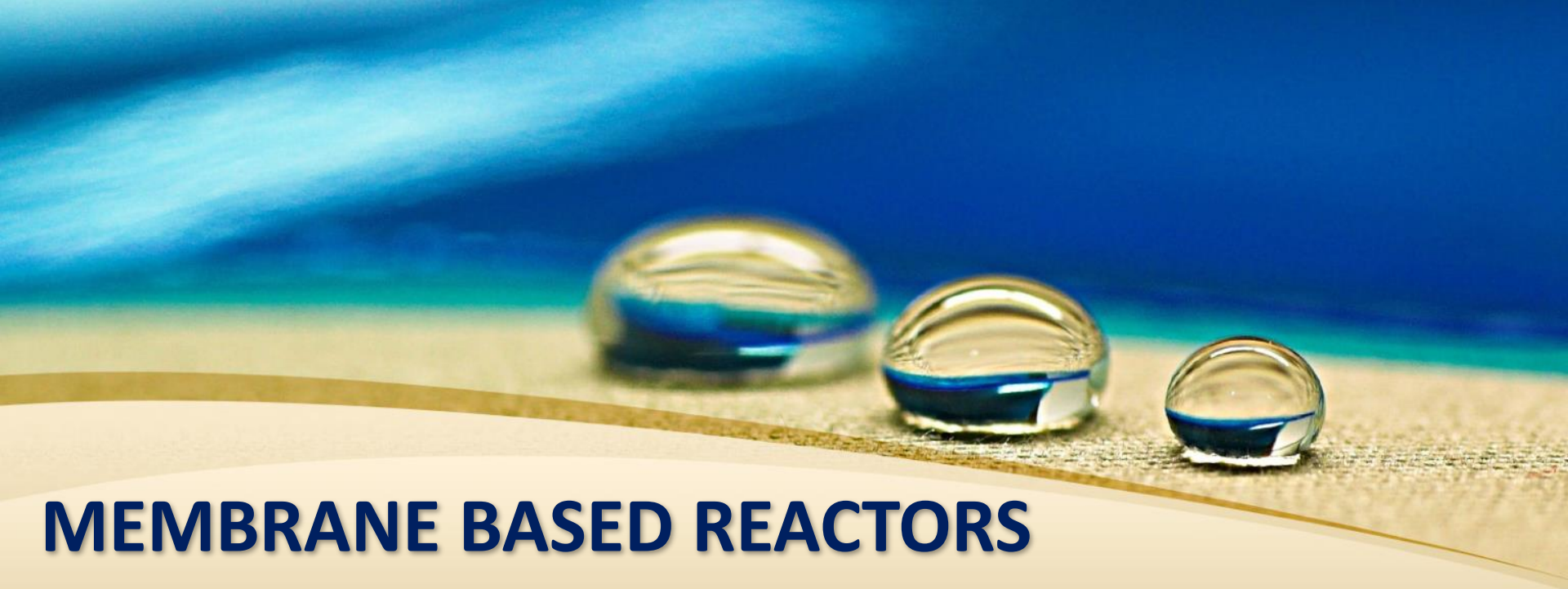

MEMBRANE BASED REACTORS for WASTEWATER TREATMENT

Ibnul Hasan Rizvi
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The Pakistan Academy of Engineering

Wastewater Treatment: a Critical Issue for Pakistan

- In Pakistan, domestic and industrial wastewater is discharged directly to a sewer system, a natural drain or a water body, a nearby field or an internal septic tank. Mainly, this wastewater needs to be treated.

Wastewater Treatment: a Critical Issue for Pakistan

- This practice poses a serious threat to human health and well-being. It is destroying the environment as untreated wastewater flows into the rivers, canals, lakes and even in the Arabian Sea, seriously compromising the massive potential of the blue economy for Pakistan.

Wastewater Treatment: a Critical Issue for Pakistan

- The United Nations Sustainable Development Goals (SDGs) are targets for global development adopted in September 2015, set to be achieved by 2030. All countries of the world, including Pakistan have agreed to work towards achieving these goals.
- There are 17 goals, the 6th goal is water & sanitation.

Wastewater Treatment: a Critical Issue for Pakistan

- Water is a scarce resource. Applying a Membrane Biotechnology Reactor (MBR) for Wastewater Treatment makes the wastewater reusable.

