoing research and development of new–age products. With a host of electric and solar energy operated pumps, Shakti Pumps is the largest and most prestigious brand in the domestic and global markets.

Shakti Pumps develops products offering advanced water pumping solutions covering a range of applications from flood and micro irrigation, horticulture, domestic water supply, commercial and industrial use.

For more information, visit: www.shaktipumps.com

11 MLD Decentralised Sewage Treatment Plant at Mira Bhayander

Subhash Sethi
Chairman, SPML Infra Limited

Subhash Sethi is Chairman of SPML Infra Limited, a company dealing in water infrastructure solutions for past four decades having executed over 650 projects. He has contributed immensely to water infrastructure development and his work has been recognized widely with several prestigious awards including Economic Times Global Asian Business Leader Award.

WORLD WATER DAY

WASTEWATER: TREATMENT & RESOURCE

The wastewater treatment market in India is estimated to reach a total market size of USD 10.185 billion by 2026 from USD 4.394 billion in 2019 clocking at an annual growth rate of 12.76%.

The home of almost 18% of the world's population, India is amongst the world's fastest–growing economies and also the second–largest populated nation. But, it ranks among the countries most vulnerable to climate change and extreme weather conditions. More extreme weather events resulting from climate change – including cyclones, disastrous floods, and prolonged drought could make it even harder for the poorest people to access clean water.

In India, around 65% of the country's population lives in rural areas, and most of them live without proper access to clean water. Water Aid's annual analysis examines the state of rural access to safe drinking water around the world and warns that diseases such as cholera, blinding trachoma, malaria, and dengue are expected to become more common and malnutrition more prevalent. Rural communities dependent on farming to make a living will struggle to grow food and feed livestock amid soaring temperatures, and women – typically responsible for collecting water – may have to walk even greater distances in their daily struggle to access clean water.

www.spml.co.in

With the rapidly changing urban face of India and increasing demand for more quality water and better sanitation services, the most important issue we are facing is to deal effectively with our wastewater. As per Central Pollution Control Board (CPCB) report, urban India is generating nearly 72.36 billion liters of sewage per day whereas the installed capacity of all STPs put together can treat only 31.84 billion liters a day. Even out of this installed capacity, developed and operationalized capacity is 26.87 billion liters and only 20.23 billion liters is the actual utilized capacity. Out of the total sewage being generated in urban India; only 28% is being treated leaving a big gap of 72% sewage not receiving any form of treatment and being released into water bodies.

12.5 MLD Effluent Treatment Plant, Bahadurgarh Industrial Area, Haryana

India with an increasing population and growing demand for water is not utilizing the valuable resource of wastewater to augment the water supply and cater to the non–potable needs of industries and irrigation. Greater consideration is needed to construct better wastewater treatment infrastructure for abetting water pollution and a reliable solution for water sustainability.

Traditional methods of wastewater treatment become increasingly challenging with the identification of more contaminants, rapid population growth, increasing industrial activities, and ever–shrinking freshwater sources. The effectiveness of the conventional process has become limited due to new challenges; increased knowledge about water pollution and public demand for better quality water have enforced the implementation of much stricter regulations. This is an age of smart technology and the same is applied in wastewater treatment and management also. Today we need a smart treatment system for treating wastewater for complete reuse purposes for all our requirements except for drinking. The water and wastewater treatment (WWT) technology market was valued at over USD 2.1 billion in 2021, and the market is projected to register a CAGR greater than 8% during the forecast period of 2022–2027 as technology intervention is expedited due to unprecedented pandemic outbreak globally claiming lives of over 61 million people.

Globally, over 3.4 million people die of water–borne diseases annually. The world faces a huge challenge in ensuring a safe water supply to 7.75 billion people.

The reuse of municipal and industrial wastewater and the recovery of potential

42 MLD Sewage Tretament Plant, Kanpur

Aging infrastructure, conventional technologies and microbial or chemical contamination are major threats to public health.

70 MLD STP, Nasik, Maharashtra

pollutants used in industrial processes become more critical. The reclamation has become easier with advanced treatment technologies which can remove various potentially harmful compounds that could not be effectively removed by conventional treatment.

Wastewater as Valuable Resource

The innovations and new technologies and ideas revolve around the simple wisdom, the reuse of wastewater results in less extraction of water and thus saving the fast depleting natural resource from extinction. It's a good proposition to address the ever–increasing water demands and explore new ideas for wastewater treatment.

New Technologies for Wastewater Treatment

Wastewater treatment technologies are crucial for urban water systems. Some of the new technologies being used and introduced for wastewater treatment globally to reclaim the resources:

- **Membrane Filtration:** Membrane filtration is essential for advanced water reclamation. Micro and ultra–filtration membranes provide excellent pre–treatment to remove a wide range of dissolved contaminants. Membrane bioreactor filtration technology is being extensively used for advanced treatment followed by RO and UV treatment to produce non–potable water.
- **Nanotechnology:** The emergence of nanotechnology and the incorporation of living microorganisms in bio–microelectronic devices has revolutionized the treatment process. The best part of nanotechnology is that it can easily merge with other technologies and modify, endorse and clarify any existing concept. It offers an innovative approach to developing and exploit these processes in completely new ways. Nanotechnology concepts are being investigated for higher–performing membranes with fewer fouling characteristics and improved hydraulic conductivity. Several new researches are being conducted for producing fabrication of membranes from nano materials for decomposition of toxic compounds during the treatment. It will also provide effective segregation of metals, bimetallic nanoparticles, mixed oxides, zeolites, and carbon compounds, etc. from the wastewater resources. With improved membranes and configurations, more efficient pumping and energy–recovery systems will be possible.
- **Automated Variable Filtration (AFV) Technology:** Automated Variable Filtration (AFV) technology is a state of the art technology used for wastewater treatment in which upward flow of influent is cleaned by the downward flow of filter media. During the treatment process itself, the filter media is cleaned by the filtered influent thus there is no requirement for any additional filter media cleaning or freshwater. The AFV process comprises two sets of media filters that can be operated in series or parallel. The two–stage series configuration is used

to produce very high–quality filtrate. This mode is ideal for refining secondary wastewater for reuse. The AFV process is equipped with actuated valves, sensors, and programmable logic controllers to automatically switch from serial mode to parallel mode during wet weather conditions or other preset operating conditions.

- The key benefits of the system are:
- Higher solids capacity
- Continuously cleaned media beds
- Elimination of ancillary equipment
- Even flow distribution
- Cost–effective to install and low operating and maintenance costs
- Average reject of 5–15%
- Extremely low power consumption
- Ease of Operation & Maintenance

- **Microbial Fuel Cells:** Microbial fuel cells is a breakthrough technology where electrical energy could be extracted directly from organic matter present in the waste stream by using electron transfer to capture the energy produced by microorganisms. Microorganisms are grown as a biofilm on an electrode; the electron donor is separated from the electron acceptor by a proton exchange membrane, which establishes an electrical current. This technology is still in its development stage and significant advances in process efficiency and economics will be necessary before it could be used widely to produce electrical energy directly from organic matter present in the wastewater.
- **New Urban Sanitation Technology:** The New Urban Sanitation Technology aims at wastewater treatment with the reuse of energy and minerals with a combination of Electro flocculation (Elflox) and Anaerobic Digestion technologies.

Elflox treatment is based on the separation of the organic pollution from community wastewater with Electrocoagulation (ECF reactor). Organic sludge of the ECF reactor is sedimented in a circular sedimentation vessel; Sludge (organic compound) which is then fed to an anaerobic reactor gets converted into Biogas which can be converted to Energy for captive utilization.

Anaerobic fermentation technology, generates optimum Biogas due to two separate processes of Hydrolysis– the long–chain carbon compounds are broken down into smaller compounds such as fatty acids; and Methanogenesis the fatty acids get converted into biogas.

- Natural Treatment Systems: The natural treatment systems (NTSs) is also improving with the emergence of new methods and technologies and a variety of physical, chemical and biological processes work simultaneously to remove a range of contaminants comprehensively. Natural treatment systems are increasingly being used to capture, retain and treat storm water, thereby converting this sheer wastage into a valuable source of water. These natural systems have the advantage of being able to remove a wide variety of contaminants including nutrients, pathogens and micro–constituents including endocrine disrupting chemicals. This treatment process is very effective for water reclamation.
- Cokeoven (CO) Byproduct Wastewater Treatment: The steel producing plants in India are using this treatment process to recover ammonia from cokeoven liquid. Water pollution problems would be worse if ammonia is not recovered, the most polluting among all the wastes from production units. In the CO effluent, most of the pollutants are in the dissolved state. Other pollutants are subjected to biological treatment along with residues of phenol and ammonia. The two most common processes used for the treatment of cokeoven effluents are trickling filter and activated sludge process.
- Urine Separating Process: Urine is part of domestic wastewater which contains up to 90% of the nitrogen and 50% of the phosphorus. The development of urine separating toilets and technologies for treating it to produce fertilizer products is a key to managing nutrients with minimal requirements for outside resources, such as additional energy. Producing the same amount of petroleum–based, nitrogen–rich fertilizer takes an enormous amount of energy and non–renewable resources.

Urine–separating toilets have already been developed and advanced research is going on to refine it further and use them for wastewater management and creating resources.

SPML Infra Contribution

SPML Infra Limited has been working in water and wastewater treatment and management segment for over 40 years now and during this period it has designed and constructed a large number of municipal and industrial wastewater treatment plants that has contributed significantly in environmental sustainability. SPML Infra has built sewage and effluent treatment plants which are fully equipped with automation system and reliable treatment technology for efficient operation and maintenance.

Some of the significant wastewater treatment plants constructed by SPML Infra Limited include:

- 240 MLD Sewage Treatment Plant in 4 modules of 60 MLD each with each module having its own primary & secondary treatment section plus sludge thickening & digestion facilities in Ahmedabad, Gujarat. Common facilities for disinfection of biologically treated water, biogas collection & flaring, supernatant/filtrate collection & recirculation system, collection of digested sludge & digested sludge dewatering system along with common chemical preparation & dosing facilities were created in this project.
- 72 MLD Sewage Treatment Plant in Okhla, Delhi based on activated sludge process with gas mixing technology complete with gasholder and compressor to generate energy.
- 70 MLD Sewage Treatment Plant in Nasik, Maharashtra along with two gas holders of 11m x 5m with gas flow meter for 4800 m^3/day of gas production.
- Executed one of India's largest and first Comprehensive Underground Sewerage Systems in Mira Bhayandar, Maharashtra having 113 km of sewer lines; 10 pumping stations, and 10 decentralized

sewage treatment plants with a total 115 MLD capacity having the latest MBBR technology.

- Executed a sewerage network and sewage treatment plant project for Kanpur city having a 130 km sewerage network of 150 to 1800 mm dia pipelines, three pumping stations of 14, 40 and 42 MLD and 42 MLD sewage treatment plant based on activated sludge process including power generation from biogas.
- SPML Infra also contributed to the prestigious XIX Commonwealth Games held in Delhi in 2010 by constructing 25 MGD (million gallons per day) effluent pumping station (EPS) including twin transmission mains for carrying 33.34 MGD treated effluent to the power plant to generate power which eventually illuminated the games.
- A number of Combined Effluent Treatment Plants were also constructed that includes 35 MLD CETP at Bawana, Delhi; 24 MLD CETP at Okhla, Delhi; 21.6 MLD CETP at Naraina, Delhi; 12.5 MLD CETP at Bahadurgarh, Haryana and 12 MLD CETP at Lawrence Road, Delhi for industries situated in these areas.

Way Forward

The new treatment processes with resource recovery along with the integration of urban water and waste management systems will improve the sustainability of our water resources. New wastewater treatment technologies can significantly reduce water abstraction from our already resource–constrained world. Reclaim water must be managed properly to maintain the integrity of the overall treatment system. The energy consumption in treatment plants also requires active management to make the entire process efficient and effective by producing enough energy from treated wastewater that could support the energy requirement of treatment plants. Technologies to meet these challenges already exist and work is going on to refine and integrate them into higher performing more sustainable systems.

The challenge is to choose the most appropriate one from the available options and develop institutional arrangements for implementing them in the most effective ways.

Zero Liquid Discharge plant installed by Thermax

Anupam Pathak
Process Engineer – R&D
Thermax Ltd.

