INDUSTRY INTERACTION SESSION 2021

MRC FUND FOR AUTOMATION & GREEN TECHNOLOGY

‘Green Technology to Purify Treated Wastewater & Harvested Rainwater as Process Water for Raw Rubber Processing and Rubber Products Manufacturing’

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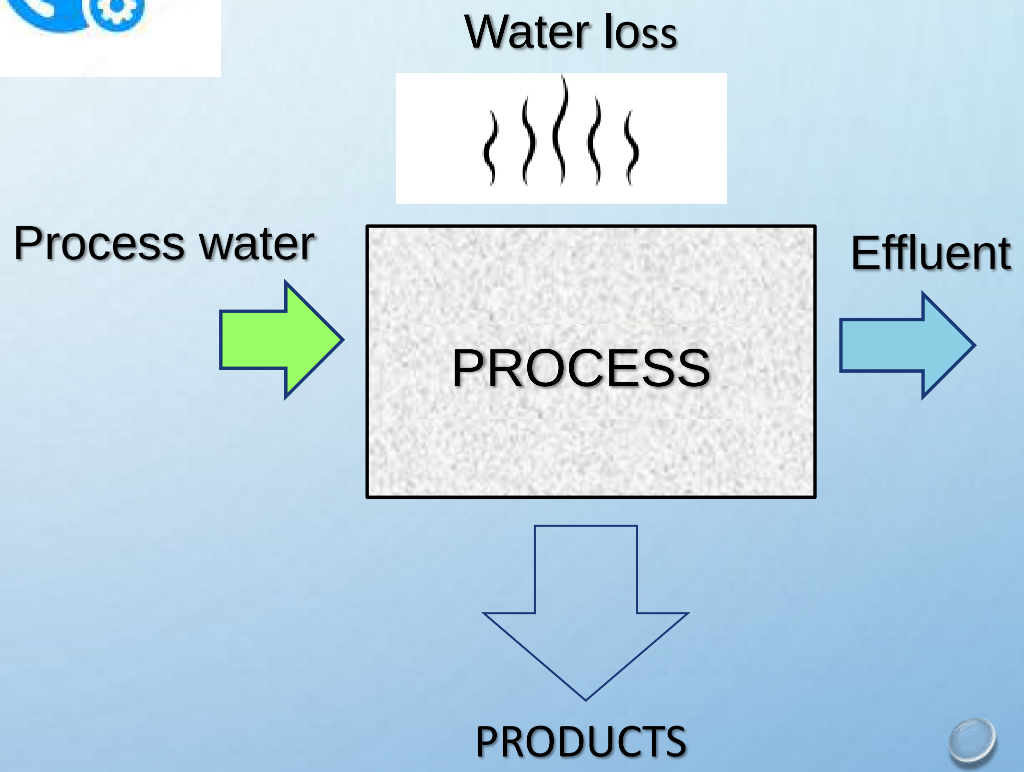
Presentation Outline

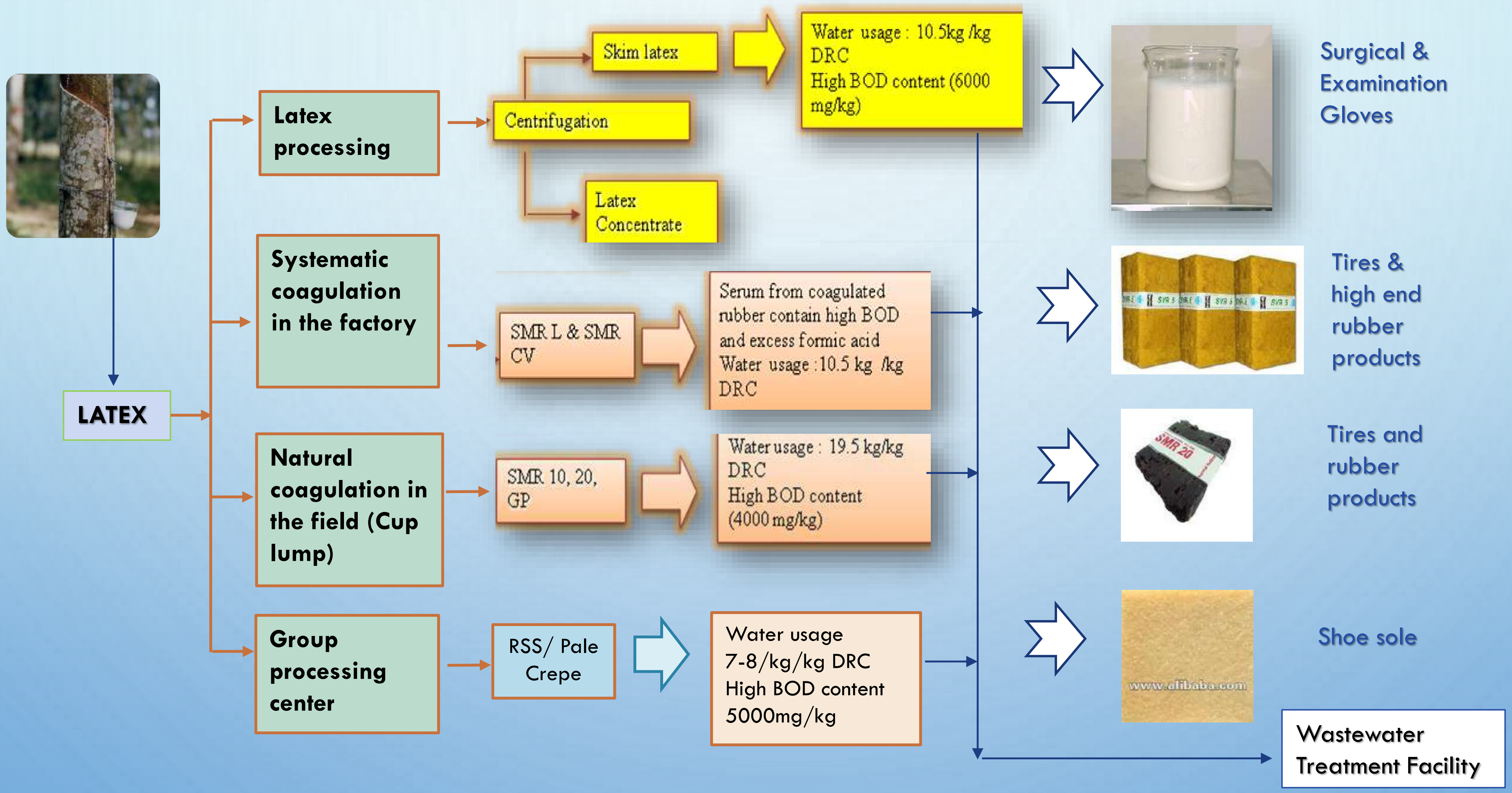
- Industrial Process Water
- Process Water Usage in Raw Rubber Processing and Glove Manufacturing
- Wastewater Treatment Systems
- Membrane Separation Technology for Treated Wastewater Recycling
- Global Wastewater Recycling Scenario
- Rainwater Harvesting and Purification & Required Criteria for Green Technology
- MRC Green Technology Fund for Water Purification & Scoring Guide

Industrial Process Water

- It is a common name for water which cannot be classified as drinking water.
- It is basically used in relation to industrial plants, industrial processes and production facilities.
- Process water has undergone extensive treatments, e.g., softening and demineralization. Treated to suit the designated industry.
- Depending on the process, however, the quality of the water may vary significantly.
- In order to use water of the required quality, it is essential to measure and monitor all the chemical, physical, microbiological and organoleptic parameters that affect the operation of a plant and the quality standards of the final product.



Process Water Requirement for Raw Rubber Processing



Glove Manufacturing Line & Process Water Usage

Public Utility Board Water Supply

Total Volume of WW

>130,000m^3/day*

WW

Latex

Chemicals

Latex compounding

Wastewater: WW

Former cleaning → Coagulant dipping → Latex dipping → Leaching → Stripping → Packaging

WW Treatment Facility

Treated WW

*Estimated figures based on Malaysian Rubber Statistics 2019 (Malaysian Rubber Board)

Daily Process Water Requirement & Wastewater Discharge

STREAMS	IMPORTANT ACTIVITY	WATER REQUIREMENT (m^3/day)	SOURCE	*WASTEWATER (m^3/day)
Mid-Stream	Raw Rubber Processing	>60,000*	Public Utility/River	50,000 -55,000
Down Stream	Latex Products Manufacturing	>150,000*	Public Utility	100,000 – 130,000

Malaysia supplies 65 percent of the world market for rubber gloves (300 billion pieces) and recording 52.7-billion-ringgit (US$12.7 billion) worth of glove exports in 2020.

