# Application of Nanofiltration Membrane
## for Removal of VOCs and Heavy Metals in Groundwater Ratchaburi, Thailand

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# Outline

Introduction

Methods

Conclusions

① Introduction
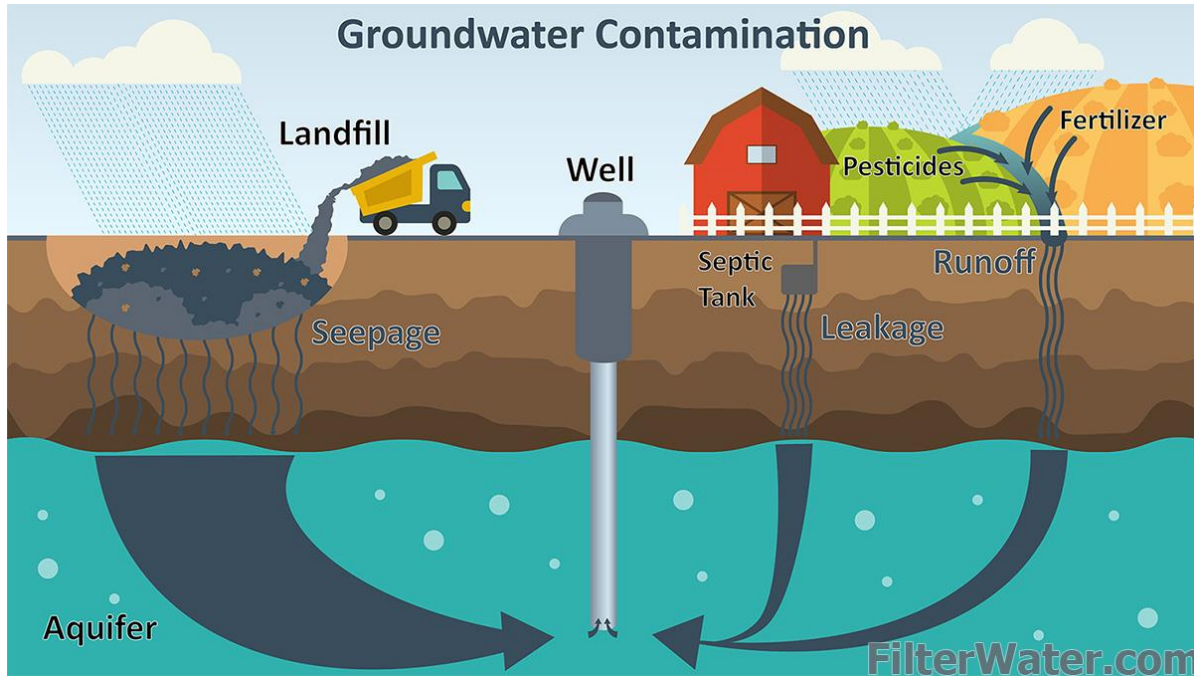
③ Methods

⑤ Conclusions

② Objectives

④ Results

⑥ Recommendations

# 1

# Introduction

Background of the study

Groundwater Contamination — diagram showing Landfill, Well, Septic Tank, Pesticides, Fertilizer, Runoff, Seepage, Leakage, Aquifer (FilterWater.com)
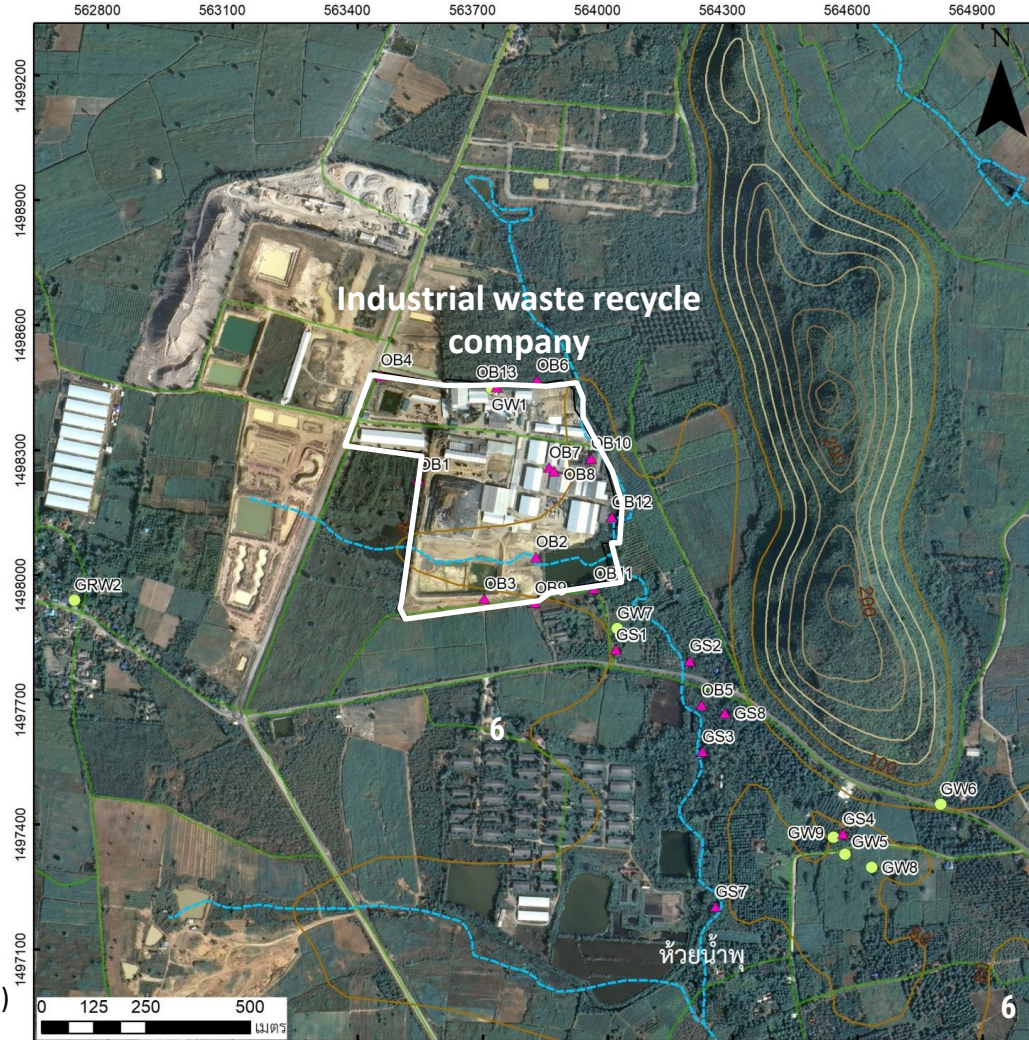
- Groundwater is the main source of fresh water that is used for domestic, agricultural, and industrial activities.