ENSURING HIGHER EFFICIENCY FROM

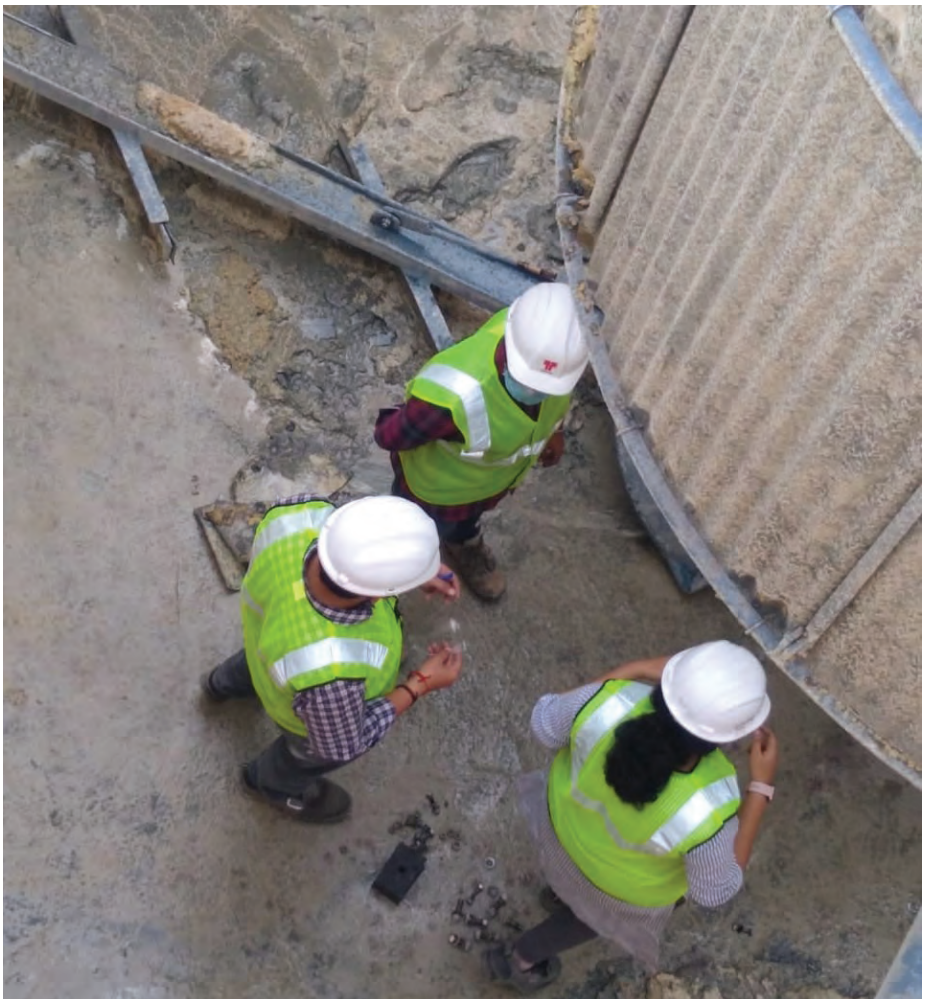
WATER AND WASTEWATER TREATMENT ASSETS

www.thermaxglobal.com | LinkedIn: bit.ly/AnupamP

One of the key challenges industries are facing today is fulfilling their freshwater demands. As per the World Bank's estimate, the present industrial water use in India is about 13% of total freshwater withdrawal in the country. Water demand for industrial uses and energy production will grow at a rate of 4.2% per year, rising from 67 billion cubic meters in 1999 to 228 billion cubic meters by 2025.

This creates a space to set up treatment facilities for water recycling and reduce dependency on conventional sources. Zero Liquid Discharge (ZLD) is an effective wastewater management system that ensures the net–zero discharge of industrial effluent into the environment. This can be achieved through recycling, recovering, and reusing the treated effluent. However, sustainable operations of recycling and ZLD are not easy due to various reasons such as changing water quality, operational costs, and related uncertainties.

Plant audit at a Thermax customer site



Evaluation of mechanical equipment by the Thermax team

Various industries have installed ZLD plants for recovering wastewater. However, operating teams may face challenges while achieving the desired performance due to the following reasons:

- Ageing infrastructure
- Changing wastewater quality and quantity
- New streams getting added due to changing product mix
- Presence of complex, emerging constituents
- Unforeseen events, uncertainties associated with operations, and feed

To overcome these challenges, customized plant audits will be helpful. These audits will not only help to find solutions for a specific case but also prevent any unforeseen event which may arise in the future. The findings from the audit can be used to minimize operational costs. Audits can help to formulate efficient ways to upgrade the existing treatment. Plant audits are useful where there is a need to decide whether retrofitting new technologies or revamping existing ones can solve the problem. Thermax provides expert services such as plant audits, treatability

Treatability studies are effective in understanding wastewater, its behavior, and suitable treatment alternatives. It helps in optimizing chemical consumption/dosages required for treating wastewater which reduces the operational costs.

Treatability/Pilot Testing for Wastewater Treatment

tests, pilot testing, and membrane autopsy. These services are crucial in identifying wastewater characteristics, design challenges and providing innovative as well as cost–effective solutions to modern–day challenges associated with existing treatment schemes faced by industries.

Treatability studies are effective in understanding wastewater, its behavior, and suitable treatment alternatives. It helps in optimizing chemical consumption/dosages required for treating wastewater which reduces the operational costs. Pilot testing, on the other hand, is suggested to reduce uncertainties while treating complex effluent streams. For example, one of the largest steel manufacturing units was generating wastewater from coke oven operations.

The wastewater was treated up to a certain extent and reused for quenching. The customer had expanded the production capacity, hence wanted to comply with stringent marine discharge standards. The expert team of Thermax carried out extensive treatability tests, and an efficient solution was offered.

Membranes are widely used for MF, UF, RO applications for recycling plants. Any deviation in water quality or operational condition can impact the membrane life, plant performance and increase operational costs. Sometimes, due to unforeseen events, the membrane may get damaged. Thermax conducts membrane autopsies for recovering membrane performance. This is an important step in understanding membrane health and the reasons for reduced performance. Thus, repetition of such events in the future can be avoided.

These customized services play a vital role in ensuring smooth operations and reducing risks of operational failures and losses. Customers can achieve and sustain desired performance from existing assets utilizing these services.

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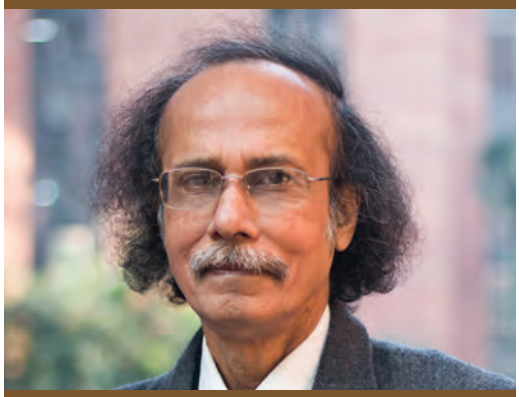
Figure 1



Dr. Syamal Kumar Sarkar
Director – Division of Regulatory Studies and Governance, TERI

About the Spokesperson

Dr. Syamal Kumar Sarkar is Distinguished Fellow and Senior Director at TERI. He heads the Natural Resources and Climate Programme and is currently associated with TERI since September 2014. During 1998 till 2003, Dr. Sarkar worked as Senior Fellow, TERI, and during 2005–2007 as Director, Division of Regulatory Studies and Governance in TERI. He is a Doctorate in Economics (1991) from the State University of New York, Stony Brook, New York. Dr. Sarkar is an IAS officer (retired). He is a former Secretary to the GoI in the Ministry of Water Resources. He was also Secretary, Department of Personnel and Training, Govt. of India (2013–14). He also worked as consultant with the Asian Development Bank and with the World Bank/PPIAF (Public Private Infrastructure Advisory Facility).

MAKING INVISIBLE GROUND WATER VISIBLE

On 22nd March 2022 the world including India observed World Water Day on the theme "Groundwater, making the invisible visible". Although ground water is invisible resource there is significant use by various users particularly in the agriculture sector, industrial sector and domestic sector. India is the largest user of ground water in the world. Out of yearly available water resources of 1123 BCM about 690 BCM water resources are from surface water contribution and the remaining from ground water contribution. As per the record of the Central Ground water control Board, India extracts ground water resources to the tune of 253 BCM per year. Out of 6584 ground water assessment units the Central Ground Water Board categorise 1034 units as over exploited, 253 as critical, 681 as semi critical and 4520 as safe. The remaining 96 assessment units have been classified as saline due to non–availability of safe ground water due to salinity problem.

Regarding demand of ground water by various users, about 228 BCM (about 90%) are yearly extracted for irrigation sector and the remaining 10% are used for domestic sector and industrial sector.

There is a significant difference in the water (surface water and ground water) that can be used beneficially and surface reservoir capacity. The live storage capacity of dams in India is around 258 BCM. The reservoirs are unequally distributed within India. For

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example 70% of India's reservoir capacity is limited to only six states – Andhra Pradesh, Gujarat, Karnataka, Maharashtra, Madhya Pradesh and Odisha. On the other hand in a states like Delhi, Haryana, Punjab and Rajasthan the water reservoir capacity is about 5% and these states have 20% of safe ground water blocks. As a result it was seen that inadequate surface reservoir capacity plays a significant pressure on India's ground water resources.

The contamination of ground water is also a big issue in India. It is due to large scale unplanned urbanisation and untreated effluents emitted by industries. For example 62% of municipal sewage generated in India is left untreated and 38% of industrial effluent is also not treated in India. As a result surface water bodies are being contaminated affecting the contamination of ground water for example 45% and 21% of districts in India are contaminated with naturally contaminants like fluoride, arsenic, affecting about 66 million people from 19 states in India. In addition contamination of ground water is due to diffused sources of pollution like fertilisers and pesticides from agricultural fields.

Climate Change Era

Human induced climate change and global warming are known to users of water. The impact of climate change on hydrological cycle is also well known. Across the world India is second most flood prone country. Increased frequency of flooding is a big problem to people, for example in urban areas this causes significant pressure on drainage systems and sanitation management. Since the reservoir capacity in India is limited and since there is variable surface water availability the next alternative is considered for making ground water capacity at a high level. Rise of sea level water due to climate change has adverse impact on ground water particularly its quality.

Programmes of the Government

It was realised by the government that ground water resources in India is under increasing stress and thus there is a need for a shift in the approach in the management of ground water. It was also felt that there is a need for adequate ground water resources for implementing Jal Jeevan Mission Programme in urban and rural areas. It may be recalled that under Jal Jeevan Mission Rural Programme the target is to give water tap connection to 15.7 crore households by 2024 at the rate of 55 litre per day per house. Similarly the "Make in India" Programme of Government of India will need water from surface as well as ground water resources thus there is a need for sustainable ground water management.

There is an act called Indian Easements Act, 1882 in India. This allows land owners the right

Figure 2
Figure 3

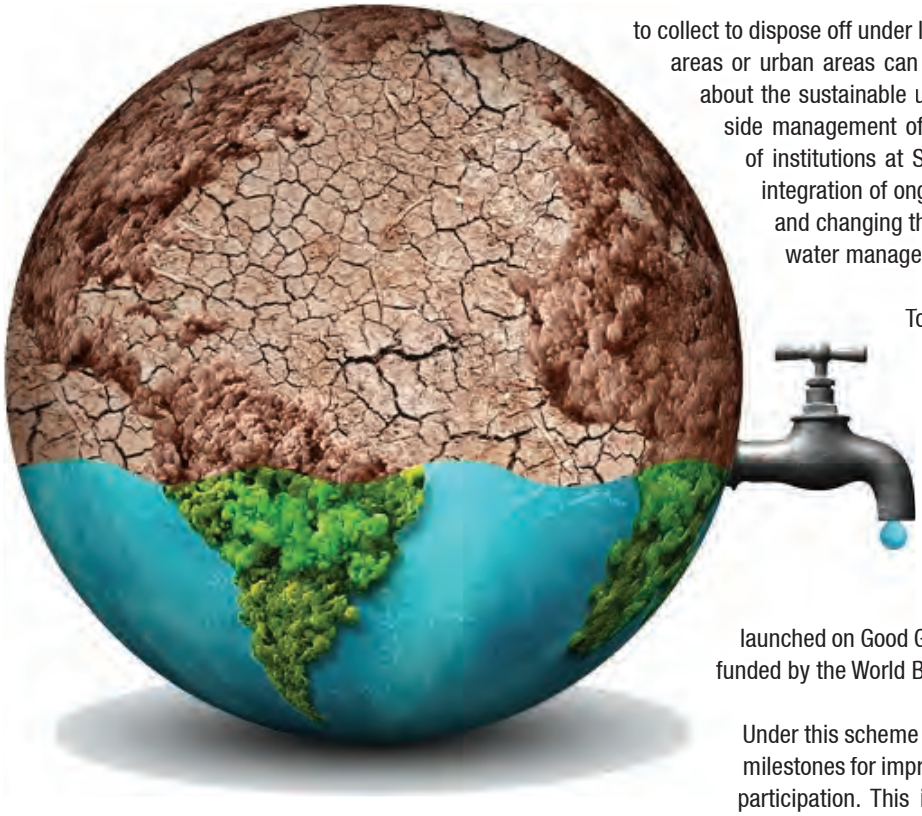

Figure 4

to collect to dispose off under land within their limits of land. So anybody in rural areas or urban areas can withdraw land without taking into consideration about the sustainable use of ground water. There is a need for demand side management of ground water this should involve strengthening of institutions at State and district levels, community mobilisation, integration of ongoing schemes with a focus on more use of water and changing the behaviour of community for sustainable ground water management.