Source: ASEAN Briefing (6-9-2021) Dezan Shira & Associates)

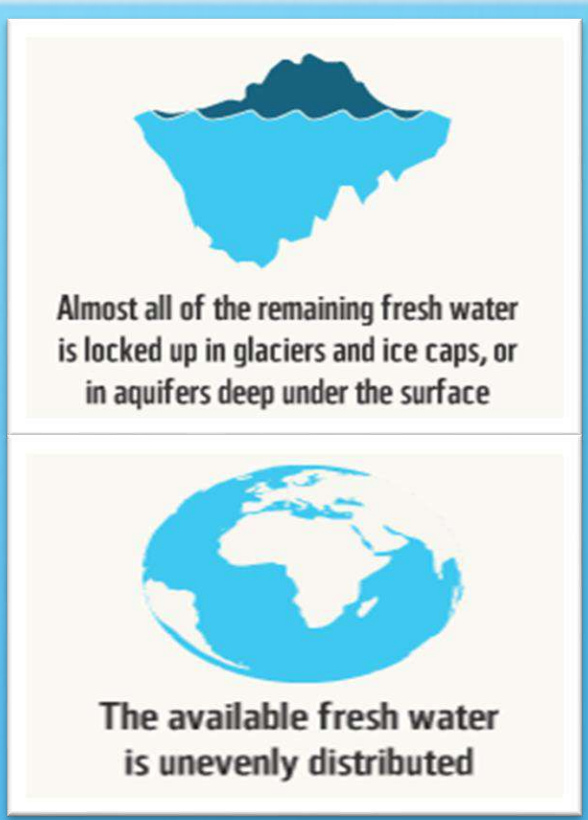
Glove manufacturing effluent

Anaerobic/Facultative Ponding System (raw rubber processing effluent)

Estimated figures based on Malaysian Rubber Statistics 2019(Malaysian Rubber Board)

Availability of Freshwater

- 97% of the water on the Earth is salt water and only three percent is freshwater; slightly over two thirds of this is frozen in glaciers and polar ice caps.
- The remaining unfrozen freshwater is found mainly as groundwater, with only a small fraction present above ground or in the air.
- Fresh water is a renewable resource, yet the world's supply of groundwater is steadily decreasing, with depletion occurring most prominently in Asia.



The Need for Alternative Process Water Source

- There would be acute shortage of water with the rapid increase of population as the surface water resources would be just enough for potable water and farming.

- More and more rivers and lakes would become intake points for public utility water supply(PUWS). Industries would face resistance to use rivers as process water source, or to discharge treated wastewater.

- Industries would be heavily dependent on PUWS and competing with potable water for its process water needs.

- Continuous increase in public utility water tariff (varies from state to state) would cause increases in the production cost and could affect sustainability of the industry.

- Over dependency on public utility water supply during dry spells led to water rationing (2013-2014), which interrupted the production and resulted in revenue losses

Therefore, an alternative process water source is of utmost importance to be in control of its supply; to maintain continuous production; possibly cost savings leading to additional revenue..

Available Technologies

- Wastewater Treatment Systems
- Membrane Separation Technology for Purification of Treated Wastewater
- Rainwater Harvesting and Purification

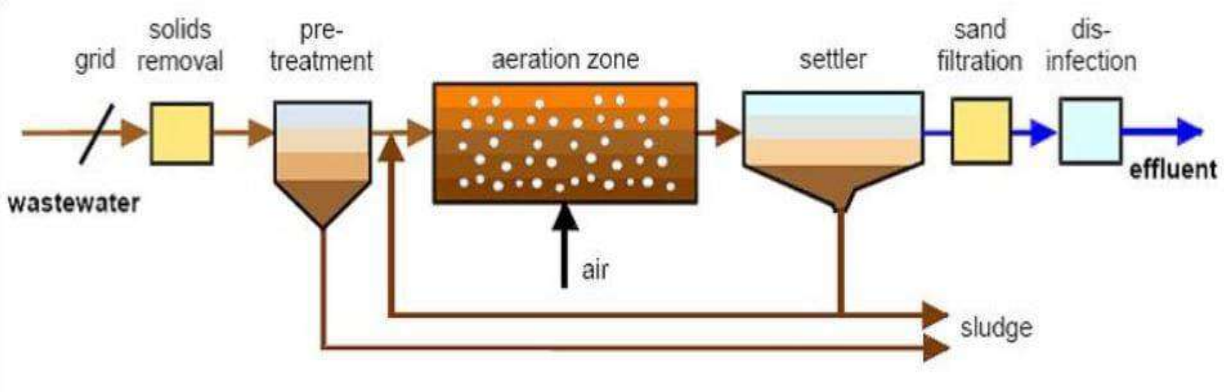
Wastewater Treatment Systems

Pre-treatment + Chemical + Primary Clarifier
- Pre-treatment: Equalization Tank
- Chemical: pH Adjustment + Coagulation + Flocculation
- Primary Clarifier

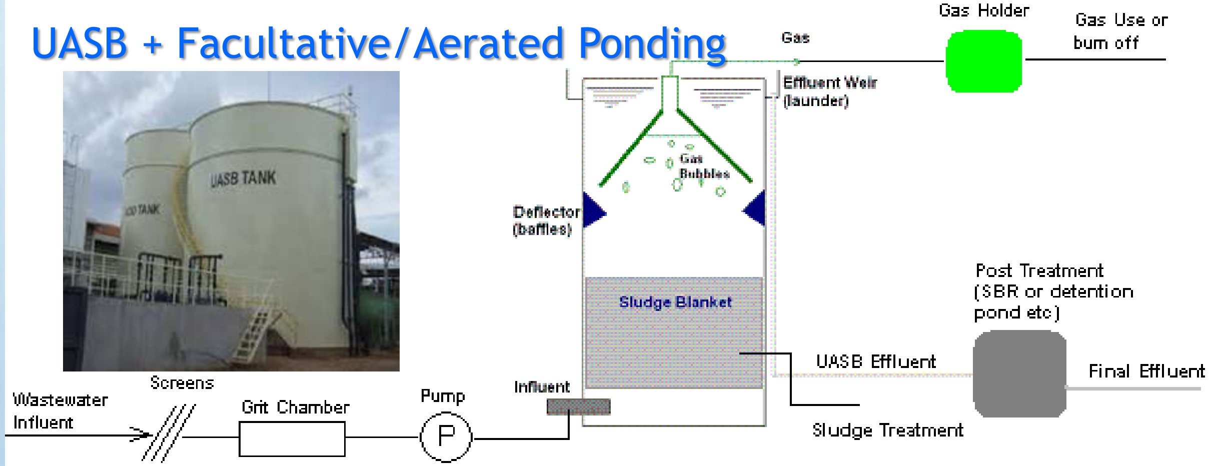
Biological Treatment System
(to reduce BOD, COD, Ammoniacal & Nitrate Nitrogen, and Suspended Solids)
- Activated Sludge System
- Sequential Batch reactor
- UASB + facultative/aerated ponding