- Common sources of groundwater contamination include improper disposal of wastes, faulty septic tanks, landfills, pesticides and fertilizers.
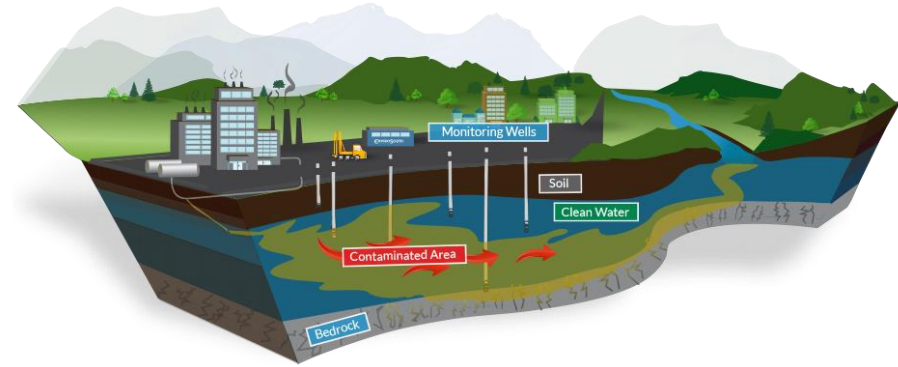
When an aquifer becomes contaminated, it can affect a wide area

and take years to clean up.

https://envirosouth.com/services/soil-groundwater-contamination-assessment/

# 🖈 The Study Area



Ratchaburi

Bangkok

Industrial waste recycle company

**Legends**

🟢 Deep groundwater wells (> 15 m.)

🔺 Shallow groundwater wells (< 15 m.)

〰️ Stream

# The Study Area

- In 2014, Groundwater and stream were reported as VOCs contaminated.

- Site characterization was conducted by MiHPT direct push drilling.

- VOCs contamination exists in the landfill area and the private property which is located within 1 kilometer from the landfill.
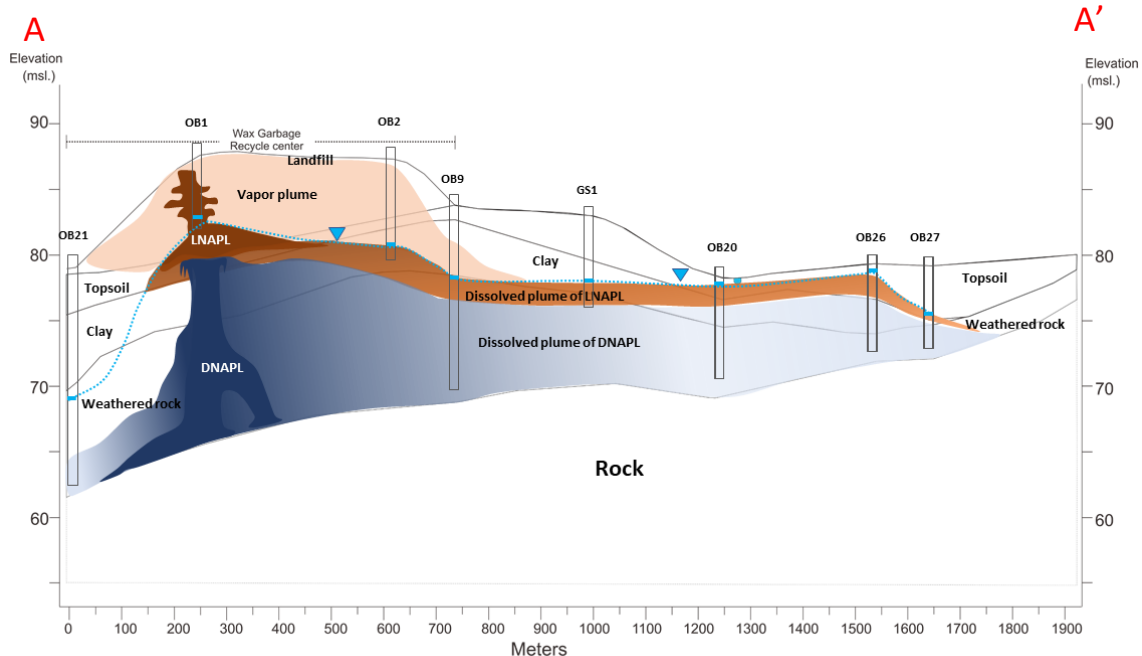