Mr. Naveed Ahmed Sheikh Program Manager, SDGs Support Unit Sindh, at the 27th Symposium at PAE presented the following Data:

- The proportion of wastewater safely treated, including municipal and industrial waste, was almost zero in 2017.
- Amongst 10,000 industries in Karachi, only 4500 are registered with the provincial environmental authority (SEPA)

Continued
Mr. Naveed Ahmed Sheikh Program Manager, SDGs

- The carrier of the effluents is:

  Lyari River – 59%

  Malir River – 25%

  Open Seacoast Via Gizri, Korangi & Gharo Creek. 15%

Continued
Mr. Naveed Ahmed Sheikh Program Manager, SDGs

- 283 MGD (million gallons per day) wastewater containing hazardous chemicals far exceeding the maximum limit is discharged without any treatment. This polluted water is used in agricultural activities along the

Continued
Mr. Naveed Ahmed Sheikh Program Manager, SDGs

- Wastewater treatment plants in Karachi are working much below the installed capacity. Out of the three, one is not functional (converted into a housing colony), while the other two combined work at approximately 50 % of the installed capacity.

Continued
Mr. Naveed Ahmed Sheikh Program Manager, SDGs

- Under the Greater Karachi Sewerage Plan (SIII), the existing plant will be upgraded to 100 MGD and 180 MGD, respectively, and a new one is being built in Korangi of 180 MGD. These are in addition to the smaller capacity wastewater treatment plants operated by DHA in Karachi.

Pakistan: getting more from water. World Bank 2019

- Water security is a significant and growing challenge for Pakistan. It influences diverse economic and social development aspects and national and regional security

Pakistan: getting more from water. World Bank 2019

- Pakistan has been blessed with a large water endowment and with extensive glacier storage that buffers supply variation, the vast increase in population and effects of climate change will push water demands even higher

Pakistan: getting more from water. World Bank 2019

- The challenges are further exacerbated by widespread pollution, degrading the available resources and seriously undermining public and environmental health.

Pakistan: getting more from water. World Bank 2019

- Pakistan cannot continue business as usual (BAU) water management. The speed at which it can tackle these challenges will have a strong bearing on the country's economic development rate and the quality of life it can offer its citizens.

Pakistan: getting more from water. World Bank 2019

- Poor sanitation costs are estimated at US$ 12 billion annually. Waterborne – diseases are a significant cause of suffering and death in Pakistan. Sewage effluents contaminate the water supply. Contaminated water and poor hygiene contribute to high childhood stunting, undermining human capital

Pakistan: getting more from water. World Bank 2019

- Heavy metal contamination especially cadmium and chromium are present in drinking water supplies. They cause headaches, joint pains, hypertension, renal disease, cancer, and diabetes.

Pakistan: getting more from water. World Bank 2019

- Effluents from marble, steel, and aluminium factories are the primary source of cadmium. Effluents from leather tanneries contribute to chromium. Industrial leaching of the lead causes lead levels to rise in surface and groundwater across Pakistan

Pakistan: getting more from water. World Bank 2019

- Sanitation infrastructure needs to be more robust. None of Pakistan's major cities has adequate sewerage or wastewater treatment capacity. The existing wastewater treatment facilities are not well maintained. Wastewater treatment capacity is only 8% of the wastewater load. Most of the urban sewage is discharged untreated into surface water bodies and used to irrigate crops. This pollutes the waterways and contaminates food supplies

Pakistan: getting more from water. World Bank 2019

- Most of Peshawar's sewerage, including three pumping stations, is unused because of poor maintenance. There are three wastewater treatment plants, but none are functional. Untreated effluent is discharged to rivers and canals and used to irrigate crops

Pakistan: getting more from water. World Bank 2019

- The Lahore sewerage system comprises 4,000 Km of underground sewers and 14 significant drains. There are no wastewater treatment facilities. Raw sewage from the drains is discharged into the Ravi River.
- Sanitation infrastructure in other large cities of Punjab is equally in poor condition as at Lahore.

Pakistan: getting more from water. World Bank 2019

- The Islamabad sewerage system has remained the same as the city has grown and is now overloaded. The recent audit indicates that treated effluents need to meet national standards

FAO(Food and Agricultural Organization) 2021

- Pakistan is one of the 36 most water-stressed countries in the world – withdrawing over 70 per cent of total renewable water resources. Pakistan's gross freshwater withdrawal is 74.4 per cent of the total renewable water resources - at a rate higher than the recharge.