Secondary Clarifier & Discharge

Activated Sludge System

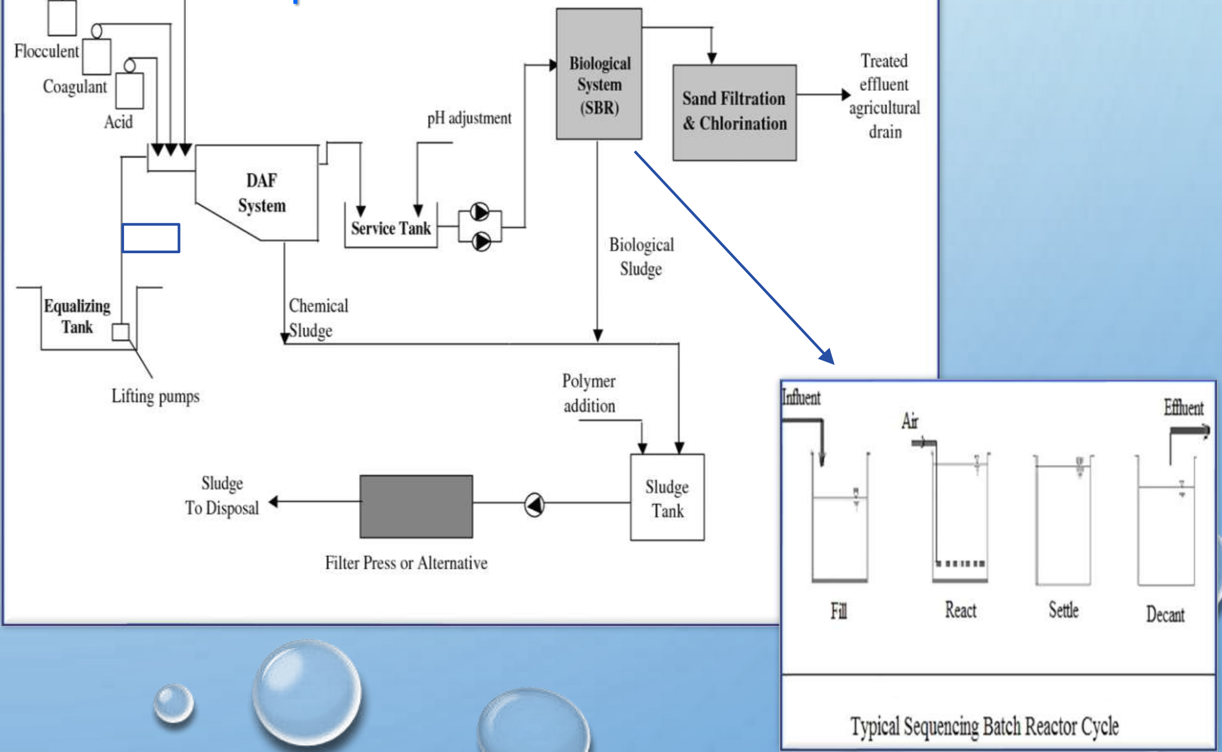


UASB + Facultative/Aerated Ponding



- High COD removal maintaining a granular sludge
- Biomass in the reactor has large settling area and compact design.
- Savings in operational costs as no energy is required for aeration
- Energy recovery from CH_4 produced to generate electricity
- Reductions in investment cost as less treatment units are required
- Smaller footprint and tall reactor design
- Can handle periodic high hydraulic and organic loading rates.
- Low sludge production does not require extensive post-treatment

Sequential Batch reactor

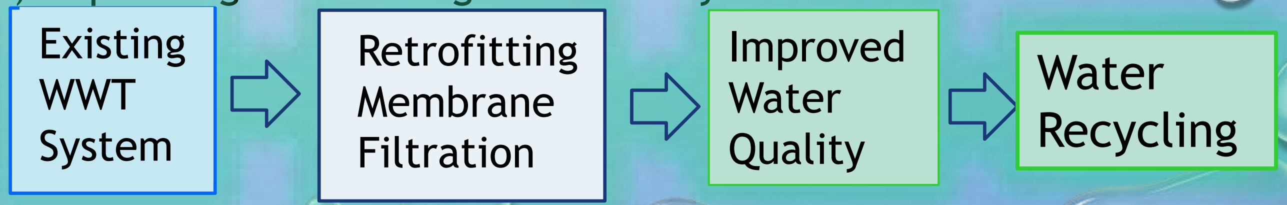


Industrial Effluent Discharge Standard, 2009

Parameter	Unit	Standard	
		A	B
Temperature	°C	40	40
pH Value	-	6.0-9.0	5.5-9.0
BOD at 20°C	mg/L	20	50
Suspended Solids	mg/L	50	100
Mercury	mg/L	0.005	0.05
Cadmium	mg/L	0.01	0.02
Chromium, Hexavalent	mg/L	0.05	0.05
Chromium, Trivalent	mg/L	0.20	1.0
Arsenic	mg/L	0.05	0.10
Cyanide	mg/L	0.05	0.10
Lead	mg/L	0.10	0.5
Copper	mg/L	0.20	1.0
Manganese	mg/L	0.20	1.0
Nickel	mg/L	0.20	1.0
Tin	mg/L	0.20	1.0
Zinc	mg/L	2.0	2.0
Boron	mg/L	1.0	4.0
Iron (Fe)	mg/L	1.0	5.0
Silver	mg/L	0.1	1.0
Aluminium	mg/L	10	15
Selenium	mg/L	0.02	0.5
Barium	mg/L	1.0	2.0
Fluoride	mg/L	2.0	5.0
Formaldehyde	mg/L	1.0	2.0
Phenol	mg/L	0.001	1.0
Free Chlorine	mg/L	1.0	2.0
Sulphide	mg/L	0.50	0.50
Oil and Grease	mg/L	1.0	10
Ammoniacal Nitrogen	mg/L	10	20
Colour	ADMI*	100	200

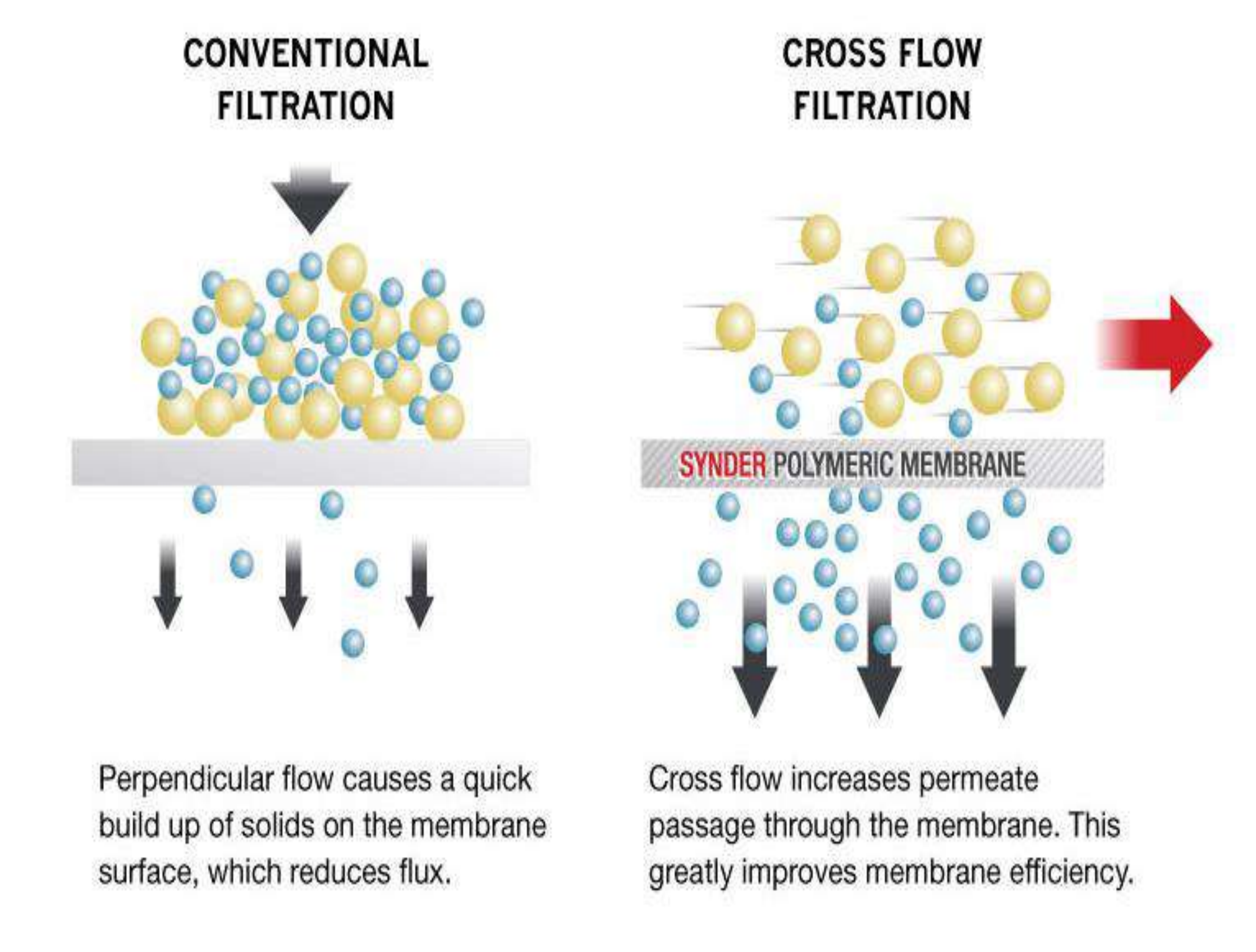
- Treated wastewater is mandatory to comply to either Standard A or B, determined by DOE.
- To undergo advance tertiary treatment process (ATTP) by membrane separation processes, TWW ideally has to comply to Standard A and Total Dissolved Solids < 500ppm. Complying to Standard B, needs additional treatment.