To address the above issue the central government initiated programme called Atal Bhujal Yojana. Its goal is to demonstrate community–led sustainable management of ground water. The scheme is being implemented in 7 states such as Gujarat, Haryana, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan, and Uttar Pradesh. This scheme is likely to benefit 9000 gram panchayat in 222 blocks/ talukas spread of 80 districts. This scheme was launched on Good Governance Day (December 25, 2019) and is partly funded by the World Bank.

Under this scheme the states are given incentives if they achieve key milestones for improving ground water management with community participation. This include public disclosure of ground level data / information, preparation of community–led water security plan, adoption of practices for efficient water use and improvement for arresting the decline of ground water level.

Concluding Remarks

To make invisible ground water visible, the central government schemes and the initiatives of the state governments are welcome steps. As per the government circular there is a ground water conservation scheme to be given by industries for their ground water use. Depending on various factors. This is not applicable to agriculture sector which is the highest user of ground water in India. There is a need to rethink on this aspect of ground water management. Sectoral policies should be harmonised. For example in some states the power sector policies allow subsidised electricity or free electricity to agricultural farmers. This leads to unsustainable use of ground water extraction, thereby contradicting the water resource conservation policy of the government. There is a need to relook at the Indian Easements Act, 1882 with the overall objective of sustainable ground water management. A definite plan should be drawn out after assessing the existing policies on ground water management for overcoming the current deficiencies in this sector. The role of the central government as well as state government is very critical.

Abdul Rahman Mohammed
CEO, Sahara Industry

Mohammed Abdul Rahman is the Founder & CEO of Sahara Industry established with the sole purpose of providing technologically advanced, most economical, and best quality water and wastewater treatment solutions. The young entrepreneur with an MBA in marketing & finance, he leads the organization with strong people management and development vision. With his guided approach and dynamic leadership, the company has achieved enormous success with group turnover surpassing INR 1000 million.

WORLD WATER DAY

WATER RESOURCE: PROPER MANAGEMENT FOR SUSTAINABILITY

2.2 billion People in the world lack access to proper and clean water sources. In India, there are over 600 million people who are facing severe to extreme water stress. Water is the most essential element required to sustain human, animal, and plant life and is needed for everything – to ensure food security, feed livestock, maintain aquatic & organic life, take up industrial production, and conserve the biodiversity and environment along with all other activities.

Water is also essential for economic development. A recent study indicates that poor rural families can double their income if they have proper access to their own water sources and the low–cost irrigation technologies can triple the annual profits of the farmers. It is difficult to imagine life without water. And also true that water can no longer be taken for granted as an unlimited resource. There is an imminent crisis approaching and we need to be mindful of it. Predictions about the future of water throw a grim picture as an estimated 50% of the total population or about 5 billion people on earth will be severely affected by water scarcity by the year 2050. In the absence of suitable corrective measures, many developing countries including India will have to face the crisis of food and water security.

The United Nations has decided on the theme for World Water Day 2022 as "groundwater: making the invisible visible". It stresses the importance of groundwater resources which are declining much faster than estimated and getting polluted due to

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all human activities. India is the largest user of groundwater sources, facing a difficult task in reducing this vital resource. Some of the main challenges being faced in terms of drying up of groundwater sources include:

India is the largest user of groundwater in the world. It uses an estimated 230 cubic kilometers of groundwater per year – over a quarter of the global total.

More than 60% of agriculture and 85% of drinking water supplies are dependent on groundwater. Urban residents increasingly rely on groundwater due to unreliable and inadequate municipal water supplies.

rapidly. Moreover, aquifers are depleting in the most populated and economically productive areas. Climate change will further strain groundwater resources.

The ever–decreasing level of groundwater will have serious implications in India as it will affect the sustainability of agriculture, food security, livelihoods, and economic growth at a greater level. Sahara Industry, being a leading name in water treatment solution providers in India, is continuously focusing its efforts on providing safe water for drinking, industrial and institutional purposes. Having been in the water industry for two decades, it has employed technologically advanced machinery

estimated 50% of the total population or about 5 billion people on earth will be severely affected by water scarcity by the year 2050.

Groundwater acts as a critical buffer against the variability of monsoon rains.

Farmlands irrigated with groundwater have twice the crop water productivity of those that rely on surface water alone. This is large because the resource allows farmers greater control over when to irrigate their fields and how much water to use each time.

Despite the valuable nature of the resource, 29% of groundwater blocks are semi–critical, critical, or overexploited, and the situation is deteriorating

and manufacturing solutions to create a robust treatment management system for water and wastewater.

Traditionally, India has been a water–rich country with an ample amount of water available in every region and is now facing an increasingly unpredictable situation and extreme water stress. We need to be very cautious with our water resources both ground and surface water as well as must take concrete initiatives to reclaim used water for non–potable reuse if we have to make water sustainable in India.

Figure 1

RESOLVING WATER CRISIS FOR PROSPEROUS RURAL INDIA

Mangesh Wange
CEO of Swades Foundation

About the Spokesperson

Mangesh Wange, CEO of Swades Foundation, has more than 27 years of General Management experience with P&L responsibility and in leading successful start–ups across multiple sectors and various organizations viz. Farm Inputs (Farm Machinery, Agri–Inputs, Animal Feeds & Micro Information), Retail and Micro Finance. Mangesh has rich experience in strategy formulation & implementation and worked for organic & inorganic growth of businesses. Mangesh started his career in Sales & Distribution with Mahindra Tractors in 1987. He also headed the S&D of Agri Input Business at Godrej Agrovet. He conceptualized and started the modern retail businesses (Aadhaar and Nature's Basket) at Godrej Agrovet Ltd. He has also worked in the Microfinance business at Fullerton India and later for Reuters Market Light at Thomson Reuters.

Water is an essential aspect of human existence, yet water scarcity affects more than 40 percent of the global population (UN, https://www.un.org/sustainabledevelopment/water–and–sanitation/). In India, over 52% of rural households lack access to piped drinking water in their homes (Jal Jeewan Mission, 2021). This long–standing water crisis compromises the holistic progress of our villages and their residents. However, rural women and young girls pay a colossal price battling water scarcity. In this article, I share how rural India's water crisis challenges the prosperity and development of rural women and children by putting their physical, mental, social, and economic well–being. These are our decade–long learnings from rural Maharashtra.

During my recent visit to Darevadi – a remote village in Nashik, Maharashtra, I met Hausabai Kamlu Gawanda a 56–year–old resident who expressed, "Due to lack of water in our village, women carried heavy water and climbed uphill to the village. Many would faint and many like me developed joint pains at an early age. Due to unclean water, children often fell sick and diarrhea was common in our village

www.swadesfoundation.org

children." We are a patriarchal society and fetching drinking water is still a woman's job. More than 39% of Indian rural women walk up to 5 km to fetch drinking water for their daily needs (Gaon Connection Survey, 2019). This daily drudgery results in joint problems, posture issues, and mental stress for rural women. This toll on their health also hampers their daily routine and time for family and kids. Over 37 million Indians are affected by water–borne diseases and 15 million children die of diarrhea every year (CBHI (2018) National Health Profile 2018, 13th Issue).

Figure 2

During the pandemic, India also struggled as it was hard for the rural population to practice frequent handwashing in water–scarce areas.

Water is essential for most tasks of our daily life. In the absence of clean water for drinking, washing, bathing, cooking, maintaining good hygiene is not possible for rural people. Poor water and sanitation infrastructure also derail menstrual hygiene for women. As India is also progressing on the goal to provide access to toilets at a household level, water is a necessity to ensure their usage and hygiene. To make India truly free of open defecation and ensure people use toilets, access to water in the house is essential. We witnessed an increase in rural households' demands for toilets when they received water in their villages.

Water also has a direct link to the nutritional status of humans. When water doesn't reach the farms, agricultural produce is affected. Especially in the drought–prone rural areas where villagers rely primarily on agriculture, crop loss also leads to hunger and starvation in rural communities. In addition, households that depend on farming in water–stressed areas spend less on food resulting in loss of essential nutritional intake. A study in rural India on the impact of draught household food consumption and nutritional intake found that Droughts statistically significantly impact household nutrition as the calorie, protein, and fat intake of rural households fell by at most 1.4 percent. This causes rural households to move away from a balanced diet (Fenella Carpena. 2019 https://doi.org/10.1016/j.worlddev.2019.06.005).

When we started our rural empowerment journey in Maharashtra, we insisted on rural women ensure their daughters attend school. However, one of the village women shared "If I let my daughter attend school, who will help me get water for the rest of my children". We realized that water is the first need for the

Figure 3

ABOUT THE ORGANIZATION

Swades Foundation is a Not for Profit organization focussing on rural empowerment through holistic development impacting over 2,700 villages in rural India. Founded by Ronnie & Zarina Screwvala, the Swades Foundation aims to empower 1 million rural lives every five years, lifting them out of poverty by empowering communities to take charge of their own lives. Swades adopts a model of holistic transformation and works in education, health and nutrition, water, sanitation, and economic development. Its unique 4 E strategy of Engage, Empower, Execute, and Exit truly empowers the community and builds village leadership to take on the mandate of transforming their own village community.

community and if we address that, it will lead the way for other social and economic changes we wish to see in our villages. Today in India, due to lack of water found that 23% of young girls drop out of school in Maharashtra as they reach puberty due to lack of safe sanitation facilities. These young girls then support their mother in carrying water and domestic chores. This vicious cycle continues and impacts generations. I have seen rural women and girls accepting this as their fate. They develop this mindset that they can never get out of this circle (Dignity for her – a report by Dasra, 2015). We have witnessed that supporting rural schools with water and sanitation facilities along with training for handwashing practices resulted in more attendance in schools in Raigad.

Our years of rich experience in the difficult terrain of rural Maharashtra has given us rich learning and confidence that it is absolutely possible to provide safe potable water direct to home sustainably at scale. It is heartening for us to see that the Government of India is ensuring every rural household has access to piped drinking water by 2024. This will help to reduce the multi–fold impact of lack of water on the health, sanitation, and wellbeing of rural Indians. However, this long road cannot be walked by the government alone. To provide water, a collaborative effort from all stakeholders – corporates, gram panchayats, district administration, development partners, corporates, and community members, can contribute in their best capacity to address this water crisis.

THE WATER CONUNDRUM

Mohammed Naser Azeez
Managing Director
Aquality Water Solutions Pvt. Ltd.

Mohammed Naser Azeez is a first–generation entrepreneur, he is an avid innovator and risk–taker. He established the acclaimed Aquality Water Solutions with the idea to provide technologically advanced water treatment solutions to domestic, institutional, and industrial clients. With an ardent interest in clean drinking water facilities, he contributed immensely to improving the lives of people with commitment, technological innovations, and quality excellence.

www.aqualitywater.com

Water is essential! This realization took us a very long time. We were not concerned about water a few decades ago as it was available everywhere in abundance. But the situation started changing and we are in the midst of a historical water crisis all over the world. Many regions are on the brink of going waterless and facing extreme scarcity. This crisis is more of a man–made than a natural condition.

Many cities across the globe are at greater risk of running out of water. Water availability is now cited as one of the greatest risks to survival, business continuity, and growth. It is very clear that the way water is managed today in many parts of the world poses serious risks to human wellbeing and sustainable development. We cannot imagine a day without water or going through our days with very limited access to clean water for drinking, cooking, washing, bathing, manufacturing, and all other activities. But in reality, it is happening with greater frequency in most places.

Water in India

Our country had an ample amount of fresh water available not too long ago. The situation has become grimmer with every passing year and we are staring at 'day zero' in most of our large cities. We were not aware or maybe did not notice the knock of the crisis at the appropriate time and here we are staring at severe scarcity in large parts of the country. The Niti Aayog study has revealed the startling fact that India is suffering from the worst water crisis in its history and millions of lives and livelihoods are under threat. A study has estimated in 2019 that about 600 million populations in India are facing severe to extreme water stress along with more than 20 megacities are facing serious risk. The Financial Express has echoed this concern by saying "in a few years' time, water would be the most precious commodity in India".