FAO(Food and Agricultural Organization) 2021

- Excessive and extended abstraction of an aquifer is causing the fusion of the fresh and saline area and secondary salination. In addition, the degraded quality of ground and freshwater due to contamination by agricultural residues from fertilisers and pesticides and industrial and municipal effluents is another dimension of water scarcity faced by Pakistan.

FAO(Food and Agricultural Organization) 2021

- Toxic industrial and domestic effluent from India and Pakistan is dumped into the Ravi River, and about ten drains of the provincial capital release industrial and municipal waste are also dumped into it. More than 450 industrial units are pumping untreated toxic water into the drains at different points. EPA estimated, that more than 594 tons of organic load are discharged into the river Ravi daily.

FAO(Food and Agricultural Organization) 2021

- The untreated municipal and industrial waste from the District Peshawar, Mardan, Nowshera, and Charsaddah is being disposed of into different drains, which finally fall into the Kabul River.

FAO(Food and Agricultural Organization) 2021

- Fertilisers, pesticides, chemicals, heavy metals, and pathogens degrade the water quality and can cause adverse effects on human health. Fertilisers and pesticides used in agricultural areas are washed off and drained into surface and groundwater aquifers

FAO(Food and Agricultural Organization) 2021

- The waste water systems in urban areas contribute to water pollution by producing and conveying untreated municipal sewerage, which pollutes freshwater bodies and the drinking water supply. Water is affected qualitatively and quantitatively, making it hazardous for human use. The effects of deterioration are intensified as a large volume of untreated effluents from agricultural, industrial, domestic, and commercial areas enter into rivers.

Singapore is leading the Way in Recycling wastewater. What Can it Teach to the Rest of the World?

- Global treated wastewater reuse is estimated at 40.7 billion m^3 annually, representing approximately 11% of the total domestic and manufacturing wastewater produced.

Singapore is leading the Way in Recycling wastewater. What Can it Teach to the Rest of the World?

- Municipal wastewater reuse is exceptionally high in the Middle East and North Africa, in countries such as the UAE, Qatar, Kuwait and Israel

Singapore is leading the Way in Recycling wastewater. What Can it Teach to the Rest of the World?

- Using an advanced filtration and treatment system, Singapore is taking the “waste” out of its wastewater by turning sewage into safe, clean drinking water.

Singapore is leading the Way in Recycling wastewater. What Can it Teach to the Rest of the World?

- Once treated, the water is used extensively by industries like the island's large microchip manufacturing sector, which is heavily water dependent. It's also put to work in the cooling systems regulating temperatures in the tall buildings dominating the skyline

A missed Opportunity to tackle Wastewater Recycling in Sindh

- Supreme Court of Pakistan mandated a commission on water and sanitation in Sindh. This was triggered by the petition filed in the Supreme Court in 2016 by a citizen (Mr. Shahab Usto) with documentary evidence on the dire condition prevailing in Sindh.

A missed Opportunity to tackle Wastewater Recycling in Sindh

- Supreme Court appointed Justice Iqbal Kalhoro to investigate and report. Justice Kolhoro submitted his report on 14th July 2017
- The Supreme Court mandated a Commission under Justice (retired.) Amir Hani Muslim in January 2018, for one year. It expired on 15 January 2019.

A missed Opportunity to tackle Wastewater Recycling in Sindh

- On February 2020, the Commission was dissolved by the then Chief Justice, Mr. Gulzar Ahmad of the Supreme Court on February 2, 2020

Membrane Biotechnology Reactor(MBR)

- Membrane Biotechnology Reactor (MBR) is now a tried and commercially successful technology to recycle wastewater to a standard which can be reused. It can be used to treat municipal and industrial wastewater.

Membrane Biotechnology Reactor(MBR)

- MBR technology is now being used to treat wastewater in industries, hospitals, commercial buildings, and apartments, shopping malls, schools, and golf courses throughout the world to stop pollution and degradation of the environment and water resources and reuse every drop of water as it will be increasingly scarce and a valuable commodity.

Why use Membrane Biotechnology Reactor (MBR) to treat wastewater?