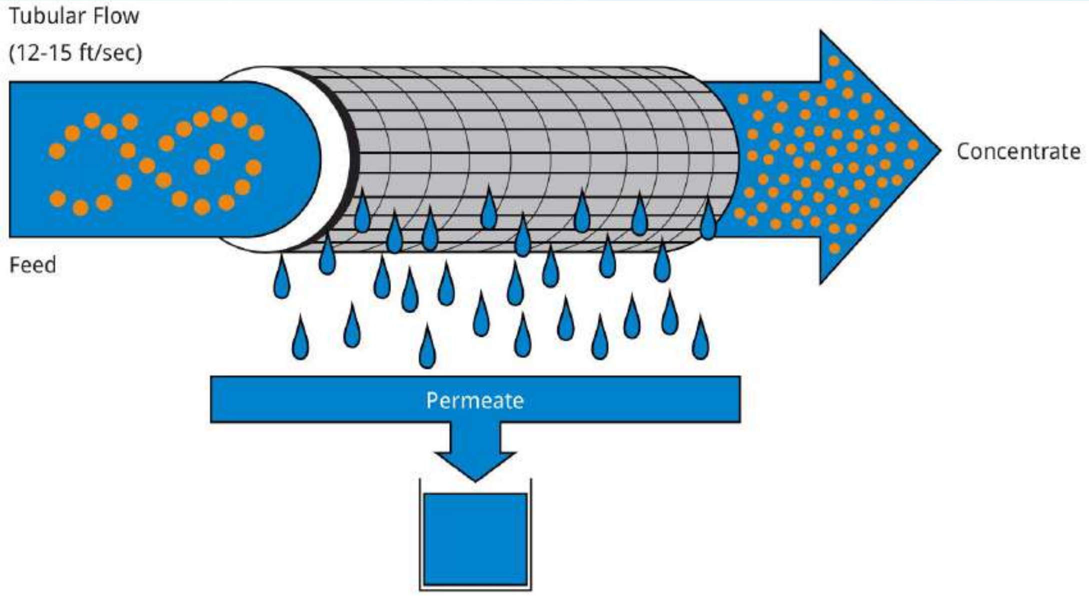
- ATTP can be incorporated into the existing WWT system to improve water quality
- This tertiary process could enhance treated wastewater recycling
- Membrane separation process is an ideal advance tertiary treatment process
- Various membrane separation processes are available (MF, UF, NF and RO) depending on the usage of the recycled water.

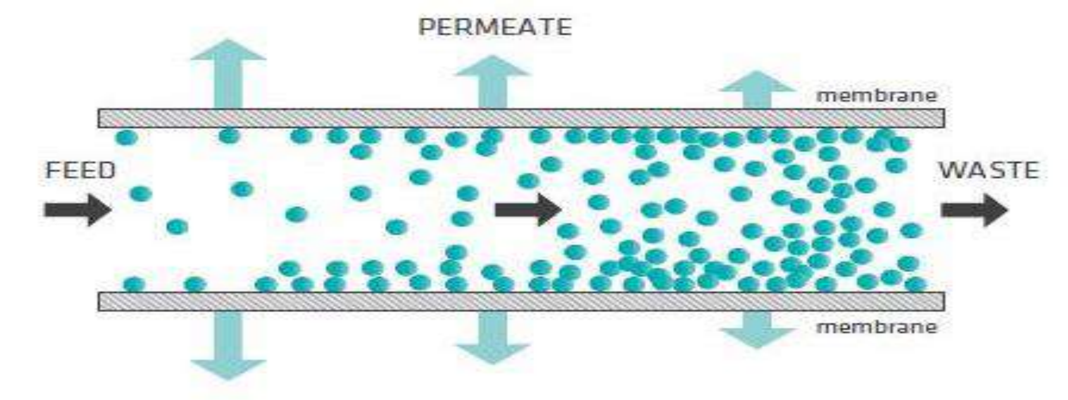


Membrane Separation Process

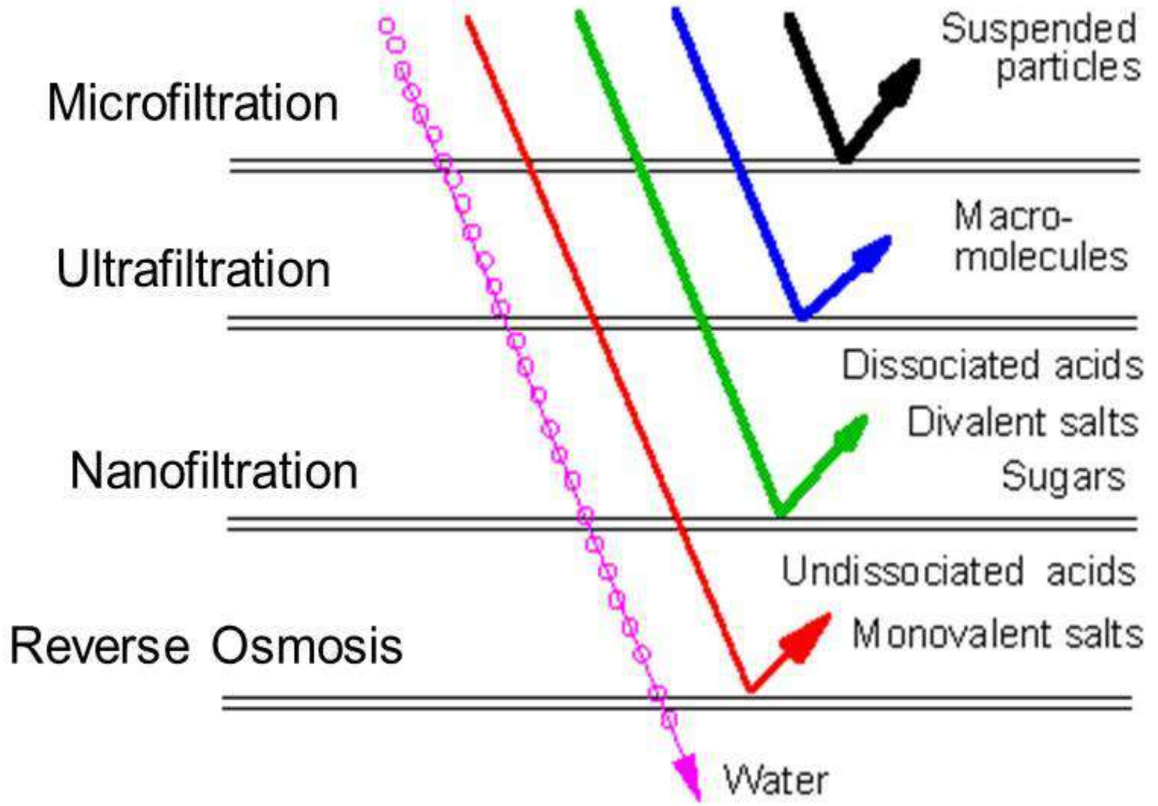
Conventional Flow and Cross flow filtration





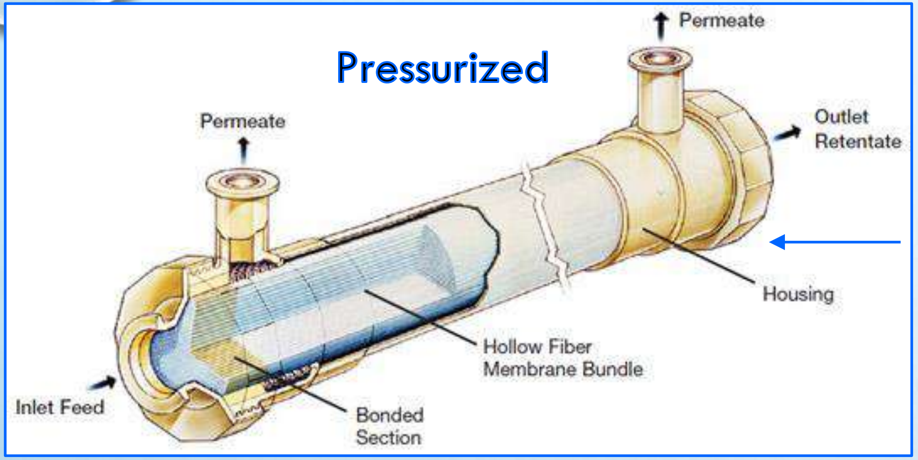


Membrane Separation Process Classification



Rejection illustration	Retention	Pressure (Bar)
	>0.01µm <5µm size particle	0.5 – 3.0
	0.01 to .001µm size particle	5.0 - 15
	>95% <50% NaCl solution	8 - 40
	>90% NaCl Solution	30 - 60