It is not only the quantity of water that has become challenging, but the quality has also

https://bit.ly/MohammedNaser

worsened drastically. To report that more than two lakh people die every year due to inadequate access to safe water is very heartening. India is an agrarian economy and almost 70% of the population is employed in agriculture, water management in irrigation is extremely crucial for India as currently about 80% of fresh water is being used by this sector only. The situation is going to get worse unless extreme and drastic steps are not employed at the earliest. By 2030, India's water demand is projected to be twice the available supply making more people face the threat of severe water scarcity with high economic consequences that will eventually make India lose around 6% of GDP. There is an ardent need to deepen our understanding of limited water resources and unsustainable usage patterns and put in place interventions that make our water use efficient and sustainable.

Balancing the Act

Making a sufficient amount of potable water available for the people has become a great challenge, especially in large cities. In developed countries, urbanization happened in a structured and planned manner whereas Indian cities have grown without appropriate planning, resulting in chaos for urban infrastructure and undue burden on the existing system. The consequential outcome is water has become less available due to the devastation of protected water source areas and widespread pollution of remaining available sources both at the surface and underground levels. Another big challenge for the Indian cities is the available water supply sources are far away from urban habitats making water exploration and transportation increasingly expensive. Dealing with these problems requires efficient water supply system (WSS) management techniques, in order to maintain a balance between supply and demand. Maintenance of this balance is achieved through operational actions, many of which require the application of forecasting tools.

The essential need of the situation mandate to make a reasonable balance between water supply and demand and that requires efficient water supply system management techniques. The balance can be achieved through suitable actions which require the application of the best suitable technology for monitoring the situation with accurate forecasting concepts and tools. In today's world, developed countries are mostly using 'state of the art' technological solutions with demand forecasting by employing artificial intelligence, guidance regarding methods and models of concepts, and proper data analysis. India being a vast geographical land, no single global method will be suitable for the entire nation. It is necessary to study each region separately, evaluating the strengths of each model or the combination of methods that will help in achieving the objective. Although there is greater use of statistical applications of machine learning and artificial intelligence, big data analysis, and other modern methodologies, there is still big scope for improvement with regard to water demand forecasting as per regional incongruence.

India has to move to a more holistic way of managing its water sources and reclaiming all generated wastewater resources to reuse while encouraging water demand management through optimum reduction of water losses.

30 KLD Water Treatment Plant by Aquality Water Solutions

Challenges Mystified

Many cities in India are at the risk of running out of water including metropolitans like Delhi, Mumbai, Chennai, Bengaluru, Hyderabad, Ahmedabad, etc. With water availability cited as one of the greatest risks to human wellbeing and business growth, it is clear that the way water is managed today poses serious risks to sustainable development. Imagine going through your day with limited access with intermittent supply only for a few hours per day or a couple of days per week, to store water in your home for drinking, cooking, washing, or bathing.

144 KLD RO Plant for Super PS Plant

4000 LPD 6 stage Drinking water plant for Amazon Campus, Hyderabad

Severe water scarcity caught India unaware and is expected to intensify further as water demand continues to increase due to rapid urbanization and on the other hand water supplies tend to decrease due to unsustainable practices and climate variability. It is not only posing a big challenge to achieving urban water security but also a deterrent to achieving the Sustainable Development Goals (SDGs) set forth by the United Nations for all member countries.

The devastating impacts of climate change on people, the environment as well as on the economies are felt in all regions of the world and in every strata of society. People living in economically disadvantaged areas with high poverty and low resources are the most vulnerable to climate change impacts and their most visible effect – water scarcity, which is affecting lives significantly.

Remedial Efforts

It is no secret that municipalities and water utilities across the country are facing budget constraints. Spending on new technology might not seem like the obvious solution, but a growing number are looking to smart water management tools to control on huge water and revenue loss and substantially attend to increasing demands. One good example is Chennai that implemented a conservation and augmentation plan with water harvesting and wastewater reclamation and reuse facilities. After the city faced a severe water shortage in 2019, it has begun to recycle wastewater at scale to meet the water needs of its industries. Two tertiary treatment reverse osmosis (TTRO) plants launched in late 2019

Commercial Water Treatment Plant by Aquality Water Solutions

are the first of its kind of facilities of this nature in India with 45 million litets per day (MLD) each and Chennai are able to recycle about 20% of sewage currently to reuse, enabling the city to reduce its consumption of fresh water.

Water demand is far outstripping supply in almost every city in India; it is time to think seriously about alternate sources to meet the water needs rather than extracting precious groundwater or desalinating water at great expense. Recycled water, therefore, adds a new, more sustainable water source for urban settlements, one that saves both fresh and desalinated water, is always available and is more reliable than rainfall which can vary from year to year.

Way Forward

Water is a finite resource. Every day is a reminder to individuals, municipal agencies, and governments of this magnificent resource that blankets the earth, is disappearing from under and over the surface. Water utilities across the globe have the continuing challenge of innovating services and delivering fresh water to their customers. In the face of constant technology innovation and market disruption, where another industry has seen terrific innovation with technology, the water industry is still lagging behind. The pandemic has created havoc and unpredicted disruptions that forced most utilities to begin their digital transformation journeys in one way or another. It is time to walk the talk and rope in smart management in all water utilities and harness the value of data and digital technology to work as a way of not only charting delivery and conservation today but to help us address the next generation of challenges, too.

SILICA – A MAJOR ROOT CAUSE OF RO MEMBRANE DAMAGE

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Physical damage to the membrane is a common phenomenon. The physical damage could be such as increasing salt passage, change in flux, and so on. With the good experience and our study in membrane autopsy, we found physical damage and irreversible damage to the membrane caused by the crystallized minerals majorly silica where colloidal silica plays a vital role. In such cases, the foulant composition contains silica near about 10% – 50%.

Silica has a major role in most of the physical and irreversible damage to the membrane by forming crystallized minerals.

Silica is one of the major culprits which can cause irreversible damage to the membrane surface. It may affect the membrane surface in different ways such as by forming deposition/fouling on the membrane or by causing an impact on the flux and increasing the transmembrane pressure on the membrane, etc.

The presence of reactive and colloidal silica in feed water plays an important role in pretreatment of water. While designing system, colloidal silica is rarely analyzed. Most of the time, the parameter analyzed is reactive silica but not the colloidal silica. Predicting the trend of colloidal silica is a difficult task because it may not be similar to that of calcium, magnesium and other minerals and metals. Silica is a complex molecule to understand, interpret and predict because it is very difficult to obtain trend of colloidal silica in water.

In such cases the pretreatment of feed water is an important part. Generally raw water pretreatment includes clarification followed by ultrafiltration which plays major role in reducing the colloidal silica. The ultrafiltration process removes the colloidal particles higher than 0.01µm but the size of colloidal silica particles can be smaller up to 0.001µm. So here we understand the limitation of UF filter and how the colloidal silica get skip from ultrafiltration process. Uncertain trend of colloidal silica and limitation of UF make pretreatment more crucial. Hence, to get rid of colloidal silica in feed water, good design and healthy operation practices of pretreatment are essential.

Let's understand the silica chemistry in detail, to understand its effect on the membrane as per the changes in different environmental conditions as well as changes in feed water chemistry.

Sources of Silica

The presence of colloidal silica is commonly found in river water, seawater, pond water, and well water as well as different types of surface water. The quality of surface water changes as per the geographical condition of that particular area. Also the raw water quality changes according to seasonal changes such as rain, flood, etc. which causes both increase and decrease in the minerals, metals, and nonmetal concentrations in the raw water.

There is a lot of variation and deviation in colloidal silica content of the sample at the same location, condition, and drawn at the same time. Thus, the variation and deviation of silica forms take place not only as per the pH and temperature but also lots of other factors.

Factors affecting silica solubility

The presence of colloidal silica in water and the solubility of silica and silicates depends on various factors. They are as follows:

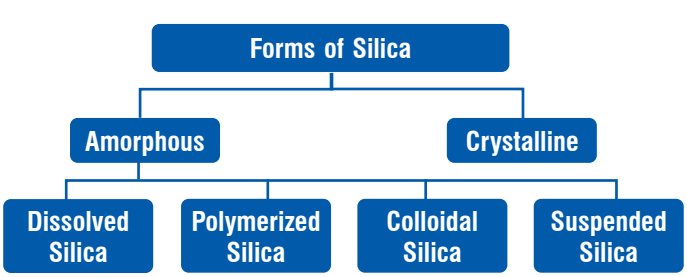
- The saturation level of silica in water.
- pH
- Temperature
- Content of different minerals and metals in water
- Source of water

Different Forms of Silica

Silica exists in either crystalline or amorphous form. Silica is observed in different forms as follows:

Dissolved (or reactive silica): 'Soluble' or 'dissolved' silica–containing monomers, dimers, and polymers of silicic acid.

- **Polymerized silica (slow reactive silica):** It is the form of Silica that results from the polymerization of silicic acid–forming particles. The oligomers of silicic acid are generally referred to as polysilicic acid or polymeric silica. Silica polymerization depends on temperature, pH, ionic strength, and concentration of silica in the water while the rate of polymerization is strongly pH–dependent. It covers a wide range of pH but comparatively, the rate is higher in neutral and slightly alkaline conditions, and decreases to a minimum at pH above 9.5 and below 6.5, respectively. Most of the time the polymerization process is mainly catalyzed by H^+ ions or OH^- ions depending on the pH. The supersaturation of water with silicic acid causes the polymerization in which silanol bond (Si–OH) on the surface of two different particles forms siloxane bonds (Si–O–Si). The siloxane bond requires less space than two silanol groups. This causes the formation of monomeric silicic acid to oligomeric silica and then a gel is formed.



H^+ ion Catalyzed polymerization reaction is as follows:

$$\equiv Si{-}OH + H^+ \longrightarrow \equiv Si{-}OH_2^+$$

(Silanol Bond of Silicic acid) (Protonated Silicic Acid)

$$\equiv Si{-}OH_2^+ + OH{-}Si \equiv \longrightarrow \equiv Si{-}\overset{H+I}{\overset{|}{O}}{-}Si \equiv + H_2O$$

(Protonated Silicic Acid) (Silanol Bond of Silicic acid) (Siloxane bond between silicic acid)

Thus the protonated or cationic form of silicic acid bind with silanol bond of neutral silicon atom to form siloxane bond.

OH^- ion Catalyzed polymerization reaction is as follows,

$$\equiv Si{-}OH + OH^- \longrightarrow \equiv Si{-}O^- + H_2O$$

(Silanol Bond of Silicic acid) (Deprotonated Silicic Acid)

$$\equiv Si{-}O^- + OH{-}Si \equiv \longrightarrow \equiv Si{-}O{-}Si \equiv + OH^-$$

(Deprotonated Silicic Acid) (Silanol Bond of Silicic acid) (Siloxane bond between silicic acid)

Thus, the hydroxide ion catalyzes the condensation of monomeric silicic acid. The deprotonated or anionic form of a silicic acid bind with silanol bond of neutral silicon atom to form siloxane bond. This reaction is accelerated in presence of salts such as Calcium Chloride and Magnesium Chloride.

Silica polymerization is also affected by the presence of other ions in water. Both calcium and magnesium increase the silica polymerization rate. Magnesium hardness is more effective than calcium hardness.

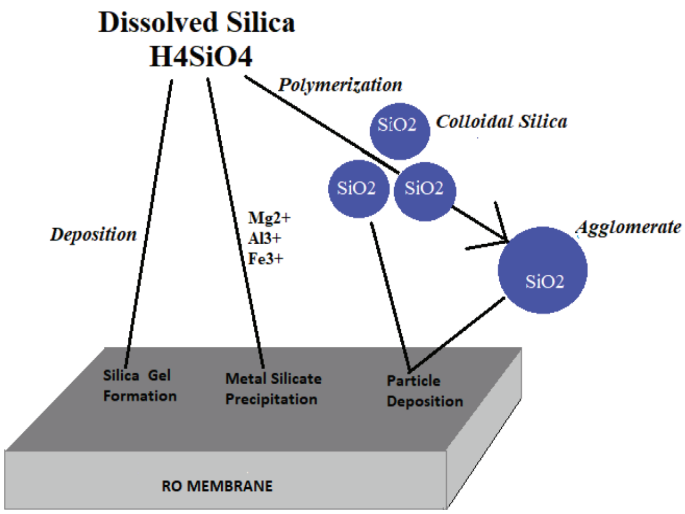
The reactivity of polymeric silica is lower than that of silicic acid due to fewer silanol groups available. Polymeric silica with low molecular weight is considered to be unstable, and to have only a transient existence.