- MBRs produce a high-quality effluent that meets stringent regulatory standards.
- MBRs have smaller footprints compared to traditional wastewater treatment plants. There is a significant saving in space and cost associated with land acquisition, construction and operation.

Why use Membrane Biotechnology Reactor (MBR) to treat wastewater?

- MBRs produce less sludge than other treatment methods- reducing the cost of sludge transport and disposal.
- Better performance in variable effluent input- can achieve more consistent and reliable wastewater treatment performance.

Why Use Membrane Biotechnology Reactor (MBR) to treat wastewater?

- Lower operation costs in the long run. Although MBRs may have a higher initial capital cost than traditional wastewater treatment methods, they can be more cost-effective in the long run. This is because MBRs require less energy, chemicals, and maintenance compared to other methods.

Why Use Membrane Biotechnology Reactor (MBR) to treat wastewater?

- MBRs can help companies to comply with strict wastewater treatment regulations, which can help to avoid fines and legal disputes.

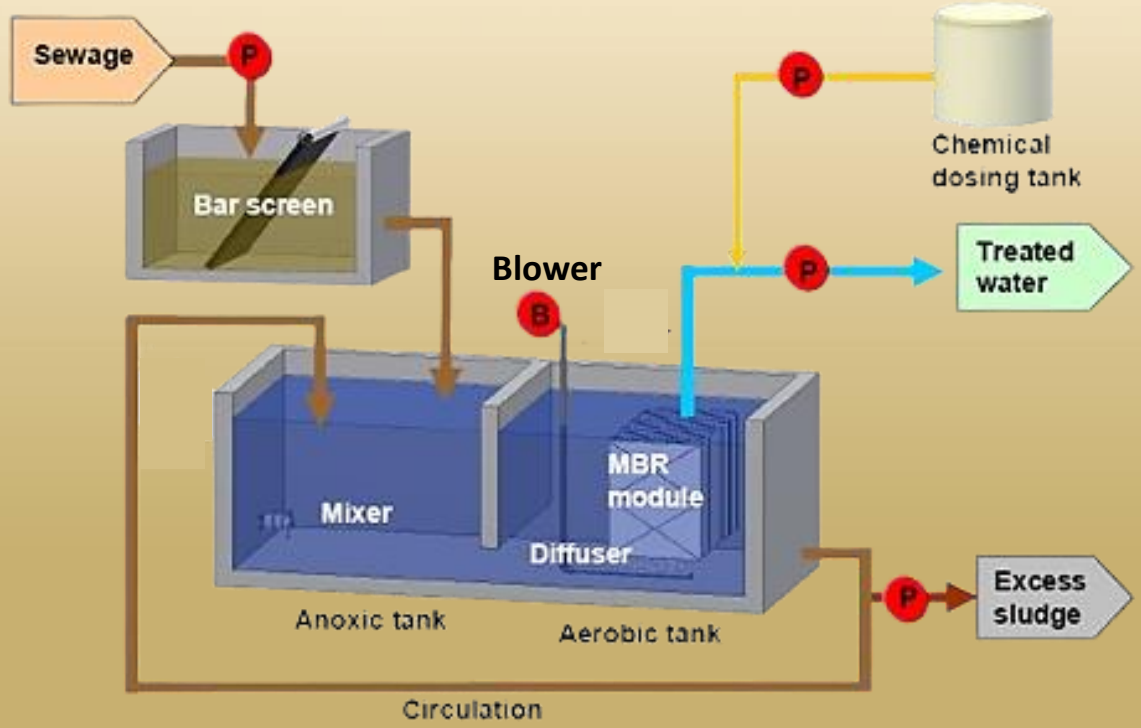
Why Use Membrane Biotechnology Reactor (MBR) to treat wastewater?

- MBRs can be easily expanded or modified to accommodate changes in industrial processes or wastewater volumes, making them a flexible and scalable solution for industrial wastewater treatment.

Membrane Biotechnology (MBR) Process

- The technology of membrane separation of activated sludge, referred to as membrane bioreactor (MBR), is the combination of two processes, activated sludge treatment together with a break of biological sludge by micro or ultra-filtration membranes with a pore size of typically 10 nm to 0.5 nm to produce the particle-free effluent.

Membrane Biotechnology (MBR) Process



Membrane Biotechnology (MBR) Process

The process typically includes the following steps:

- Pre-Treatment: Wastewater enters the MBR system through a screen or grit chamber to remove large solids and debris.