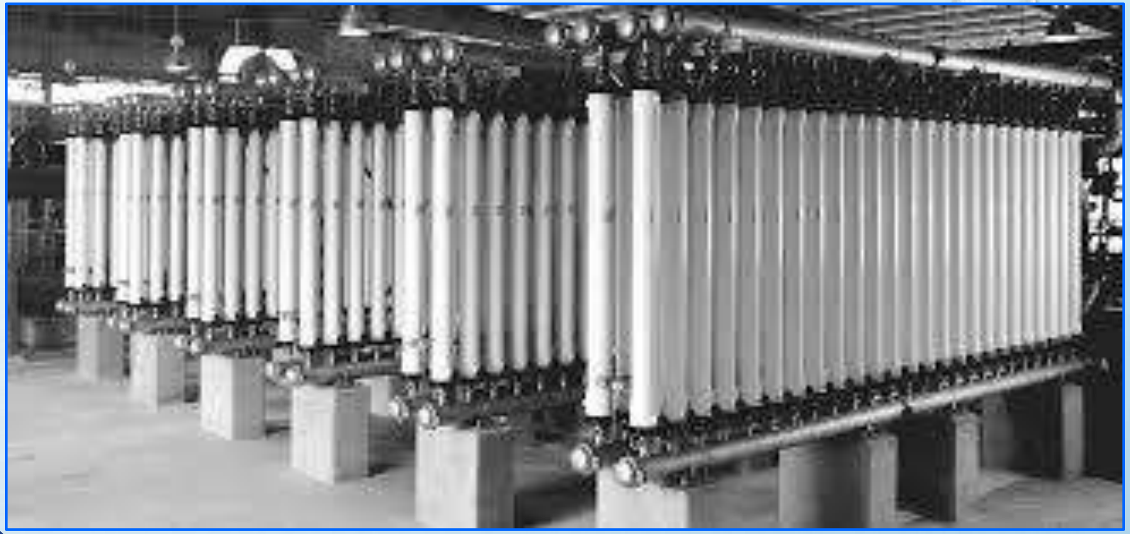
Membrane Modules Configuration for Industrial Application

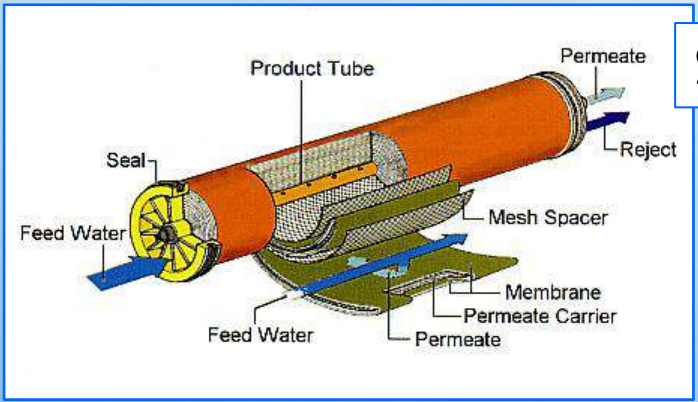


Pressurized

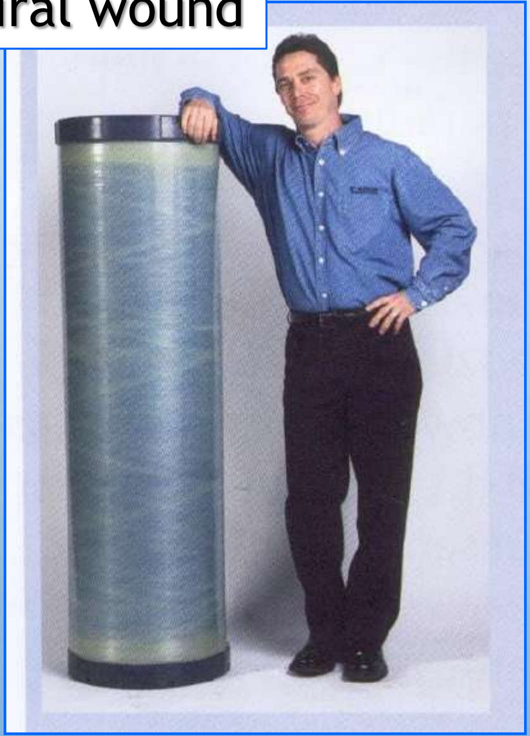
Hollow-fiber

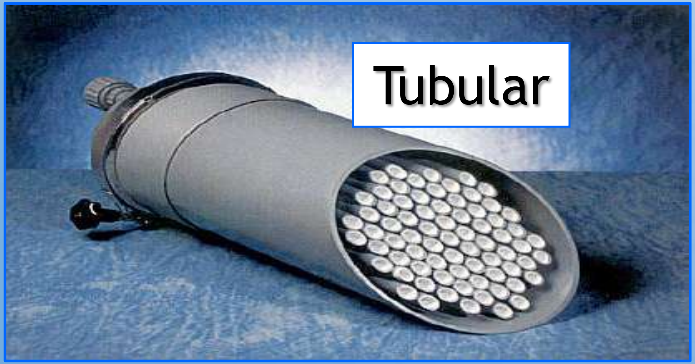
Submerged



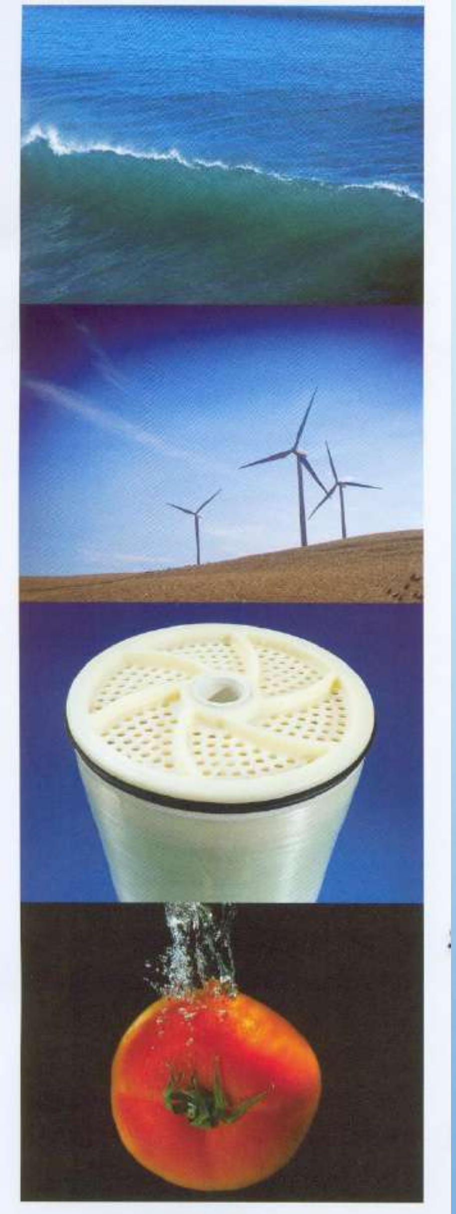


Spiral wound

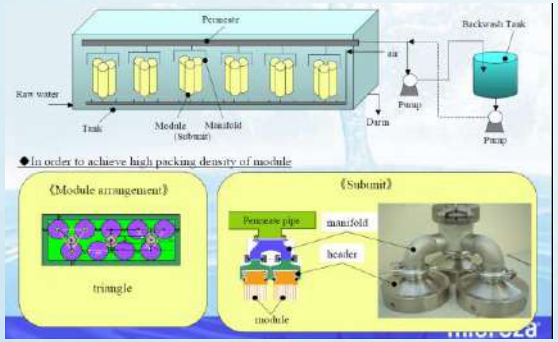


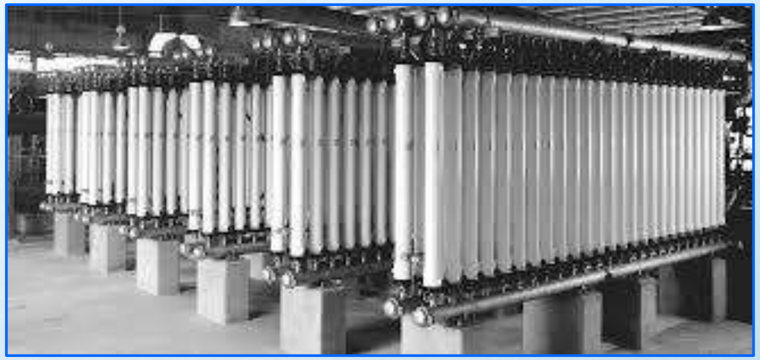


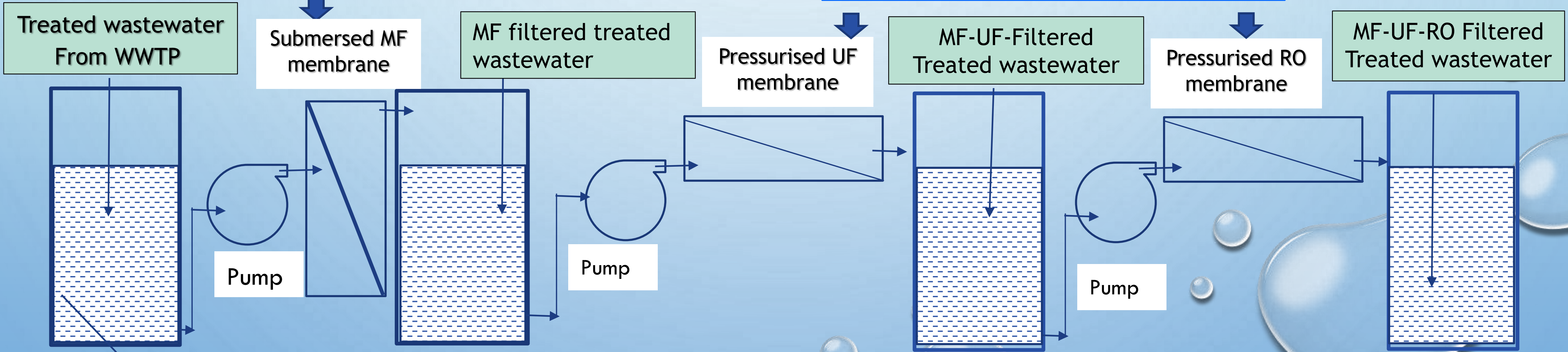
Membrane Modules Configuration for Industrial Application (Cont.)