Landfill area

MiHPT direct push drilling

Shallow well

# Distribution of Contaminated Groundwater
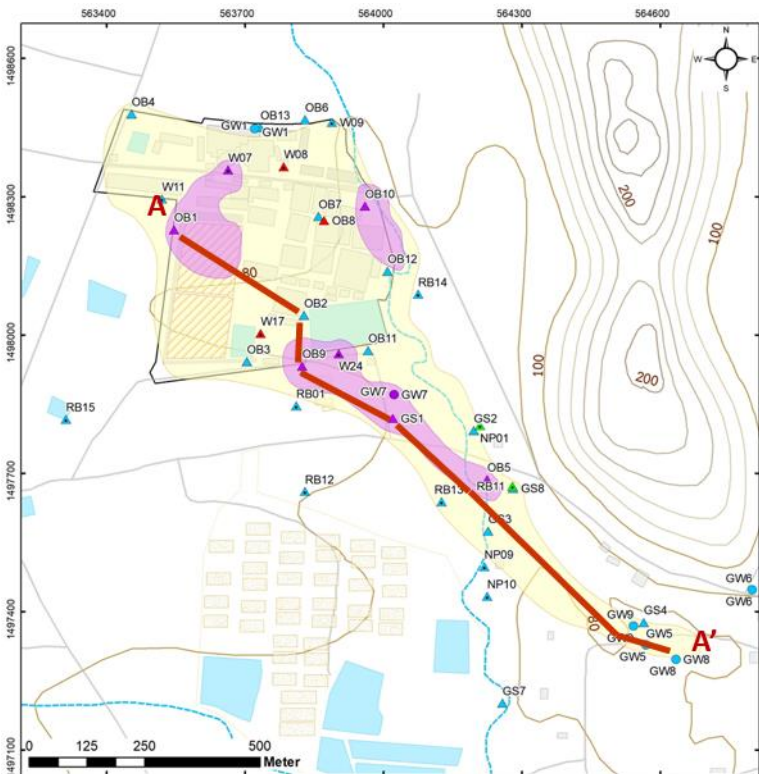


vinyl chloride > 30 μg/L

vinyl chloride > 2 μg/L

Hydrogeochemical cross section
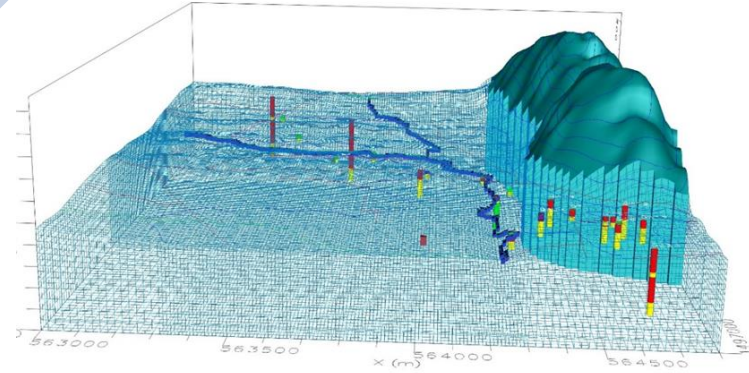
# 2

## Objectives

# Objectives

**1** Define the hydrochemistry of contaminated groundwater



**2** Examine the efficiency of nanofiltration membrane for removal of pollutants in groundwater as well as the potential implementation of the membrane
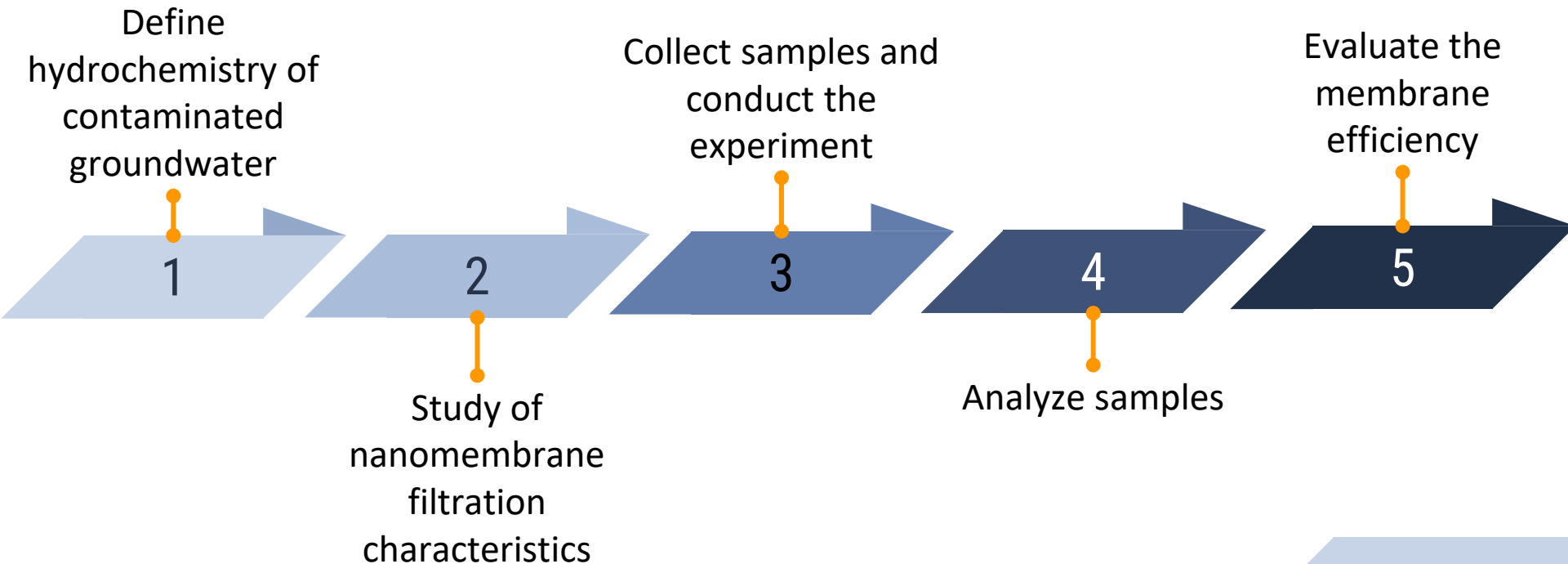
# 3