- Biological Treatment: The wastewater is then sent to an aerobic bioreactor tank where microorganism breaks down organic matter into simpler substances like carbon dioxide and water. The organism in the bioreactor consumes the organic matter, reducing the wastewater's biochemical oxygen demand (BOD) and total suspended solids (TSS).

Membrane Biotechnology (MBR) Process

- Membrane Filtration: The wastewater is filtered through a membrane system after the biological treatment. There are two types of membrane filtration systems: immersed and side-streamed. Immersed membranes are submerged in the bioreactor tank. The membranes have a pore size of fewer than 0.1 microns, allowing them to filter out bacteria, viruses, and other particles effectively.

Membrane Biotechnology (MBR) Process

- Disinfection: After the membrane filtration, the treated wastewater is disinfected to kill any remaining pathogens. This can be done through chemical disinfection using chlorine, ultraviolet (UV) radiation, or ozone.

Membrane Biotechnology (MBR) Process

- Effluent discharge: The final step is to discharge the treated wastewater into a water body or reuse it for non-potable purposes.

Capital & Operating Cost of Membrane Bioreactors (MBR)

- The capital expenditure (CAPEX) cost of a membrane bioreactor (MBR) for wastewater treatment can vary depending on several factors, such as the plant's size, location, the cost of labour, and the technology used.

Capital & Operating Cost of Membrane Bioreactors (MBR)

- The typical CAPEX cost of an MBR system for wastewater treatment is between $ 3,500 to $ 6,000 per cubic meter of capacity

Capital & Operating Cost of Membrane Bioreactors (MBR)

- The other factor affecting the CAPEX cost of MBR for wastewater treatment includes the type and quality of membrane material used, the type of biological process employed, the system's energy efficiency, and the system design's complexity.

Capital & Operating Cost of Membrane Bioreactors (MBR)

- Initial CAPEX cost of MBR for wastewater treatment may be higher than traditional wastewater treatment technologies; MBRs offer several benefits, including higher treatment efficiency, smaller footprint, and lower operating costs over the long run.

Capital & Operating Cost of Membrane Bioreactors (MBR)

- The operating cost (OPEX) of a Membrane Bioreactor (MBR) for wastewater treatment can vary depending on several factors, such as the size of the plant, the type of membrane used, energy and chemical consumption, labour cost and maintenance expenses

Capital & Operating Cost of Membrane Bioreactors (MBR)

- The OPEX of an MBR for wastewater treatment can be divided into the following categories.
- Energy Consumption: This includes the cost of electricity required for pumps, blowers, and other equipment used in the process. Air scouring is used extensively to reduce membrane fouling, raising the cost of energy. Energy costs comprise 27 to 34% of the total operating expense (OPEX). The energy consumption of treated wastewater can range from 0.3 to 1.5 kWh/m^3.

Capital & Operating Cost of Membrane Bioreactors (MBR)

- Chemical Consumption: This includes the cost of chemicals such as disinfectants, coagulants, and flocculants used in the process. The chemicals required vary depending on the influent wastewater's quality and the treated water's specific requirement.

Capital & Operating Cost of Membrane Bioreactors (MBR)

- Membrane Replacement: Over time, the membrane used in an MBR system will need to be replaced. The replacement cost can vary depending on the type and quality of the membrane.

Capital & Operating Cost of Membrane Bioreactors (MBR)

- Labour Cost: This includes the cost of skilled operators for operating and maintaining the process

Capital & Operating Cost of Membrane Bioreactors (MBR)

- Maintenance Expenses: This includes maintaining and repairing the equipment used. The cost can vary depending on the age and condition of the equipment.

Major Manufacturers of Membrane Bioreactors (MBR)

- Siemens/ U.S. Filter Systems
- Zenon Systems
- Kubota Membranes
- Beijing Origin Water Technology Co. Ltd.
- Toray Industries
- Samsung Engineering
- XYLEM
- Veolia Water Technologies:
- Huber Technology is a German company

The main characteristics due to which the MBR technology is expanding are:

- Astonishing class of reclaimed water
- Growing scarcity of water
- The progressively severe regulation for the best quality of effluent from wastewater.

The main characteristics due to which the MBR technology is expanding are:

- Reducing the capital investment
- Technology acceptance
- Potential for the advancement of present plants.