- **Colloidal (or unreactive silica):** Highly polymerized silica is generally referred to as colloidal silica. It is a nonreactive form of silica. Colloidal silica is formed due to the polymerisation of silicic acid–containing particles and three–dimensional gel networks of silica.
- **Suspended (or particulate silica):** Some silica species are always in transition depending on pH and concentration of other silica species. In the case of the detection process only colloidal, reactive, and total silica is easily detected.

Silica Precipitation in Different Conditions

Dissolved silica separate out from the supersaturated solution in three forms:

- Monomeric silicic acid deposits on any solid surface that have an –OH group on it with which it can react.
- Colloidal particles due to polymerization of silica which grows to form a 3D polymer. These colloidal particles grow to form large particles that may deposit on surfaces.
- Biogenic amorphous silica by living organisms – Sessile micro–

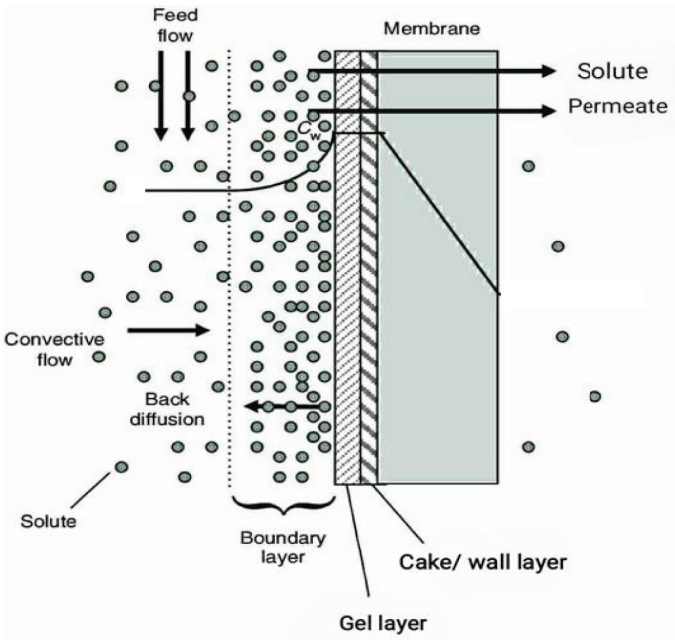


organisms, Diatom, and algae present in the biofilm may absorb the colloidal silica. Also, soluble silica has a higher affinity toward the extracellular biopolymers produced by micro–organisms. Amorphous silica deposits in presence of calcium carbonate and calcium sulphate.

Concentration Polarization Condition in RO membrane System

In the case of RO systems, separation of salts concentration polarization results in an increase in silica concentration or accumulation of silica at the membrane surface to form a thin boundary.

This concentration polarization decreases the permeate flux as well as affects the rejection of solute through the membrane surface.



Concentration Polarization condition in case of RO membrane

The cake layer formed on the membrane surface is responsible for hydraulic resistance and creates a hurdle for diffusion back of the solute into the concentrate water, resulting in a decreased permeability and salt rejection.

Effect of Silica on Membrane

- The accumulation of higher concentration of colloids near the membrane surface affects the performance of the RO system in several ways:
- An increase in pressure drop is responsible for the decrease in water flux.
- The decrease in water flux and increase in solute flux through the membrane affect the separation efficiency of the membrane.
- An increase in ion concentration on the membrane surface causes the solutes to exceed their solubility limits and is then finally responsible for precipitation and scaling.

Thus, a higher concentration of silica along with changes in pH may increase fouling possibilities on the membrane surface.

The membrane fouling phenomenon depends on the changes in silica solubility limit due to changes in the concentration polarization layer on the membrane surface.

Solubility of Different Salts of Silica

- In high salinity waters, sodium could prevent silica deposition on the membrane surface.
- The presence of carbonic acid (H_2CO_3) imparts the silica both acids as well as the base characteristics. This causes changes in the interaction of silica with membrane surfaces.
- Silica forms a complex with a hydrated form of calcium, aluminum, magnesium, and iron elements. This complex form polymerizes and creates colloids.
- Silicates of potassium and sodium are soluble but the silicates of iron, aluminium, and crystalline silica are having very low solubility and are a nonreactive form of silica.

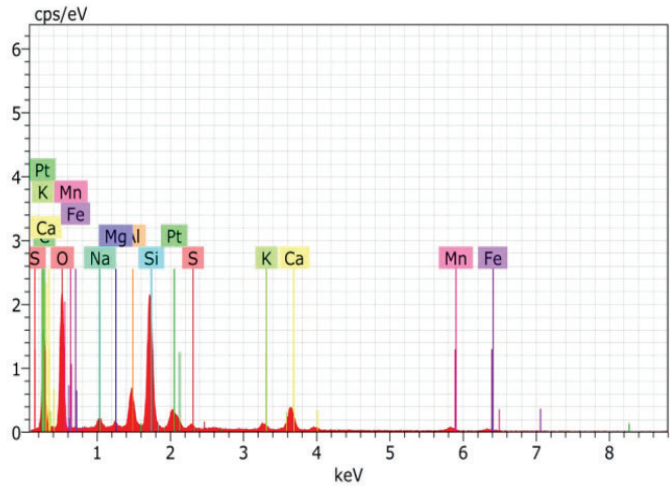
The reactive silica consists of low ionized forms (such as monomeric silicic acid) at a pH of 6–9 and forms silica gel or cake–like silica structure on the membrane surface. The concentration of silica or silicate compounds increases in the bulk solution of the RO feed and scale begins forming on the membrane surface. Thus it becomes less permeable, resulting in a decrease in permeate flux.

Fouling of Silica on Membrane Surface

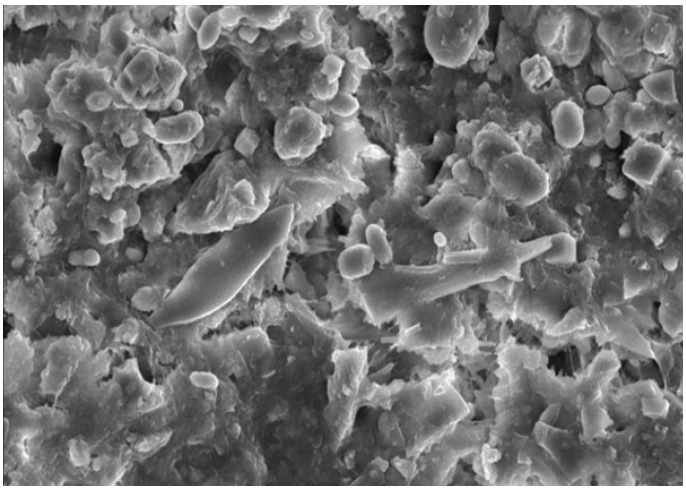
Fouling by polymerized silica, colloidal silica, or silica gel, because of the polymerization of supersaturated silicic acid, in feed water occurs when the supersaturation level of silica takes place. This process of fouling is more rapid at higher temperatures, but comparatively slower at lower temperatures. Presence of multivalent metal ions such as Fe^{3+}, Al^{3+}, Ca^{2+}, and Mg^{2+} in feed water act as catalysts during the polymerization process.

These ions form complex with silica, which causes the polymerization and fouling of silica on the membrane surface.

The reaction between $Mg(OH)_2$ and silicate ions leads to the formation of



EDS Spectrum



SEM image of Silica Fouling on Membrane

magnesium silicate precipitates. These precipitates have been shown to be a major foulant because of their insolubility according to the changes in temperature and pH.

In presence of calcium carbonate and calcium sulphate, amorphous deposits of silica are formed. The colloid of silica which is formed by the complex of hydrated minerals and metals with silica grows through polymerization and bridge between organic and inorganic matter to form a gel–like layer on the membrane surface. Therefore, the scaling potential of feedwater is dependent on the pH and SiO_2 content in the concentrate.

Effect of Organic Compound and Silica on Membrane

Apart from the above, silica also reacts with organic components including different types of proteins, humic acids, and polysaccharides. The presence of silica along with organic compounds in feed water causes comparatively more impact on flux than individual organic or inorganic fouling. The deposition of silica on the membrane causes the formation of thin film on the membrane which also causes an impact on the polyamide layer.

The hydrolysis of trimesoly chloride (which is the part of the polyamide membrane) causes the formation of the carboxyl group. The silica may form a bond with carbon in the carboxyl group by substituting oxygen. The decrease in the carboxyl group may cause an impact on flux. These changes in the carboxyl group cause irreversible damage.

Removal of Silica Fouling on Membrane

The removal of scaling is difficult and expensive.

The presence of silica foulant leads to panic and harsh cleaning which are responsible for different types of physical damages. The acid and alkali cleaning also causes impact on silica fouling processes.

- The possibility of metal silica fouling increases due to frequent acidification of feed water.
- During the alkali cleaning processes, as pH increases above neutral, silicic acid dissociates into the silicate anion $(SiO_3^{2-})n$. This can react with different minerals such as calcium, magnesium as well as multivalent metals like iron, manganese or aluminum to form insoluble silicates. Among all these aluminium is one of the most powerful element which causes precipitation of silica. The presence of both Al3+ and Fe3+ in the pretreated feedwater causes the precipitation of silica even at below the saturation concentration level of silica. Hence, to maintain the concentration of both Al^{3+} and Fe^{3+} in feed water it is very important as both Al^{3+} and Fe^{3+} salts are used as coagulant in water treatment processes. So, post coagulation concentration of Al^{3+} and Fe^{3+} should be below 0.05mg/l or less.
- Hydrofluoric acid can remove the silica but in such cases the possibility of the oxidation of polyamide membrane may increase.

Thus any of the cleaning process may cause the damage to the membrane.

Control of fouling of Silica:

For preventing membrane fouling by surface waters with high silica content, the effective control of silica is essential.

The fouling of Silica can be controlled in different ways:

- Operating systems at low silica concentration levels.
- Controlling the feed water silica concentration (e.g., by lime softening or other processes).
- Selecting the proper Silica inhibitor or dispersant which will inhibit silica polymerization or cause the dispersion of the silica precipitate and form the soluble metal silicates.
- Effectively controlling the scales such as calcium carbonate, calcium phosphate as well as metal and mineral concentration in feed water.
- Maintaining the pH of the system is less than 8.3 to avoid the precipitation of metal–silicate.

To get rid of reactive and colloidal silica problems understanding the effective pretreatment is essential and to design effective pretreatment, adequate data on reactive, colloidal, and total silica is required.

So, negligence of the reactive silica and colloidal silica will cost a lot.

GRAFiL UF MEMBRANE: INDIA'S CONTRIBUTION TO THE GLOBE

Sunil Dhole
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ABOUT THE AUTHOR

Dr. Sunil Dhole *completed his bachelor's in Chemical Engineering from Amravati University Maharashtra did Masters (2002) and Ph. D. (2006) from IIT Kanpur. After a post-doctoral research fellowship at non-Newtonian Rheology group at UCL, Belgium (2007-2008) he joined Reliance Technology Group as Senior Research Scientist (2008-2011). His journey of entrepreneurship started in 2011 with the formation of Kanpur based company "Technorbital Advanced Materials Pvt. Ltd." The company has been started with the objective of converting potential lab-scale research in to the commercial reality. Sunil's expertise is in new generation water filtration membranes, air purification membranes, and new generation waste water treatment technologies.*

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Introduction

Water and energy are fundamental resources used for economic, social, and cultural development. These resources have been long presupposed as abundant. With the increase of population and the developments brought by the industrial revolution, their increased demand, and scarcity are now an undeniable result.

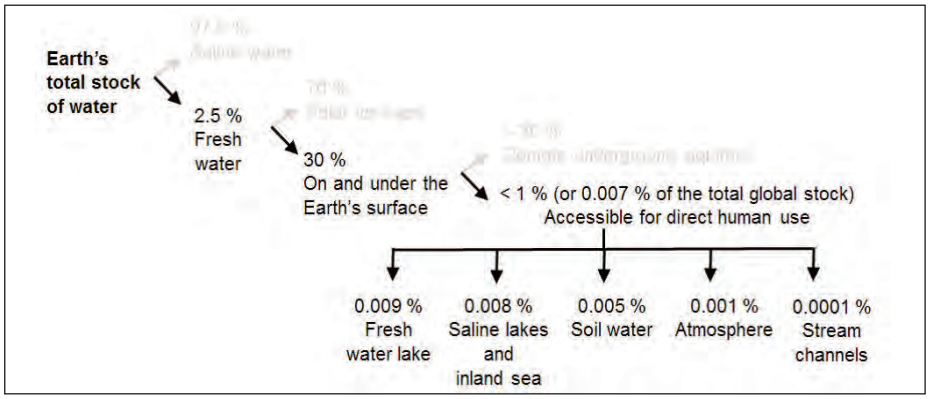
Water and energy have always been crucial for the world's social and economic growth. Their supply and use must be sustainable. This article discusses opportunities for membrane technologies in water and wastewater treatments. The article shall also touch upon the very recent developments in ultra–filtration membranes.