# Methods

# Methods

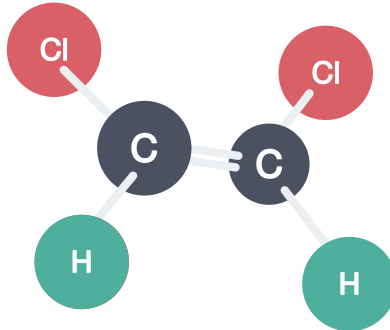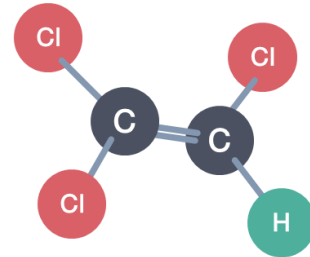**1** — Define hydrochemistry of contaminated groundwater

**2** — Study of nanomembrane filtration characteristics

**3** — Collect samples and conduct the experiment

**4** — Analyze samples

**5** — Evaluate the membrane efficiency

# Chemicals of Concern

**Heavy Metals**

**Volatile Organic Compounds**
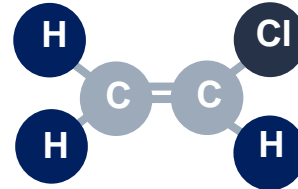
Ni 28 Nickel

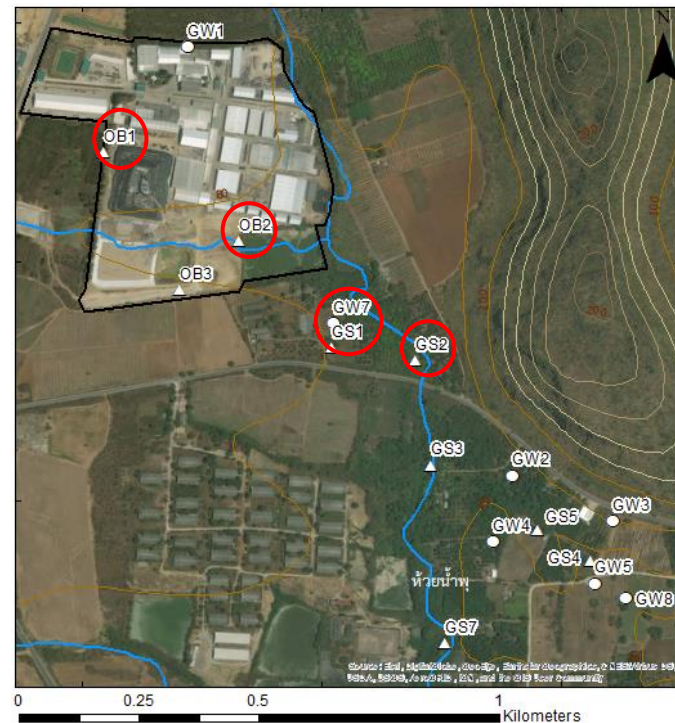Mn 25 Manganese

**Benzene**

**TCE**

**cis-1,2 DCE**

**Vinyl Chloride**

# Vinyl Chloride Concentration in 2016-2020

# Membrane Filtration



Bacteria

Virus

Multivalent ions

Monovalent ions

MF
microfiltration

UF
ultrafiltration

NF
nanofiltration

RO
reverse osmosis

particles
(>0.2 μm)

macro molecules
(Mw 2kD-500kD)

molecules
(Mw 200D-2kD)