Retrofitting of Membrane Systems to Existing WWT Plant







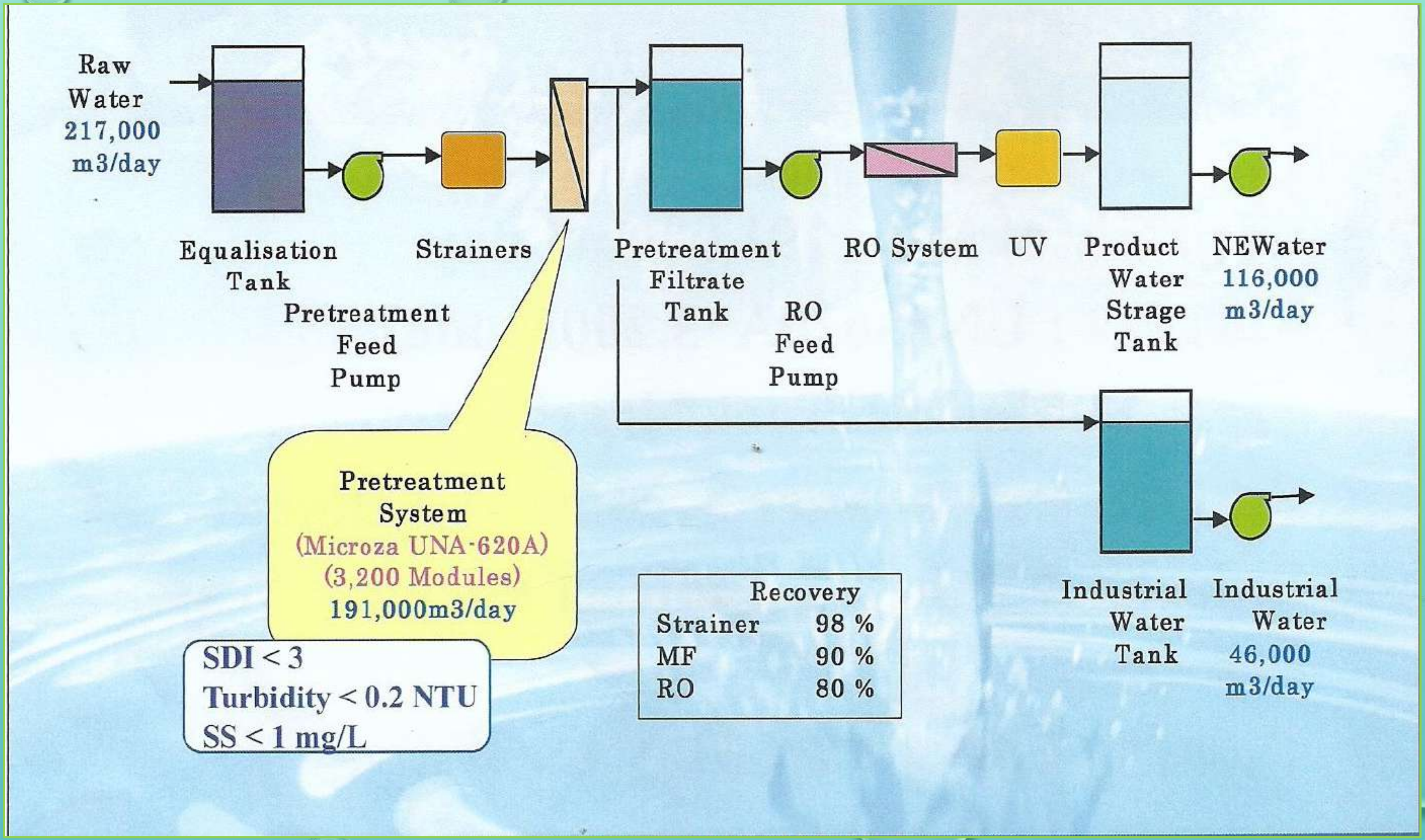
This water quality must comply to DOE's Industrial Effluents discharge Regulations (2009) Std. A or B, depending on the factory's location.

Uses of Treated Wastewater after Tertiary Treatment by MF, UF and RO and System Cost

Treated Wastewater (TWW)	TWW+MF	TWW+MF+UF	TWW+MF+UF+RO
• General Washing • Factory floor washing • Flushing toilet	• Washing compounding equipment • Washing dipping tank.	• Diluting latex • Former cleaning • Pre-leaching water • Boiler water • Preparing coagulant and former release agent.	• Post-leaching water • Diluting acid, alkali and preparing general compounding chemicals. • As denoised water for analytical instruments

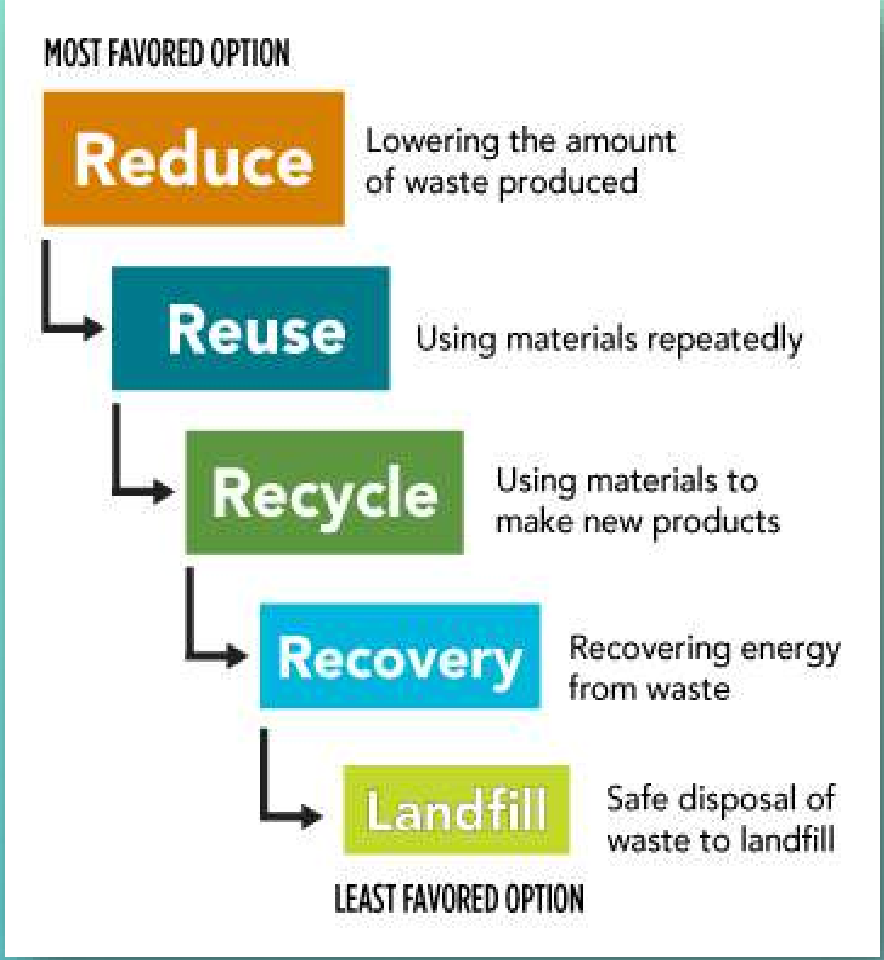
Treated Wastewater Recycling	System/Estimated Cost	
m^3/day	MF/UF RM (mil)	MF/UF/RO RM(mil)
2500	3.3-3.5	4.0-4.5
2000	2.8-3.0	3.5-3.8
1500	2.2-2.5	3.0-3.5
1000	1.5-1-8	2.3-2.5
500	0.9-1.2	1.5-1.8

