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Wastewater Recycling by Membrane Applications – An Environmental Friendly Solution

Engineering

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ABSTRACT

Water-related problems are increasingly recognized as one of the most immediate and serious environmental threats to humankind and water reuse is a partly solution for this problem. Also reusing water and especially wastewater manifolds the benefits. Company can reduce water consumption and treatment needs, with associated cost savings. Wastewater reclamation with membrane filtration techniques has gained increasing popularity in many regions over the world. These techniques are referred as environmentally sound technologies because they help to protect the environment and are less polluting. Membrane process technology helps to meets the stringent requirements for discharge or is acceptable for reuse. It is also environmental friendly techniques as it is not generating any pollution.

Introduction [9], [10]

Water use has more than tripled globally since 1950, and one out of every six persons does not have regular access to safe drinking water. Lack of access to a safe water supply and sanitation affects the health of 1.2 billion people annually (WHO and UNICEF, 2000[10]. The latest Global Environment Outlook of the United Nations Environmental Programme (UNEP)[10] reports that about one third of the world's populations currently live in countries suffering from moderate-to-high water stress, where water consumption is more than 10% of renewable freshwater resources. These problems may be attributed to many factors. Inadequate water management is accelerating the depletion of surface water and groundwater resources.

Water quality has been degraded by domestic and industrial pollution sources as well as non-point sources. In some places, water is withdrawn from the water resources, which become polluted owing to a lack of sanitation infrastructure and services. Over-pumping of groundwater has also compounded water quality degradation caused by salts, pesticides, naturally occurring arsenic, and other pollutants. In urban areas, demand for water has been increasing steadily, owing to population growth, industrial development, and expansion of irrigated agriculture land. Population growth in urban areas is of particular concern for developing countries. Many parts of the world are facing changes in climatic conditions, such as rainfall patterns, flood cycles, and droughts, which affect the water cycle.

Faced with these challenges, there is an urgent need to improve the efficiency of water consumption, and to augment the existing sources of water with more sustainable alternatives. Numerous approaches, modern and traditional, exist throughout the world for efficiency improvements and augmentation.

Among such approaches, wastewater reuse has become increasingly important in water resource management for both environmental and economic reasons. Wastewater reuse has a long history of applications, primarily in agriculture, and additional areas of applications, including industrial, household, and urban, are becoming more prevalent.

Environmentally Sound Technologies (ESTs) encompass technologies that have the potential for significantly improved environmental performance relative to other technologies. Broadly, these technologies protect the environment, are less polluting, use resources in a sustainable manner, recycle more of their wastes and products, and handle all residual wastes in a more environmentally acceptable way than the technologies for which they are substitutes. The adoption and use of ESTs carefully considers both human resource development and local capacity building.

Wastewater treatment by reverse osmosis leads to water that is clean enough for reuse within the factory. Reverse osmosis can handle high TDS (total dissolved solids) level and the combination of reverse osmosis with spiral wound element is appropriate for existing wastewater.

Water Recycling [9]

While recycling is a term generally applied to aluminum cans, glass bottles, and newspapers, water can be recycled as well. Water recycling is reusing treated wastewater for beneficial purposes such as agricultural and landscape irrigation, industrial processes, toilet flushing, and replenishing a ground water basin (referred to as ground water recharge). Water is sometimes recycled and reused onsite; for example, when an industrial facility recycles water used for cooling processes. The term water recycling is generally used synonymously with water reclamation and water reuse.

Through the natural water cycle, the earth has recycled and reused water for millions of years. Water recycling, though, generally refers to projects that use technology to speed up these natural processes. Water recycling is often characterized as "unplanned" or "planned."

A common example of unplanned water recycling occurs when cities draw their water supplies from rivers. Water from these rivers has been reused, treated, and piped into the water supply a number of times before the last downstream user withdraws the water.

Planned projects are those which are developed with the goal of beneficially reusing a recycled water supply. Using water more than once is an effective strategy in overcoming the water needs of developed and developing nations, especially in arid and drought stricken areas and should be given high priority and taken seriously because, in reality, there is no new water on our horizon.

Why to Recycle Water [9]

Increased water demand

Water consumption has been increased since last few years because of

1. Urbanization & industrialization
2. Reduced rain falls
3. Depletion in natural water resources.

Prevention of water pollution

1. Disposal of inadequately cleaned wastewater contaminates other fresh water resources.
2. The waste water generating company will recycle water properly only if they are forced to generate their fresh water re-

source from the waste water generated by them.
3. It is economical to use recycled water than to pay for consuming fresh water & wasting waste water.

Social Obligation
1. Inadequately treated wastewater may damage your own health and (health of your relatives, friends) the surrounding in general.
2. Damaged nature around you will bring down your own quality of living.

Benefits to the unit
Water Can be used in boiler and cooling towers.

Sometimes Water can be used as potable distilled water. This saves- Fresh raw water cost, Water treatment costs, Boiler & cooling water blow down losses, Greatly reduced heat exchanger fouling increases productivity and energy efficiency, Lowers cost of production.

Reduces likely public liability costs.

Promotes public goodwill 'brand' image and recognition in society. This increases share value, Employee motivation & self-esteem, Business growth.

Improves productivity due to better health of employees and their attendance. Employee motivation and pride in their job.

It is environment friendly. Hence no effluent disposal cost & no objection from Pollution Control department.