ions

solvent
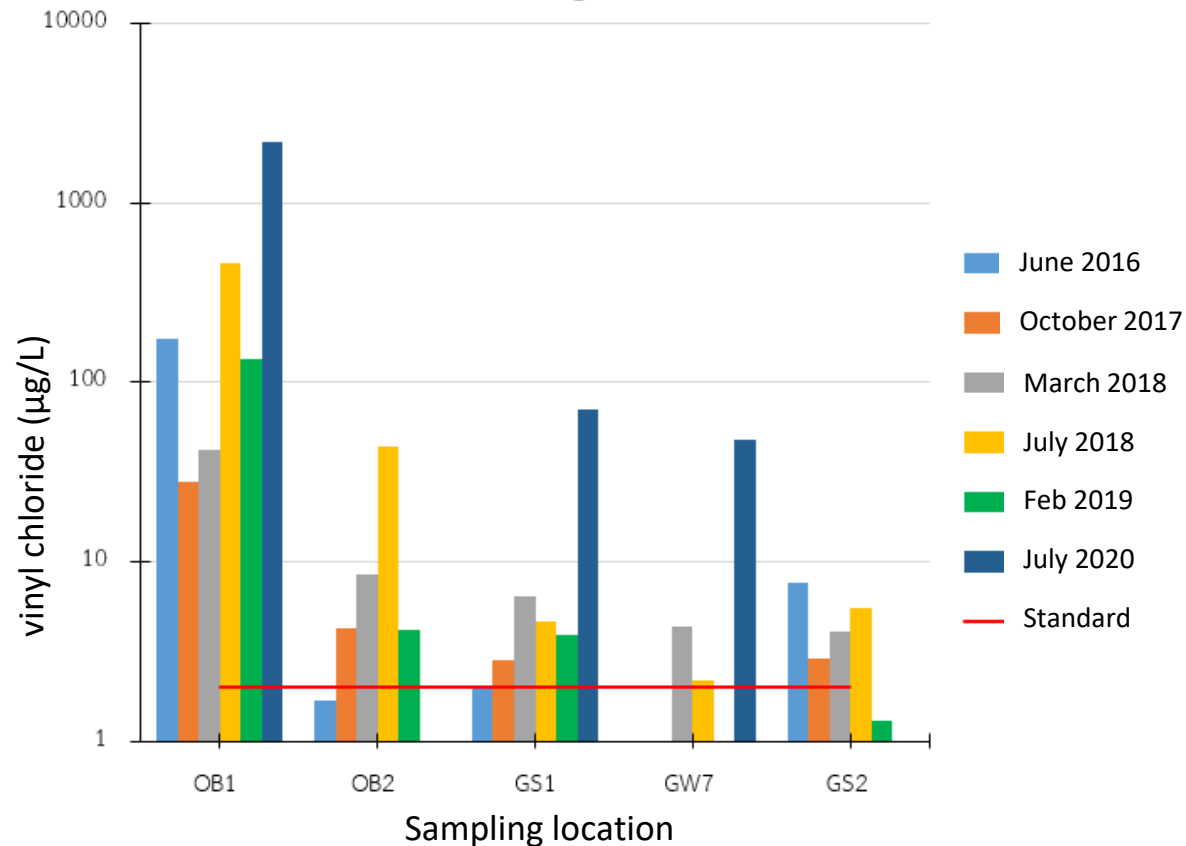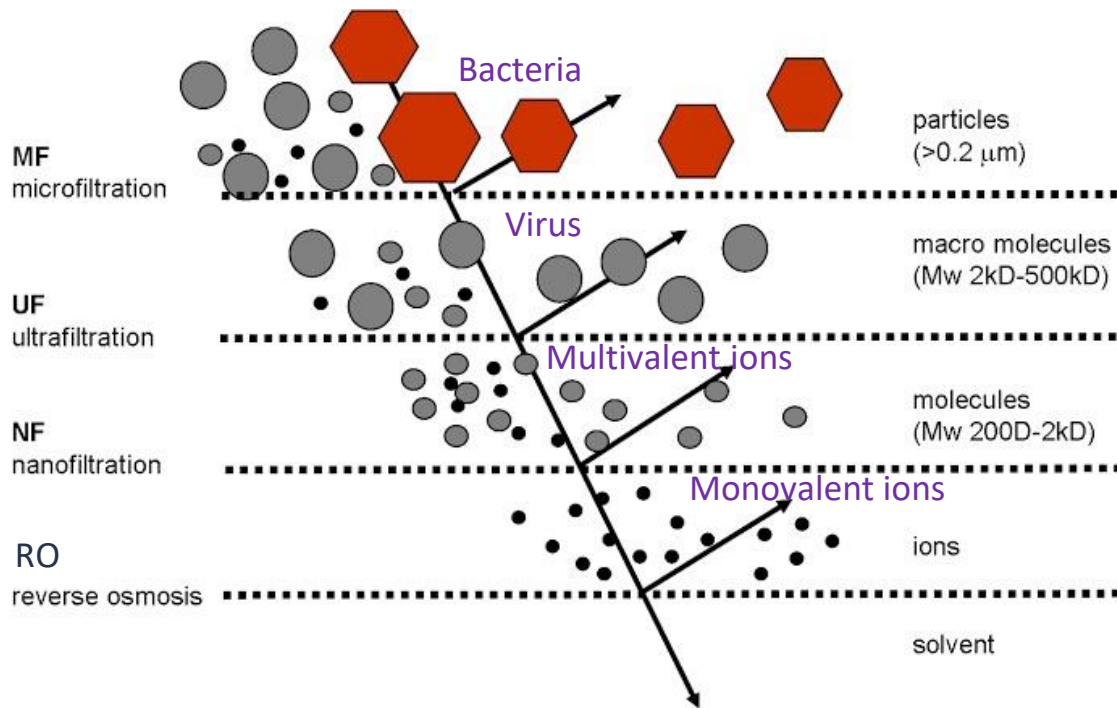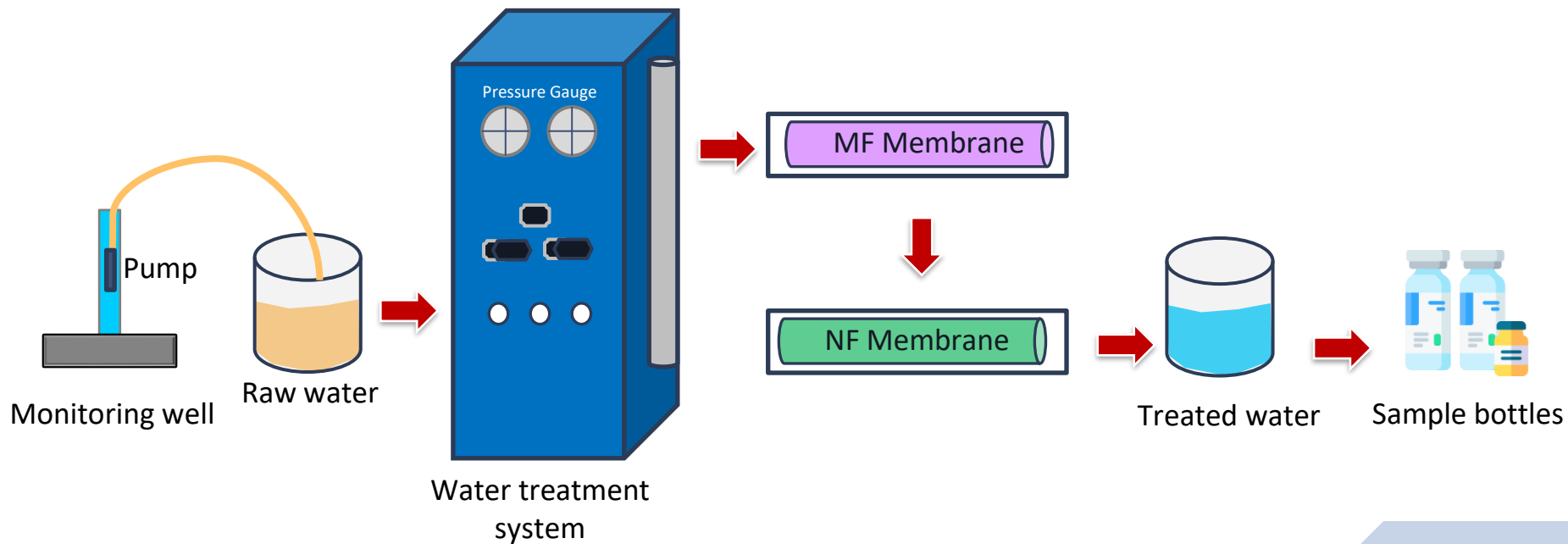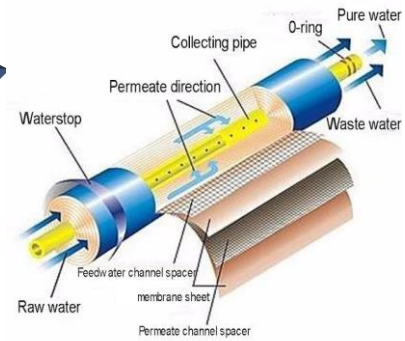
## Filtration system developed by