Singapore NEWATER Plant Using Various Types of Membrane Systems



Usefulness of Wastewater Recycling

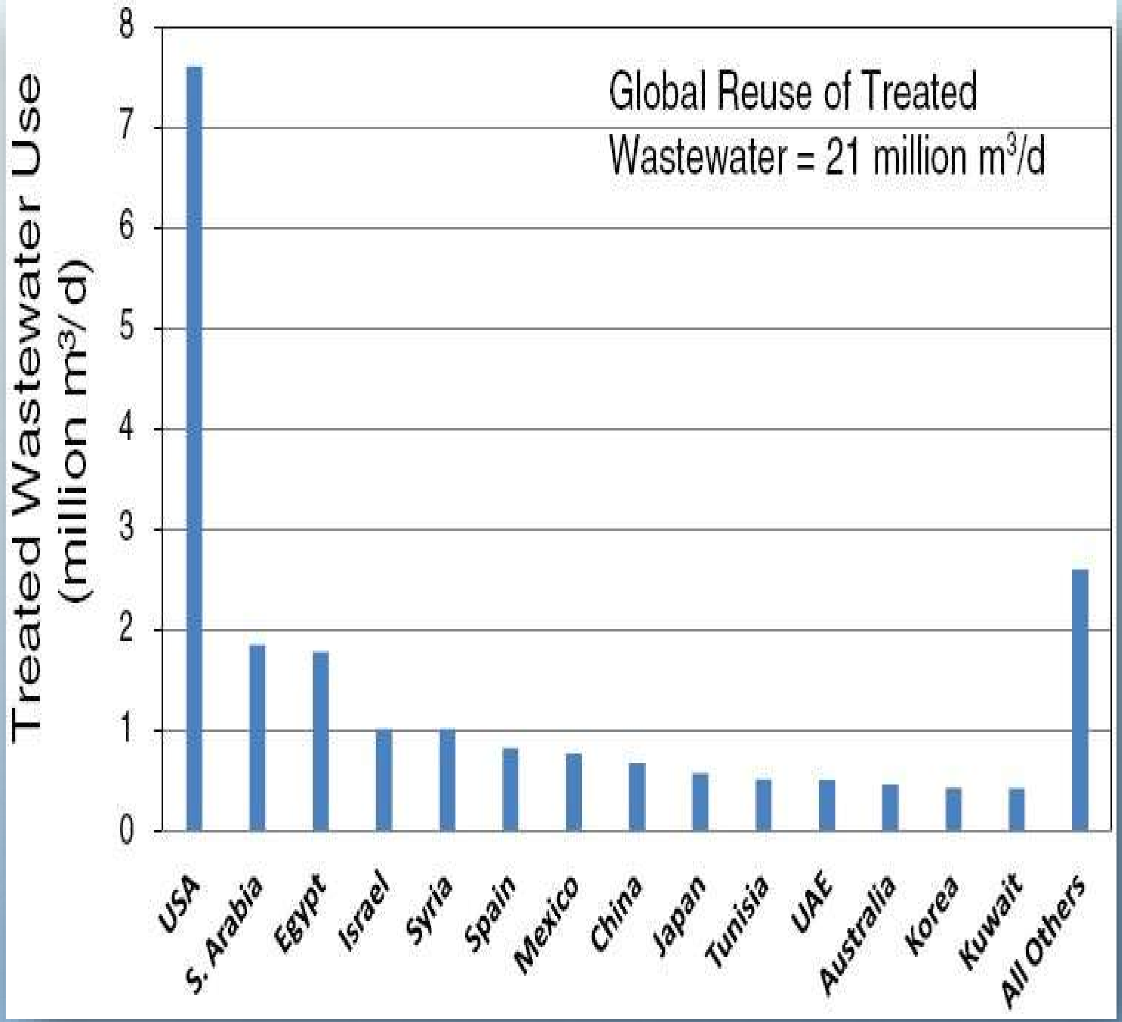
4R Strategy to reduce Waste



- Clean water would become scarce in the future; reusing treated wastewater is most ideal option.
- Estimated discharge of > 100,000 m^3/day of treated or partly treated wastewater into water course can be avoided.
- With water tariff ever increasing, substantial savings could be made using recycled water.
- Estimated reduction in water utilization cost by 25-30% and 50% reduction by 2020 (*MRB's study, 2018*).
- Reduce domestic water consumption, which preserves water resource and maintains environmental sustainability.
- Attain self-sufficiency and in control of factory's process water requirement
- Adopting sustainable water use practices could strengthen their brand reputation and gives green image.
- The factory could qualify for MIDA's Tax Incentives for Green Industry

"Methods to increase water supply beyond what is available from the hydrological cycle are desalination and water reuse" by Menachem Elimelech & William A. Phillip ***Science*, 333, 6043 (2011) 712717**

Global Scenario of Wastewater Recycling



RAINWATER HARVESTING AND PURIFICATION

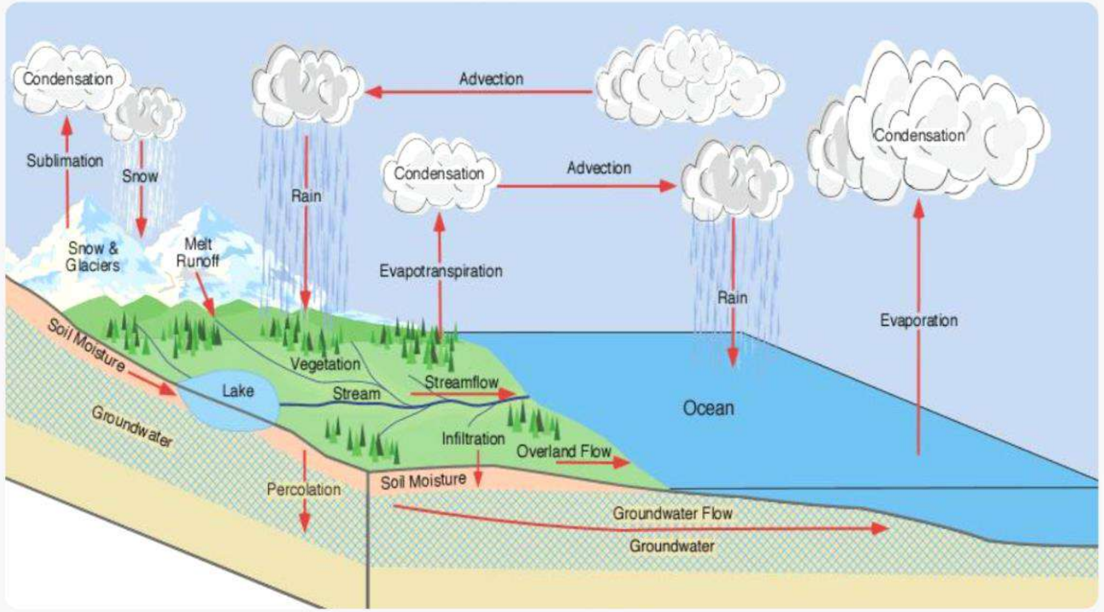
Malaysian Rainwater Resources

- Malaysia's ample rainfall (receiving over 2800mm annually) could be easily collected on roof tops and abundant runoff water could be collected, pre-treated in-situ and stored in underground storage facility.
- Malaysia is well positioned to harvest rain water for both potable and non-potable uses.
- This water could be subsequently treated to various quality and stored in elevated tanks and used as process water to supplement PUB water supply.

Break Down of Rainwater Resources

Source: National Hydraulic Research Institute of Malaysia (NAHRIM), 2016

Break down	billion m^3
Annual Rainfall	990
Evapotranspiration	360
Surface Runoff	566
Annual recharge	64
Surface artificial storage	25
Groundwater storage estimate	5,000



- Therefore there is an urgent need to take up rain/roof water harvesting/conservation methods to make it a sustainable process water source.