Water is an invaluable vital natural resource for human life. Currently, the world is undergoing a critical water quality crisis because of the increasing number of populations, poor practices of industrialization and urbanization, as well as the uncontrollable discharge of polluted and harmful water. However, almost one billion people in the world do not have ready access to safe drinking water and over 3.6 million people around the world die each year from drinking unsafe water. A broad range of water treatment technologies is available/been used for wastewater recycling and for purification of drinking water. Physical water treatment, membrane–based processes have received significantly increased interest over the last few decades.

Membrane and Membrane Characteristics

A membrane is a thin layer of material that will only allow certain compounds to pass through it. Which material will pass through the membrane is determined by the size and the chemical characteristics of the membrane and the material being filtered.

A number of different materials are used to prepare membranes for use in water treatment. These materials can be broadly classified as either Organic (polymer membranes) or Inorganic (ceramic membranes).



GRAFiL UF Plants

Several types of membranes are used based on the size of contaminants, such as MF for suspended particles (100–1000 nm), UF for bacteria and viruses (5–100 nm), and NF for dissolved particles (1–5 nm).

MF and UF are technically more popular than NF regarding the fouling and cost factors. Both ceramic and polymer materials can be used to fabricate MF and UF membranes. Ceramics have advantages of high chemical stability and mechanical strength, ease of cleaning, long and reliable lifetime.

Membrane Materials

Membranes are made from either organic polymers or ceramic materials. Polymers offer the advantage of low–cost production but may contain natural variations in pore size. And are prone to fouling and degradation. Ceramic membrane offers excellent quality and durability but is economically unfeasible for large–scale operations, although they may be well suited for industrial applications. Table 1 lists the most common types of polymer materials used to construct membranes.

Materials	Abbr.	Advantages	Disadvantages
Polyvinylidene fluoride	PVDF	High Chlorine tolerance Simple Cleaning Chemicals	Cannot sustain pH>10
Polyether Sulphone & Polysulphone	PES/ PS	Chlorine tolerance Reasonable cost	Brittle material requires support or flow inside to outside
Polyacrylonitrile	PAN	Low cost, typically used for UF membranes	Less chemically resistant than PVDF.
Cellulose Acetate	CA	Low cost	Narrow pH range Biologically active
Polypropylene	PP	Low Cost High pH range tolerance	No chlorine tolerance Expensive chemical cleaning required

Table 2: Polymer Membrane Materials and Characteristics

The mechanical properties of polymer membranes (% elongation, tensile strength, hardness) determine their application and this make a strength very important parameter.

It has been shown that morphological parameters such as pore size and pore architecture have a major effect on the properties of polymeric membranes because if pore size increased, a mechanical strength decreased.

A decrease in the tensile strength with pore enlargement is usually due to the decrease in surface area of the membrane. Two types of membranes have been characterized in this study hollow fiber membrane and flat sheet mat. The hollow fiber membranes were based on polyethersulfone (PES HF) and polyvinylidene difluoride (PVDF HF) polymers, widely used for membrane preparation.

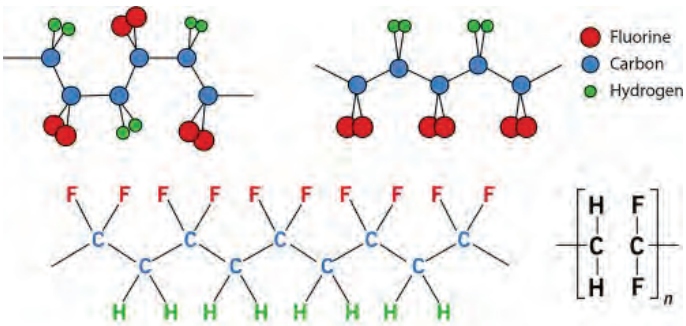
The flat sheet mat membranes were based on polyvinylidene difluoride (PVDF) polymer of different molecular weight.

PVDF (POLYVINYLIDENE FLUORIDE)

Structure	
Molecular Formula	–(C2H2F2)n–
Properties	PVDF exhibits excellent Mechanical strength Toughness, stiffness, High dielectric strength, Abrasion resistance, Creep resistance, High purity, Chemical inertness, Low flammability, and Low moisture absorption

Bond Properties	The carbon/fluorine bond is one of the strongest chemical bonds known.
	PVDF is a thermoplastic. The powder particles are expanded by heat during the curing process, becoming plastic and forming a homogeneous film.
Applications	Chemical processing, Electricity, batteries and electronic components, Construction and architecture, Healthcare and pharmaceutics, Biomedical research, Ultra–pure applications, Nuclear waste handling, Petrochemical, oil and gas, Food, beverage processing, Water, wastewater management.

PVDF Chemistry



Polyvinylidene fluoride (PVDF)

The unique mechanical properties of PVDF are based on its semi–crystalline structure. Poly (vinylidene difluoride) (PVDF) consists of a CH2–CF2 unit, as shown in Figure

The carbon–fluorine bond in PVDF is a polar covalent bond between carbon and fluorine that is a component of all organofluorine compounds. It is one of the strongest single bonds in organic chemistry.

The high electronegativity of fluorine (4.0 for fluorine vs. 2.5 for carbon) gives the carbon–fluorine bond a significant polarity/dipole moment.

The partial charges on the fluorine and carbon are attractive, contributing to the unusual bond strength of the carbon–fluorine bond. The bond is labeled as "the strongest in organic chemistry," because fluorine forms the strongest single bond to carbon. Carbon–fluorine bonds can have a bond dissociation energy (BDE) of up to 544 kJ/mol. The BDE (strength of the bond) is higher than other carbon–halogen and carbon–hydrogen bonds.

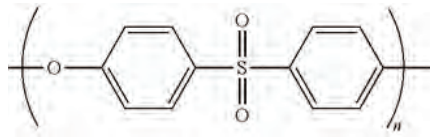
The carbon–fluorine bond length is typically about 1.35 ångström.

It is shorter than any other carbon–halogen bond, and shorter than single carbon–nitrogen and carbon–oxygen bonds, despite fluorine having a larger atomic mass.

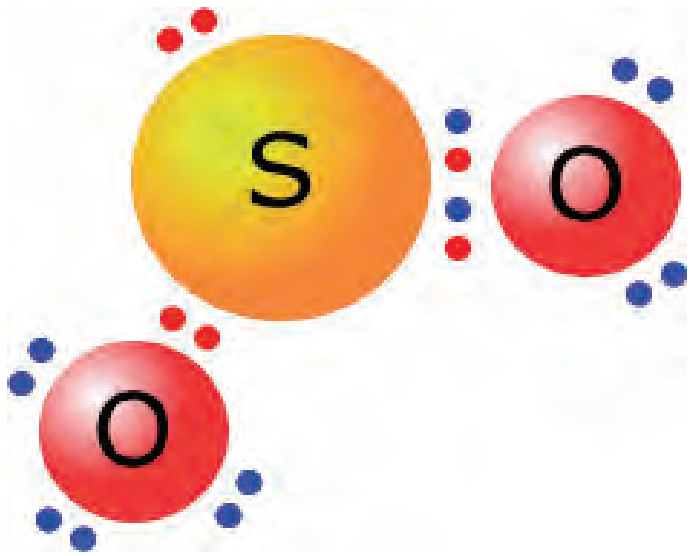
The short length of the bond can also be attributed to the ionic character/ electrostatic attractions between the partial charges on carbon and fluorine.

The C–H bond is very weakly polar because H and C don›t have identical electronegativities, they are very close.

PES (PolyetherSulphone)

Struture	
Molecular Formula	(C12H8O3S)n
Properties	It is an amorphous, transparent thermoplastic. It is rigid, tough, and dimensionally stable over a wide temperature range.
	Sulfone group provides high temperature performance
	An amorphous polymer which possesses bonds of high thermal and oxidative stability
Physical , Mechanical, Chemical Property	It has outstanding long–term resistance to creep at temperatures up to 150°C. It can be easily processed and exhibits low mold shrinkage. It is also capable of being used continuously under load at temperatures of up to about 180°C and in some low–stress applications to 200°C.
	Polyethersulfone is especially resistant to acids, alkalis, oils, greases, and aliphatic hydrocarbons and alcohols. It is attacked by ketones, ester, and some halogenated and aromatic hydrocarbons. The high–temperature oil and gas resistance allow Polyethersulfone to be used in automotive applications.
Limitation	Very high cost. Applicable for highly demanding applications Processing at high temperature and pressure Attacked by polar solvents such as ketones, chlorinated solvents and aromatic hydrocarbons Low resistance to UV light

PES Chemistry



Carbon and Sulfur have similar electronegativities, the effect of this increased polarizability for sulfur is that sulfur behaves or reacts as if the bond were polar.

Sulphur is a larger atom so it has more, loosely held electrons than carbon. This means that a sulfur atom is more polarizable than a carbon atom. Although carbon and sulfur have similar electronegativities, the effect of this increased polarizability for sulfur is that sulfur behaves or reacts as if the bond were polar. Take the case of a nucleophilic attack on a C–S C–S bond. As the nucleophile approaches, the C–S C–S bond will tend to polarize because of sulfur›s polarizability. That's why PES Polymer is Hydrophilic.

The figure shows that Sulfur Dioxide is a process of covalent bonding since Sulfur and Oxygen are both non–metals.

Sulfur Dioxide is a resonance structure and can be expressed in three different forms. This is a polar molecule, as the Oxygen atoms have a higher electronegativity, and pull the electrons closer to their nucleus also due to the angle of the bonds. In addition, Sulphur and Oxygen both satisfy the octet rule and achieve the state of noble gas in their bonding.

Dipole moments of Sulfur Dioxide will be a little stronger because the atoms are bigger, compared to other nonmetals, due to the number of electrons. That is why the boiling point and melting point are small; the bonds being much easier to break in these induced moments.

General Details About PES Polymer

There are different manufacturers that produce PES commercially such as:

- BASF company with trade names as Ultrason E and Ultrason S,
- Solvay company with a trading name as Radel PES, and
- Sumitomo chemical company with a trading name as Sumika excel.

When the PES membrane is used in water purification, microorganisms that are present in almost all aquatic environments, convert soluble salts and nutrients present in water to materials that are semisolids or solids resulting in blocking the membranes. Consequently, problems related to membrane quality start to appear such as increasing the cost of membrane maintenance, decreasing the lifetime of membranes as well as poor separation performance.

Chemical modification of the PES membrane is used as a fundamental solution to increase hydrophilicity and to develop anti–fouling membrane materials.

Modification of PES membranes is based on three methodologies, which are surface treatment including:

- Physical adsorption,
- UV irradiation,
- Plasma treatment, etc.

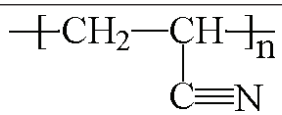
Blending method, which is considered as a surface treatment, and bulk modification.

Amine functions to PES membrane either to increase the hydrophilicity of the polymeric membrane or to introduce nanomaterials/monomers/enzymes on the surface of PES membrane.

The hydrophilicity of PES membrane is measured by the contact angle which is in turn affected by different factors such as the membrane roughness, the porosity, the pore size, and the pore size distribution. However, when the roughness of the membrane surface rises up, it means the contact angle increases, which affects the hydrophilicity measurements measured by the contact angle.

The generated radicals attack specific bonds such as C–C, C–H, and C–S bonds except the aromatic C–H and C–H bonds. The produced radicals then react with gas species, and the residual radicals react with O2 and N present in the atmosphere. When CO2 plasma technique is used, oxygen species introduced on the membrane surface in types of acid, ester, and carbonyl functional groups. H2O plasma method produces hydroxyl, carboxyl, and carbonyl functional groups whereas plasma treatment species containing nitrogen functional groups produce amide, amine, and imine functional sites on the surface, which eventually increase the hydrophilic properties of the membrane.