The International Environmental Research Institute (IERI)
Gwangju Institute of Science and Technology (GIST)
Republic of Korea

# Experimental Setup

# Drinking Water Treatment System



- Membrane is spiral-wound type with polyamide thin-film

- The module is cylindrical shape of 101.6 cm long and 6.4 cm diameter

- Pressure 0.4-0.6 Mpa

- Flow rates 2 L/min.

18

# Groundwater Sampling



- Pump groundwater samples from 4 monitoring wells

- Collect samples before and after passing through nanofiltration system

- Measure pH, temperature, and electrical conductivity at the site

- Analyze in laboratory for VOCs and heavy metals
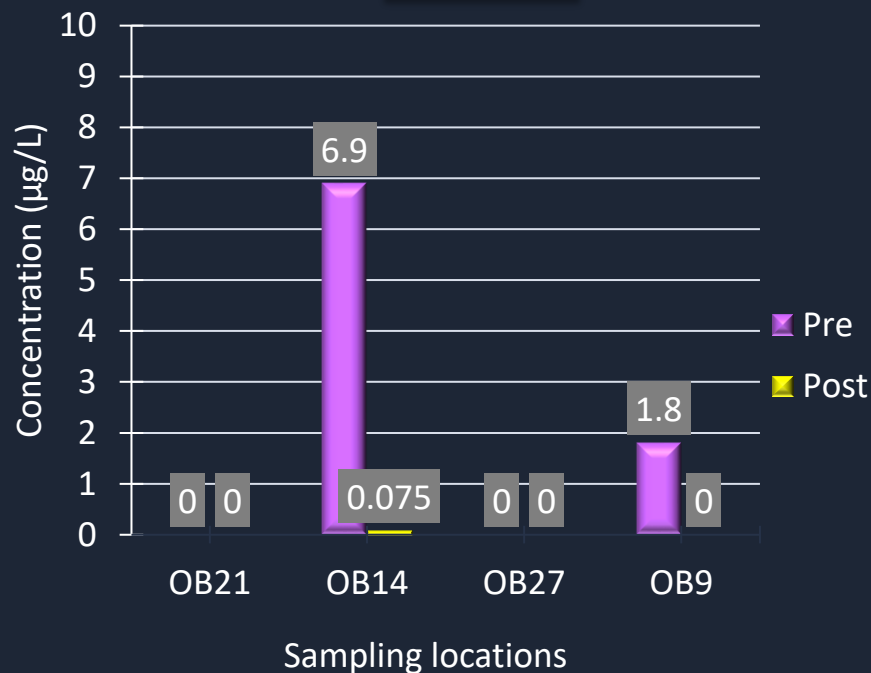
# 4