Description of Technology [3], [5], [6]
Water reclamation and desalination with membrane filtration techniques have gained increasing popularity in many regions over the world. Membrane technology can be used to treat raw water making it pure enough to be used for a variety of purposes. It can also treat industrial wastewaters to meet stringent discharge regulations. In many cases, membranes can produce treated wastewater that is clean enough for reuse within the factory. In membrane filtration the range of particle sizes is extended to include dissolved constituents (typically .0001 to 1.0 μm) [5].

During the past decade, the utilization of membrane-based separation processes has been under active development in dyestuff industries. This particular technology has progressed to the point of producing high-quality wastewater, which either satisfactorily meets the stringent requirements for discharge or is acceptable for reuse.

Membrane process technology [2], [5]
Membrane processes are modern physicochemical separation techniques that use differences in permeability (of water constituents) as a separation mechanism. During membrane treatment, water is pumped against the surface of the membrane resulting in the production product and waste stream (fig.1)[5]. The membrane typically a synthetic material less than 1 mm thick, is semi permeable – meaning that is highly permeable to some components in the deed stream and less permeable (or impermeable) to other.

During operation, permeable components pas through the membrane and impermeable components are retained on the feed side. As a result, the product stream is relatively free of impermeable constituents and the waste stream is concentrated in impermeable constituents.

The influent to the membrane module is known as the feed stream (also known as feed water). The liquid that pass through the semi permeable membrane is known as permeate (also known as product stream or permeating stream) and the liquid containing the retained constituents is known as the concentrate (also known as retentate, reject, and retained phase or water stream). The rate at which the permeate flows though the membrane is known as the rate of flux.

Membrane process mainly includes
Microfiltration (MF),
Ultra filtration (UF),
Nano filtration (NF),
Reverse Osmosis (RO)

The general characteristics of membrane processes including typical operating ranges are reported in table 1. For this particular application reverse osmosis is selected because it can sustain at high TDS concentration as mentioned earlier.

Membrane Process	Membrane driving force	Typical separation mechanism	Typical Operating range, μm	Permeate Description	Typical Constituents
Microfiltration	Hydrostatic pressure difference	Sieve	0.08-2.0	Water + dissolved solutes	TSS, turbidity, protozoan oocysts and cyts, some bacteria and virus
Ultrafiltration	Hydrostatic pressure difference	Sieve	.005-0.2	Water + small molecules	Macromolecules, collides, bacteria, proteins
Nanofiltration	Hydrostatic pressure difference	Sieve + solution/diffusion	.001-.01	Water + very small molecules	ionic solutes Small molecules, viruses, some hardness
Reverse Osmosis	Hydrostatic pressure difference	Sieve + solution/diffusion	.0001-.001	Water, very small molecules, ionic solutes	Very small molecules, color, hardness, sulfates, nitrate, sodium, other ions

Table 1: – General characteristics of membrane processes. [5]

Reverse osmosis [1], [5], [6]
When two solutions having different solute concentration are separated by a semi permeable membrane, a difference in chemical potential will exist across the membrane. Water will tend to diffuse through the membrane from the lower concentration (higher potential) side to the higher concentration (lower potential) side. In a system having a finite volume, flow continues until the pressure difference balances the chemical potential difference.

This balancing pressure difference is termed the osmotic pressure and is a function of the solute characteristics and concentration and temperature. If a pressure gradient opposite in direction and greater than the osmotic pressure is imposed across the membrane, flow from the more concentrated to less concentrated region will occur and is termed reverse osmosis.

Membrane Configurations and Fouling [5], [8]
In the membrane field, the term module is used to describe a complete unit comprised of the membranes, the pressure support structure for the membranes, the feed inlet and outlet permeate and retentate ports, and an overall support structure. The principal types of membrane modules are

1) Tubular,
2) Hollow fiber, and
3) Spiral wound.

Membrane fouling [6]
The term fouling is used to describe the potential deposition

and accumulation of constituents in the feed stream on the membrane. Membrane fouling is an important `consideration in the design and operation of membrane systems as it affects pretreatment needs, cleaning requirements, operating requirements, cost, and performance. Constituents in wastewater that can bring about membrane fouling are identified in Table 2.

Types of Membrane Formation	Responsible Constituents	Remarks
Fouling (cake formation sometimes identified as biofilm formation)	Metal oxides, Organic and inorganic colloids, Bacteria, Microorganisms, Concentration polarization	Damage to membrane can be limited by controlling these substances
Scaling (Precipitation)	Calcium sulfate, Calcium carbonate, Calcium fluoride, Barium sulfate, Metal oxide formation, Silica	Scaling can be reduced by limiting salt content, by adding acid to limit the formation of calcium carbonate, and by other chemical treatments (e.g. the addition of anti scalants)
Damage to membrane	Acids, Bases, pH extremes, free chlorine, Bacteria, Free oxygen	Damage to membrane can be limited by controlling these substances. Extent of damage depends on the nature of the membrane

Table 2- Membrane Fouling [3], [5]

Conclusion

Recognizing that water-related problems are one of the most important and immediate challenges to the environment and public health, it is important to act now. Water scarcity and water pollution are some of the crucial issues that must be addressed within local and global perspectives. One of the ways to reduce the impact of water scarcity as well as minimizing water pollution is to expand water and wastewater reuse. Simultaneously wastewater recycling have tendency to give certain benefits. Reverse osmosis is considered environmentally sound technology(EST).

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