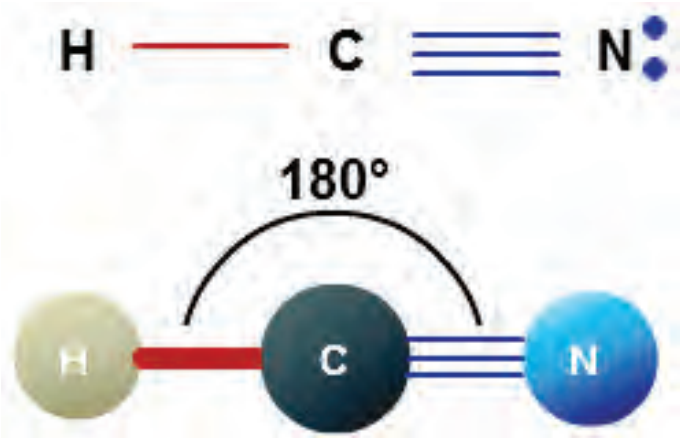
PAN (Polyacrylonitrile)

Structure	
Molecular Formula	(C3H3N)n
Properties	It is the most resistant polymer among all to degradation by sunlight, mainly by ultraviolet rays. Has the ability to form oriented fibers It is quite inert and resistant to most organic solvents and acids, being only attacked by highly polar liquids and concentrated solutions of bases. Its fibers are resistant to breakage, produce high volume, are soft, comfortable, and thermal insulating, having properties similar to natural wool. In the form of fibers, when heated, it does not melt and maintains its morphological structure, a property that is used for the production of carbon fiber, insulating fibers, anti–flame fibers and blankets for the filtration of hot gases.
Temperature Property	Thermoplastic, it does not melt under normal conditions. It degrades before melting. It melts above 300 °C if the heating rates are 50 degrees per minute or above
Solubility	PAN is soluble in polar solvents, such as dimethylformamide, dimethylacetamide, ethylene and propylene carbonates. sodium thiocyanate, zinc chloride and nitric acid.

On the other hand, polyacrylonitrile (PAN) is considered to be a good polymer in membrane industry due to its commercial availability, good thermal stability, resistance against organic solvents and its improved chemical stability against chlorine, sodium hypochlorite, sodium hydroxide.

Despite its brittleness in dry conditions, PAN membranes are known as low fouling due to their hydrophilicity when compared to polysulfone (PSF), polyethersulfone (PES), polyethylene (PE) and polypropylene (PP)

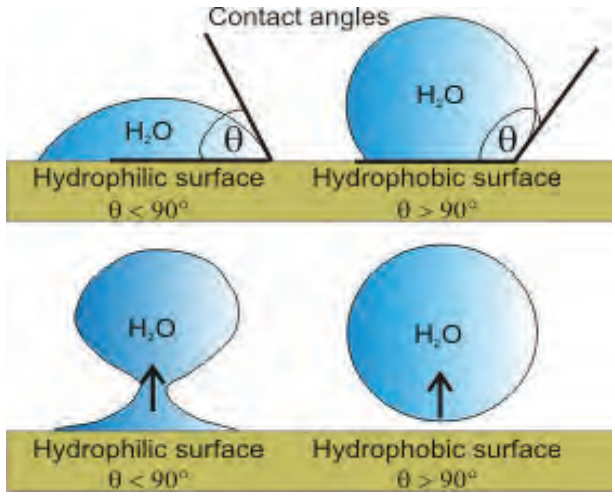
PAN Chemistry



- Both the C–H and the C–N bonds are polar.
- Nitrogen is more electronegative than carbon which is more electronegative than hydrogen. The hydrogen atom takes on a partial positive (+) charge and the nitrogen takes on a partial negative charge (–). This results in an unequal sharing of the bonding electrons resulting in a net dipole for molecule since the two dipoles do not cancel out.
- PAN has a highly polar group, which is attractive for water and makes PAN less hydrophobic than PVDF.
- PAN nanofibres are hydrophobic but not as much as PVDF fibres.
- PAN is a semicrystalline polymer with high polar nitrile groups possessing a high dipole moment.
- The high polarity of PAN polymers increases the hydrophilicity of the nanofibre layer.
- Unlike PAN, PVDF nanofibres are highly hydrophobic. PVDF polymers are durable and have high mechanical strength.

What is Hydrophilicity and Hydrophobicity?

- Hydrophilic surface has a strong affinity to water and spreading of water on such surface is preferred. The degree of hydrophilicity of the substance can be measured by measuring the contact angle between the liquid and solid phases.
- Hydrophobic materials are known as non–polar materials with a low affinity to water, which makes them water repelling. A contact angle of less than 90° indicates hydrophilic interaction where as an angle greater than 90° indicates a hydrophobic interaction. More recently, superwetting such as superhydrophilicity has been receiving an increased focus in the literature due to its potential significance. Superhydrophilic surface has a contact angle of less than 5°.
- The applications of such an important property are significant. For example, hydrophilic surfaces can be used in anti–fogging applications, biomedical, filtration, heat pipes, and many others. Hydrophobic and superhydrophobic materials have been successfully applied in many sectors, such as: (I) the removal of petroleum from aqueous solutions,



(II) applied to plastic, ceramics, and mesh to contribute to the oil removal from aqueous solutions, (III) hydrophobic layers have a strong self–cleaning effect on plastics, heat pipes, metals, textiles, glass, paints, and electronics, (IV) hydrophobic layers improve the anti–freezing behavior of heat pipes which prevents unwanted build–up and (V) they function as a water and dust protecting coat on electronics.

- The hydrophilic term characterizes a membrane in relation to its behavior in an aqueous environment. The membrane's interaction with water is determined by its chemical composition and corresponding surface.
- Hydrophilic membranes have an affinity to water. Their surface chemistry allows these materials to be wetted immediately. Hydrophilic membrane is extremely imperative in water treatment to avoid the fouling of organic matter on the membrane surface. Diverse methods have been developed to render the hydrophobic polymeric membranes with improved hydrophilicity including surface modification and blending modification.
- Most polymeric membranes can be regarded as hydrophobic membranes, e.g., PVDF, PTFE, PP, PE, and PSF membranes. Hydrophobic membranes usually possess a unique advantage in membrane distillation, oil/water separation or membrane contactor.
- Nonpolar molecules do not contain ions, possess a dipole moment, or become hydrated.
- Small hydrocarbons like butane (CH3—CH2—CH2—CH3) are somewhat soluble in water, because they can dissolve without disrupting the water lattice appreciably. However, 1–butanol (CH3—CH2—CH2—CH2OH) mixes completely with water in all proportions. The replacement of just one hydrogen atom with the polar —OH group allows the molecule to form hydrogen bonds with water and greatly increases its solubility.
- Simply put, like dissolves like. Polar molecules dissolve in polar solvents such as water, while nonpolar molecules dissolve in nonpolar solvents such as hexane.

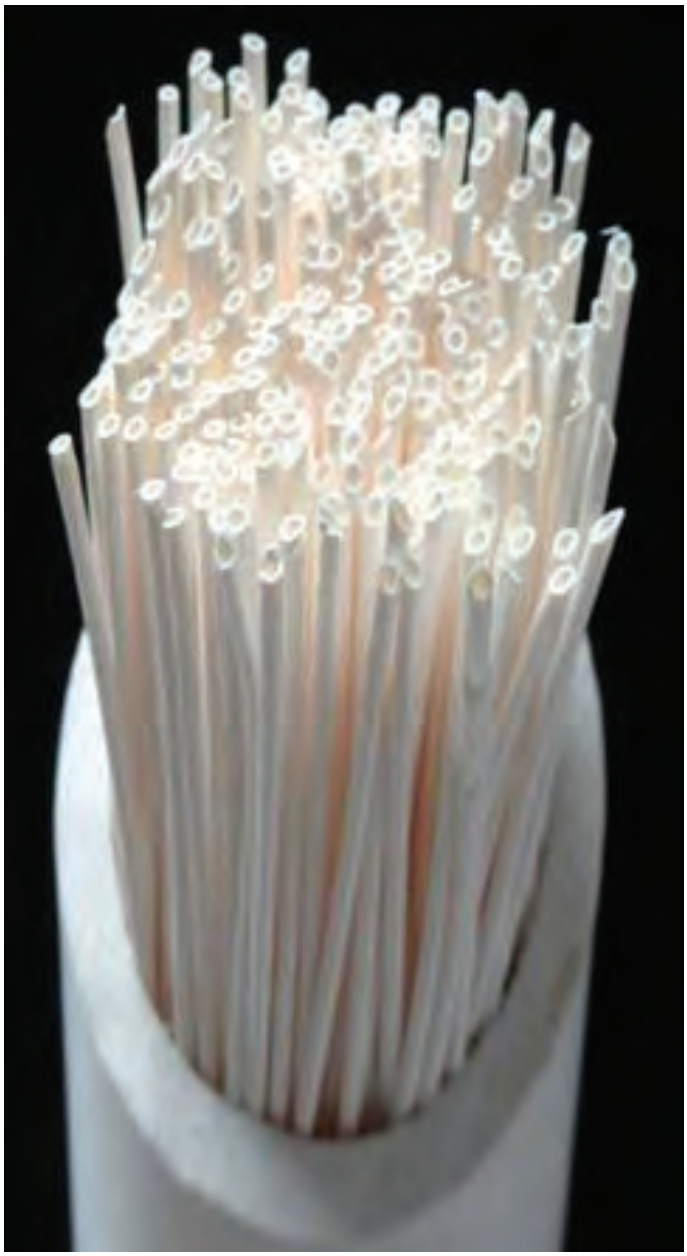
Which Functional Group are responsible for Hydrophilicity

- Hydrophilic functional groups include
- Hydroxyl groups (resulting in alcohols though also found in sugars, etc.),

- Carbonylgroups (givingriseto aldehydes and ketones),
- Carboxyl groups (resulting in carboxylic acids),
- Amino groups (i.e., as found in amino acids),
- Sulfhydryl groups (giving rise to thiols

Why PAN Polymer is more hydrophilic than PVDF Polymer?

In PVDF Polymer C – F bond and in PAN Polymer C – N both are Polar bond but PAN Polymer is more hydrophilic because of the electro–negativity difference. To find which one of the bond is least polar you need to find the electro negativity difference between the atoms that are involved in bonding. The more is the electro negativity difference (ΔEN) the more is the bond polarity and vice versa.



GRAFIL Hollow Fibres

Here are the electronegativity values:

- Carbon – 2.44
- Fluorine –3.98
- Oxygen – 3.44
- Nitrogen – 3.04
- Electro negativity Difference of C–F bond is –1.54
- Electro negativity Difference of C–N bond is –0.6
- Electro negativity difference of C–N bond is more so this bond is more polar than C–F Bond. That is why PAN is more hydrophilic than PVDF.

PolyNorbit based UF membranes: GRAFiL

Based on the understanding of the above mentioned various chemistries of different polymers, Technorbital has invented the magic co–polymer "PolyNorbit". This co–polymer (PolyNorbit) innovated by Technorbital has led to the innovation of GRAFiL – UF membranes which have:

- Better cleanability due to Polynorbit polymer.
- Higher fluxes compared to conventional membranes
- Inherent anti–fouling properties
- Good resistance to acids and alkali
- High strength
- Can be easily modified to achieve multiple functionalities
- Energy Efficient
- It can be cleaned using plain water or negligible mild chemicals when required
- Prevent bio–fouling tendency and algal development on the membrane surface

The membrane technology of Technorbital is developed in collaboration with the India's premier research lab CSIR (NCL–Pune, India). A famous house–hold non–electric water purifier TATA–Swach is based on the same technology of Technorbital.

Summary

Finally, in emerging countries, the regulations for water treatment, and in particular for wastewater effluent disposal are tightening, but the technical know–how for water processing is low. Innovative companies like Technorbital offer products which can fill niches in the market, overcome imperfections of existing products and help to comply with upcoming regulations. Technorbital brings to the market reliability and effortless innovative products like GRAFiL UF membranes.

Acknowledgements

I am thankful to Sanjeev Srivasstava (Aktion India) and his team for the support in preparing this article.

Similarly, many thanks to the management team of Technorbital (Dr. Sreekumar Veedu, Mr. Shaju P M and Manish Agarwal) for the support and encouragement.

THE COST OF A NON–STANDARD WOUND POLYPROPYLENE CARTRIDGE FILTER

Himanshu Budhia
Director, GSE Filter Pvt Ltd

ABOUT THE AUTHOR

Himanshu Budhia *demonstrated a history of working in the environmental services industry. He has strong professional skills in Water Treatment, Business Development, Industrial Water Treatment, Industrial Engineering, and Air Filtration.*

www.gsefilter.in

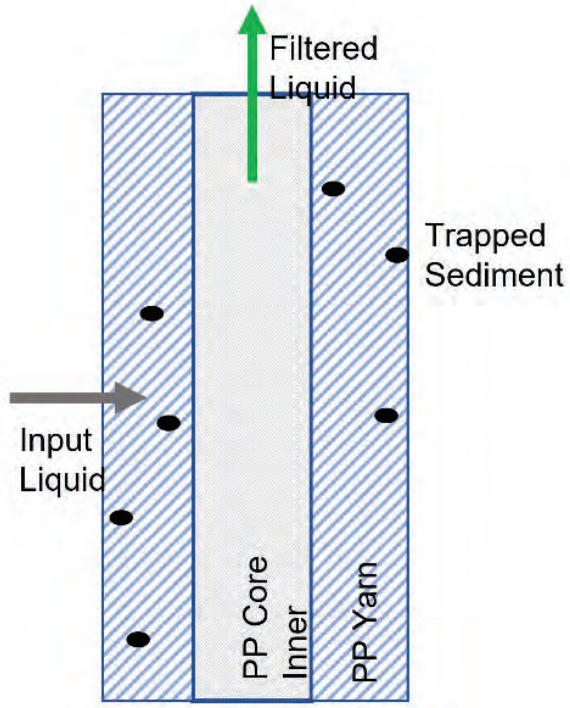
What is a Wound Polypropylene Filter Cartridge?