# Results

# Chemical Analysis Result

# Nanofiltration Membrane Efficiency



Benzene — Concentration (µg/L) vs Sampling locations (Pre/Post): OB21: 0, 0; OB14: 6.9, 0.075; OB27: 0, 0; OB9: 1.8, 0
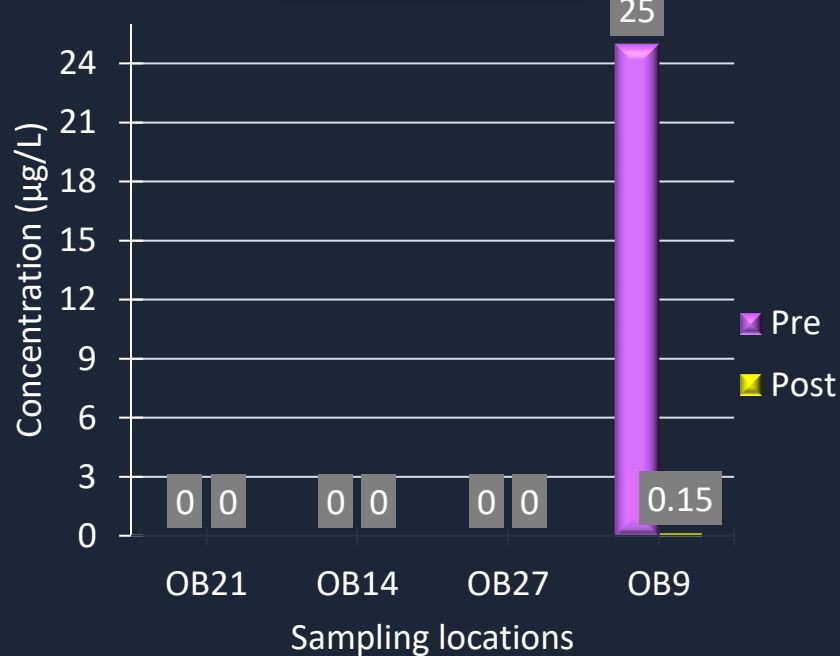
Vinyl Chloride — Concentration (µg/L) vs Sampling locations (Pre/Post): OB21: 0, 0; OB14: 0, 0; OB27: 0, 0; OB9: 25, 0.15