Rainwater Harvesting

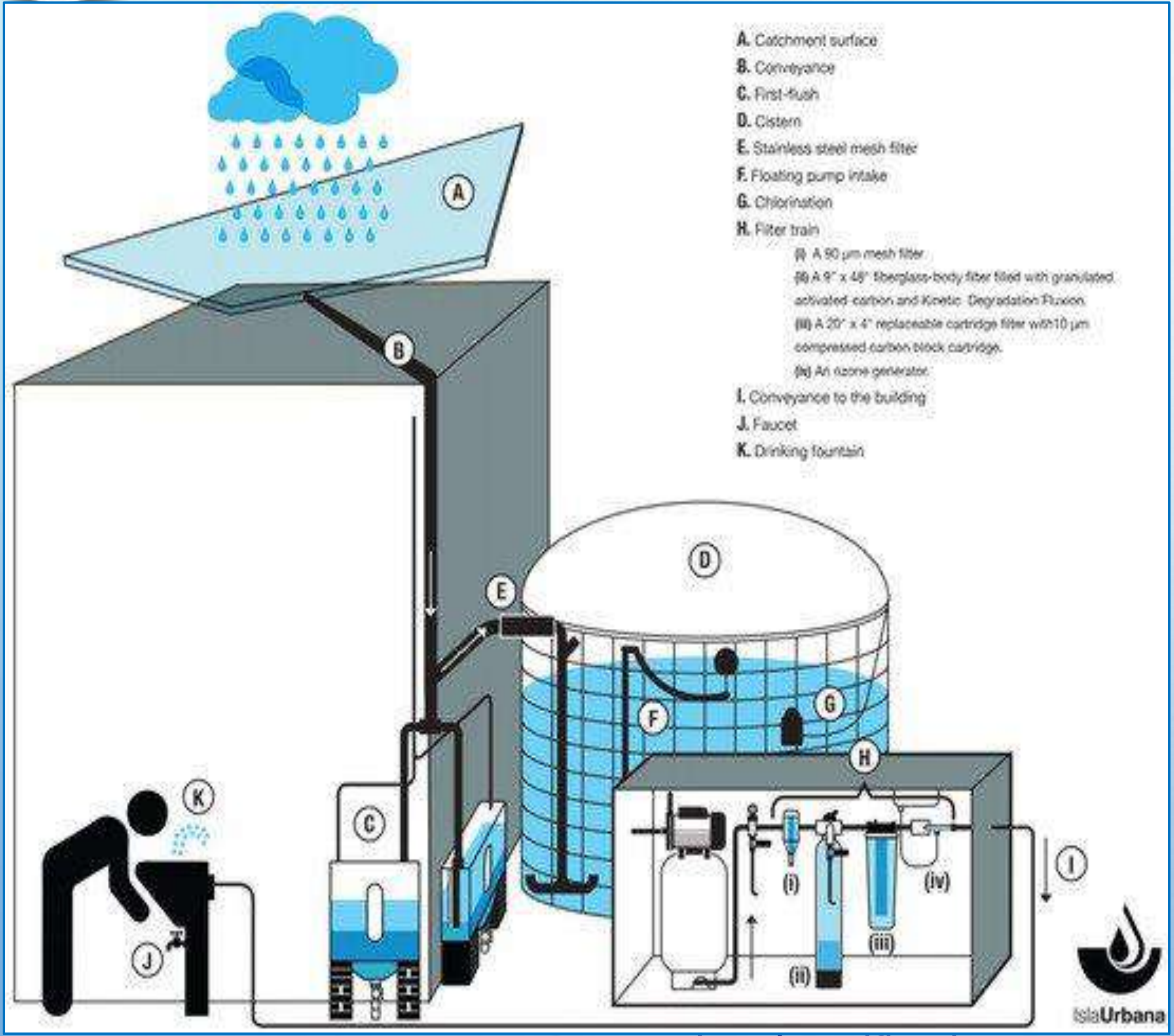
Collection from Roof of factory

- Independent and ample supply of water in the dwelling.
- Water received is free of costs.
- Use of this water significantly reduces water bills for purchased water from municipal supply

Gravity Fed Rainwater Harvesting System

- Costs incurred for purifying the water for potable use are nominal.
- Harvesting rainwater is not only water conserving, it is also energy conserving since the energy input required to operate a centralized water system designed to treat and pump water over a vast service area is by-passed.

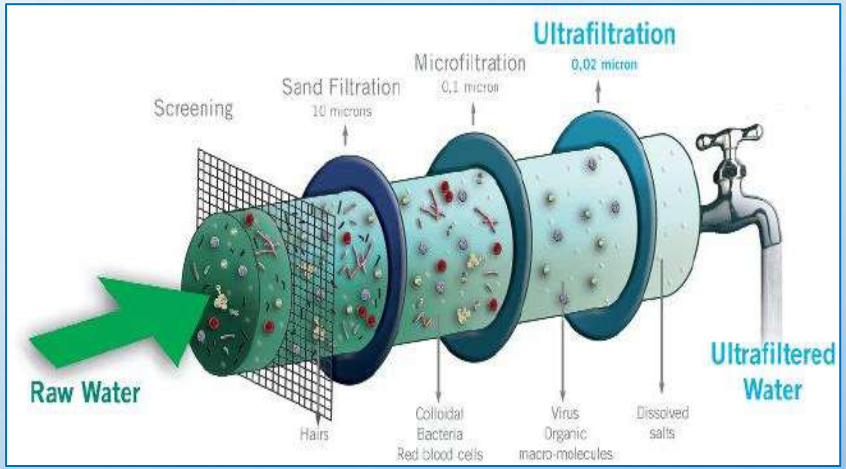
Rooftop Rainwater Harvesting & Purification

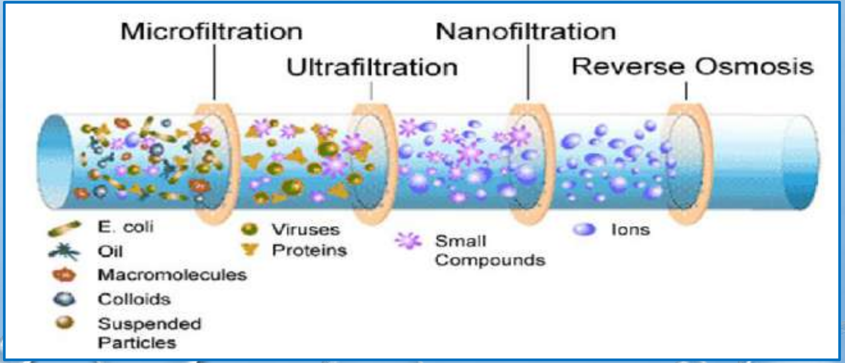


Conventional Purification Process

Purification by Membrane Process

Harvested and pre-treated rainwater must undergo tertiary treatment by MF/UF/RO for high end-uses in manufacturing line.





Criteria for Special Fund for Harvesting and Purification of Rainwater

- Rainwater is relatively clean if collected directly or from rooftop, if surrounding air is not polluted and without suspended solids can be used for general cleaning. Does not qualify for the special fund.

- Surface run-off collected and pre-treated by passing through grid and coarse filtration and used for general cleaning; don’t qualify for special fund.

- Importance will be given to the technology used in purifying the harvested water for high-end use.

- Quantum of rainwater harvested, purified and used in actual manufacturing process is important.

- Hight projected amount of harvested and purified water utilized in manufacturing activities after implementation of proposed project, will be considered.

- Harvested rainwater without undergoing purifying treatment and used for general cleaning will not get much consideration although it reduces the consumption of PUWS.

MRC's Green Technology Fund For Water

- In an effort to promote the use of sustainable water sources as process water in the rubber products manufacturing industry, the government through MRC initiated the above fund.
- This special fund or matching grant not exceeding RM one million, is a form of financial incentive and assistance given to qualified applicants intending to fabricate systems, utilizing green technology to obtain water and utilize it in the manufacturing line as process water.

Evaluation of the Fund will Focus on the following Criteria

- The amount of water utilized in the manufacturing line using the proposed system must ideally bring about as much reduction as possible in the utilization of Public Utility Water supply(PUWS). Higher weightage for **higher reduction** in the usage of PUWS.
- The system proposed will have a high weightage for the grant if it is able to purify the treated or harvested water to the **highest water quality possible** which can be utilised in manufacturing process line.
- More Green Technology weightage will be given for **Wastewater Recycling and Rainwater Harvesting & Purification**.
- Location of factory **within 5km radius of river upstream** (upriver - closer to water catchment point) will be given more weightage and reduces as distance gets further to down stream (downriver).

Green Technology Scoring Guide for Water

		45%	35%	15%	5%
Quality of Response	**Percent score**	**Mixture Amount of Treated Water to PUWS**	**Quality of Treated Water - Total Dissolved Solids**	**Source of Water Supply**	**Location of Water Intake Point PUWS**
Excellent	90-100	More than 50%	Less than 101ppm	Wastewater recycling only	Treated wastewater discharge point is located at upstream of Water Intake Point of PUWS, within 5km distance (conform to standard A)
Good	80-89	Between 31-50%	Between 101-200ppm	Combination of wastewater recycling and rainwater harvesting	Treated wastewater discharge point is located at upstream of Water Intake Point of PUWS, beyond 5km distance (conform to standard A)
Moderate	50-79	Between 15-30%	Between 201-500ppm	N/A	Treated wastewater discharge point is located at downstream of Water Intake Point of PUWS (conform to standard B)
Low	0-49	Less than 15%	More than 500ppm	N/A	N/A

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Thank You