These are filter cartridges that are used to remove impurities in the form of sediments in a liquid. They are manufactured by winding a continuous strand of polypropylene yarn over a perforated supporting core. This core is also normally made of polypropylene. The criss–cross winding creates a multi diamond–shaped pattern across the length of the filter. The closeness of the winding pattern can be varied to produce filters of different porosities. A very close pattern would mean that only very fine particles can pass through it. This would mean that its porosity is low. A more spaced winding would mean that particles of a larger size can pass through it. For example, a low porosity 1 Micron Rated cartridge would have a close pattern. This filter would only allow particles of size smaller than 1 micron to pass through it. A higher porosity 10 Micron–rated cartridge would have a more spaced pattern. This would allow particles of less than 10 microns to pass through it.

Polypropylene (PP) is the popular choice for these filters because it is insoluble and inert to a wide range of liquids. In applications involving drinking water, food and beverages, dairy, pharmaceuticals – a virgin grade PP must be used. Recycled PP can have detrimental health effects.

They work on the "Depth Filtration Technology"

The sediments are trapped within a bed of depth of fibers by adsorption or absorption. The irregular pores in the bed cause a torturous path to trap fine particles. The filtration happens due to direct interception, inertial impaction, diffusion, and electro–kinetic effect. There is a gradual increase in pressure drop across the cartridges until such time that the cartridges are fully choked. In these filters, the trapped particles are more difficult to remove. This can be done by backwashing and chemical treatment. These are NOT recommended as such procedures severely affect the micron rating of the filters.



Schematic Drawing of Filtration through a Wound PP Cartridge Filter

International Standard Dimensions of the Wound PP Cartridge Filter

The Wound PP Filter product is a popular choice across the world. There are millions of installations of housings around the world that have these filters fitted inside them. The housings are deployed for the following international standard dimensions of the filters.

- **Outer Diameter:** 63mm (2.5")
- **Inner Diameter:** 27mm / 28mm (1.1")
- **Lengths:** 254mm (10") / 508mm (20") / 762mm (30") / 1016mm (40")

A Wound PP 10" cartridge of 5 Micron Porosity would have a weight of around 165gms

Non–Standard/Low–Quality Cartridge in Terms of Dimensions

Many times, a small change in dimensions of the outer diameter and inner diameter of the cartridge can go undetected to the naked eye. The schematic drawing shows a classic example. It compares a standard cartridge (OD: 63mm / ID: 28mm) vs a non–standard cartridge (OD: 58mm / ID: 32mm). The change is a small one, but when you analyze it, the non–standard cartridge has approximately 27% less yarn in terms of volume and 15% less yarn in terms of weight. This would be a significant cost saving for a company that is mass–producing such filters.

This small change in dimensions could go undetected by an innocent buyer. They fall prey to a lower–cost cartridge while comparing it with the ideal cost of a standard cartridge. However, this lower–cost cartridge would significantly change the performance parameters of the cartridge. The "flow rate" through the cartridge and its "dirt holding capacity" would be drastically reduced. The life of the cartridge would be reduced. This would thereby increase the spare cartridge cost and the down–time cost of changing the cartridges in a big way. The cost–saving enjoyed while procuring the non–standard cartridges is nullified and reversed in the long run.

Non–Standard/Low–Quality Cartridge in Terms of Weight

The PP yarn is the media that provides filtration. The inner core is just a support to the yarn. Therefore, it is quite logical that it is the weight of the PP yarn which is of importance while ascertaining the quality of a cartridge and pegging it against a price.

Refer to the below table.

PARAMETER	STANDARD	NON STANDARD	
Outer Diameter	63mm	58mm	
Inner Diameter	28mm	32mm	
Yarn Volume (10")	61 cc	44 cc	
Yarn Weight (10")	134 gms	115 gms	← Yarn wt reduced
Core Weight (10")	31 gms	**50 gms**	← Core wt increased
Cartridge Weight (10")	165 gms	165 gms	← Cartridge wt is same

The non–standard cartridge has been produced using lesser pp yarn. This is compensated by using a heavier supporting core. The weight of the finished cartridge is thus maintained to manipulate the sale. The non–standard cartridge is offered in the market at a lower price than a standard cartridge whilst confirming that the weight of the cartridge is the same as the standard cartridge. As explained earlier the flow rate and the dirt holding capacity of such cartridges will be lower. It would reach its change overpressure drop levels much faster.

Non–Standard/Low–Quality Cartridge in Terms of Micron Rating

A user selects a cartridge of a certain porosity to address the needs of their application – drinking, product processing, machinery requirement, process requirement, etc. Ethics would demand that a supplier provides a cartridge, rated to the micron rating as required by the user. For example, if a user needs a cartridge rated to 1–micron porosity, the supplier needs to give a 1–micron cartridge and not a 5–micron cartridge. Using a higher porosity might affect the process greatly.

As explained earlier, the wound PP cartridge can be made in different porosities by machine settings. The lower porosity cartridge could have the yarn strand closer to each other and they would be "tighter" and slightly "heavier". For a user, it would be very difficult to identify and confirm the porosity of a cartridge by looking at it. The user would need to trust the word of the supplier, the marking on the label if any on the cartridge, or a test certificate given by the supplier.

It is quite unfortunate that in many cases, cartridges of the same porosity are labeled with different porosity ratings and made available for sale. The

advantages to an unscrupulous manufacturer indulging in such practices would be:

- Mass production of a particular porosity would mean less machine downtime and cost–saving
- Selling a 10–micron cartridge with a label of 0.5 Mic / 1 Mic / 5 Mic would mean cost savings as the 10–micron cartridge would be slightly lighter in weight requiring a lower amount of PP yarn.
- Non–availability of accessible and economical testing rigs would mean that the chances of the customer verifying the porosity are very bleak.

Let us take a reverse osmosis plant as an application. The wound PP cartridges are popularly used as a pre–treatment of the input water to reduce the sediments going into the membrane. Normally a 1 Micron or a 5–micron cartridge is selected for this process. Using a higher porosity cartridge like a 10–micron one could allow that much more sediments to pass through it and reach the high–pressure pump and membrane. This would severely affect the life of the pump and also choke the membranes faster. The pump and membrane being expensive components, the cost to the user because of a non–standard cartridge could be very high.

Non–Standard/Low–Quality Cartridge in the Material Grade of Polypropylene Polypropylene can be recycled. This process would include different additives to bring back the PP in a raw material form suitable for a particular application. For example, recycled PP could be used to manufacture PP yarn. Recycled PP being cheaper, is a raw material option available to manufacture wound PP cartridges. Such cartridges would be available at lower prices and pose a better proposition to the buyer.

Applications like drinking water, food, beverages, pharmaceuticals, dialysis, etc. require cartridges manufactured using virgin grade PP only. Recycled PP could have additives that might cause cancer and other health hazards.

Conclusion

Filtration is an important process in any application. When it involves drinking water, the trade of supplying filters becomes a noble one. It is the moral responsibility of the manufacturer of the filter to provide standard products meeting necessary norms. At the same time, it is important for a customer to be educated and aware of the right product while having options to choose from.

Wound PP Cartridges of Brand N–Zo from GSE Filter Pvt Ltd

GSE Filter Pvt Ltd is a manufacturer of Wound PP Cartridge Filter, and these are popular under the brand name Nzo. These cartridges come with the below features:

- Manufactured using Virgin Grade PP Yarn and PP Core
- International Standard Dimensions
- Use of a selective absorption intelligent yarn to provide for higher efficiency and lower pressure drop
- Manufactured in different and authentic porosity levels
- Product tested and validated by IAPMO to achieve a 99% filtration efficiency in a 5 micron and 10–micron cartridge
- Product tested and validated by IAPMO to achieve a dirt holding capacity of 184.2 gms per 10", which is amongst the highest in the market.

Buyer/Seller: Rural Development Department
Tender Number: 2022_ NANDE_785391_16

Requirement: Constructing solid waste and waste water management at gokunda tq. kinwat dist

Tender Detail: Constructing solid waste and waste water management at gokunda tq. kinwat dist nanded

constructing solid waste and waste water management at gokunda tq. kinwat dist nanded

Document Fees: INR 6,000

EMD: INR 59,966

Tender Estimated Cost: INR 5,996,562

Closing Date: 23/04/2022

Document Sale To: 23/04/2022

Location: Nanded – Maharashtra – India

Contact Details: Rdd–Ceo–Nanded||nanded–Rws Gokunda Tq. Kinwat Dist Nanded

Buyer/Seller: Bahour Commune Panchayat
Ref. Number: 48684352

Tender Number: 2022_DLA_9633_1

Requirement: Providing waste water treatment plant for liquid waste management for irulancnandai pond in bahour commune, puducherry

Document Fees: INR 1,050

EMD: INR 148,419

Tender Estimated Cost: INR 7,420,940

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Location: Not Classified – Puducherry – India

Contact Details: Irulanchandai

Buyer/Seller: Rural Development Department
Ref. Number: 48770035

Tender Number: 2022_NANDE_785391_13

Requirement: Constructing solid waste and waste water management at tamsa tq. hadgaon dist

Tender Detail: Constructing solid waste and waste water management at tamsa tq. hadgaon dist nanded constructing solid waste and waste water management at tamsa tq. hadgaon dist nanded

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EMD: INR 82,190

Tender Estimated Cost: INR 8,219,011

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Buyer/Seller: Public Health And Engineering Department
Tender Number:2022_ PHED_371015_3

Requirement: Drinking water supply and hand wash arrangement with tube well fitted with submersible pump & motor including waste water disposal system at 56 nos. anganwadi centres in jangipara block under district under division, p.h.e. dte.

EMD: INR 190,157

Tender Estimated Cost: INR 9,507,848

Closing Date: 18/04/2022

Document Sale To: 18/04/2022

Location: Hooghly – West Bengal – India

Contact Details: Phe||central Circle (phe)||hooghly Division hooghly

Buyer/Seller: Rural Development Department
Tender Number: 2022_ NANDE_785391_7

Requirement: Constructing solid waste and waste water management at wadi tq. nanded dist nanded

Tender Detail: Constructing solid waste and waste water management at wadi tq. nanded dist nanded constructing solid waste and waste water management at wadi tq. nanded dist nanded

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Tender Estimated Cost: INR 9,618,246

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Buyer/Seller: Urban Administration And Development
Tender Number: 2022_UAD_192432_1

Requirement: Interception and diverson work of waste water and proposed treatment unit sewage and recycle arragement of the treated sewage from gatar ghat , mohan ghat and masura ghat nalla nearby katni river katni as per tender document

Tender Detail: Interception and diverson work of waste water and proposed treatment unit sewage and recycle arragement of the treated sewage from gatar ghat , mohan ghat and masura ghat nalla nearby katni river katni interception and diverson work of waste water and proposed treatment unit sewage and recycle arragement of the treated sewage from gatar ghat , mohan ghat and masura ghat nalla nearby katni river katni as per tender document

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EMD: INR 250,000

Tender Estimated Cost: INR 50,000,000

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Venue: Trade Centre, Tamilnadu, India
Website: www.waterexpo.in

Water India – Water Expo Pune
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Website: www.waterindia.net

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Website: www.eurasiaweb.com

World Environment Conference (WEC 22)
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Website: www.worldenvironment.in

Aquatech China
8–10 June, 2022
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Website: www.aquatechtrade.com

Water India Bangalore
9–11 June, 2022
Venue: Manpho Convention Centre, Nagware Ring Road, Bangalore, India
Website: www.waterindia.net

Indian Plumbing and Watertech Expo (IPW India)
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Venue: Delhi, India
Website: www.ipwindia.in

International Water and Wastewater Technology Show
4–6 August, 2022
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World Water Summit 2022
21–23 August, 2022
Venue: New Delhi, India
Website: www.worldwatersummit.in

Delhi Water Expo 2022
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