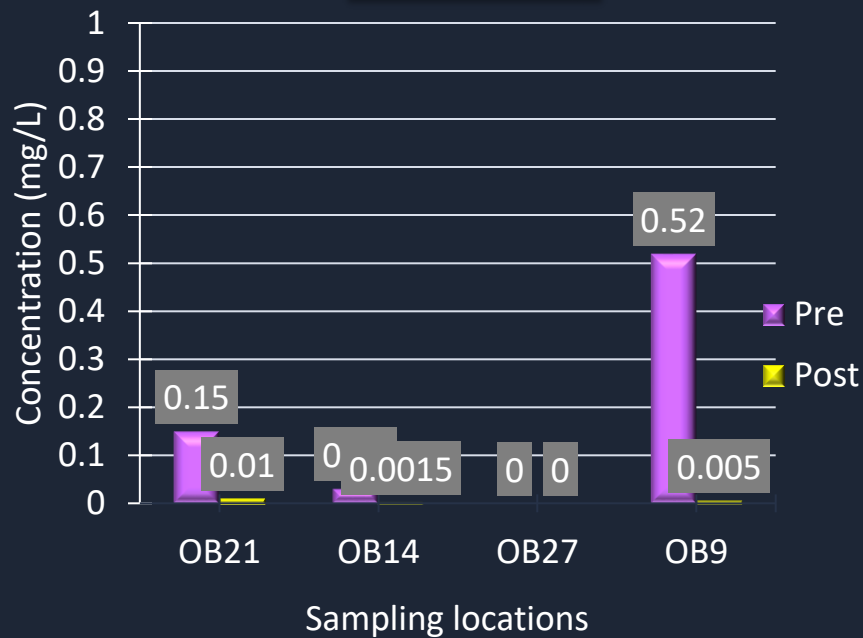# Nanofiltration Membrane Efficiency

# Nanofiltration Membrane Efficiency



Nickel — Concentration (mg/L) vs Sampling locations (Pre/Post):
- OB21: Pre 0, Post 0
- OB14: Pre 0.026, Post 0.0006
- OB27: Pre 0, Post 0
- OB9: Pre 0.073, Post 0.0006
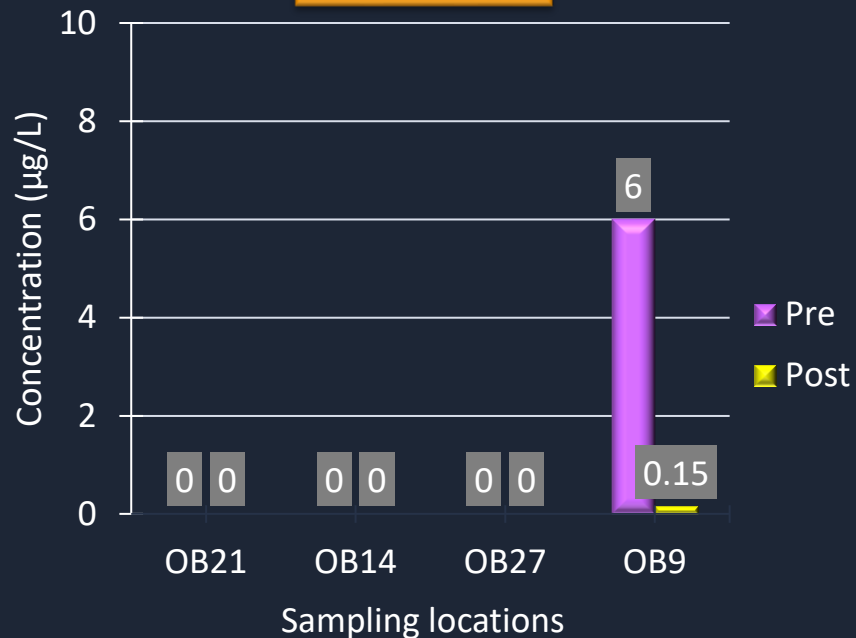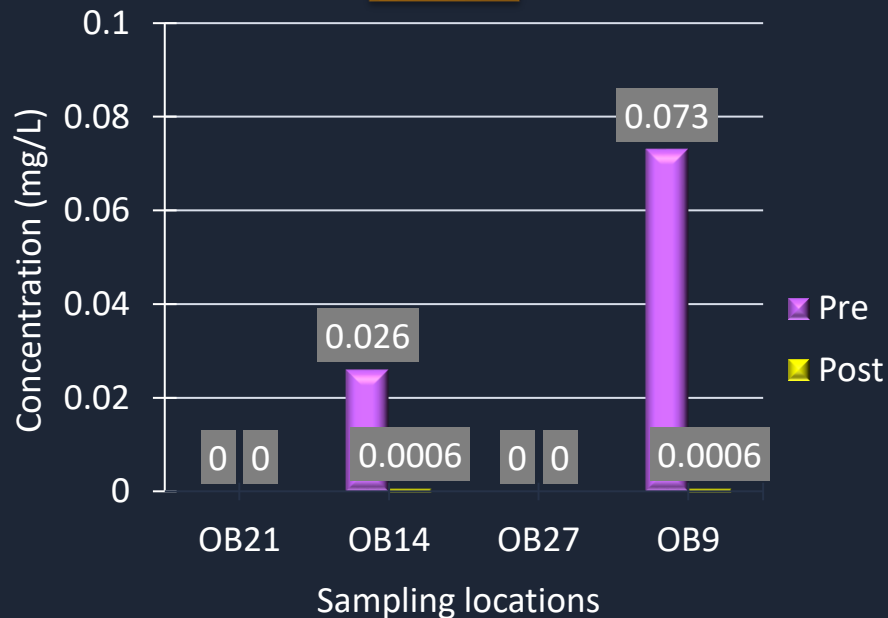
Total dissolved Solid — Concentration (mg/L) vs Sampling locations (Pre/Post):
- OB21: Pre 567, Post 98
- OB14: Pre 485, Post 73
- OB27: Pre 456, Post 41
- OB9: Pre 902, Post 120
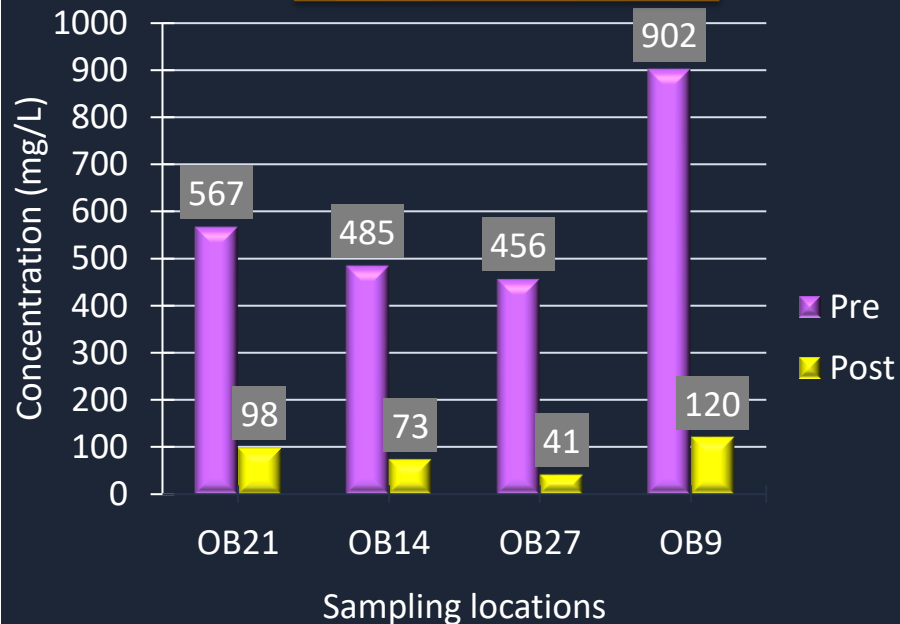
# Comparison of Membrane Efficiency



Water treatment system

MF Membrane

Filtered water

MF Membrane
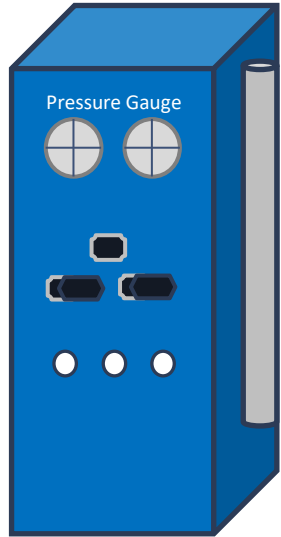
Carbon Membrane

Filtered water

MF Membrane

Carbon Membrane

NF Membrane

Filtered water

# Comparison of Membrane Efficiency



VOCs

# Comparison of Membrane Efficiency



Heavy metals
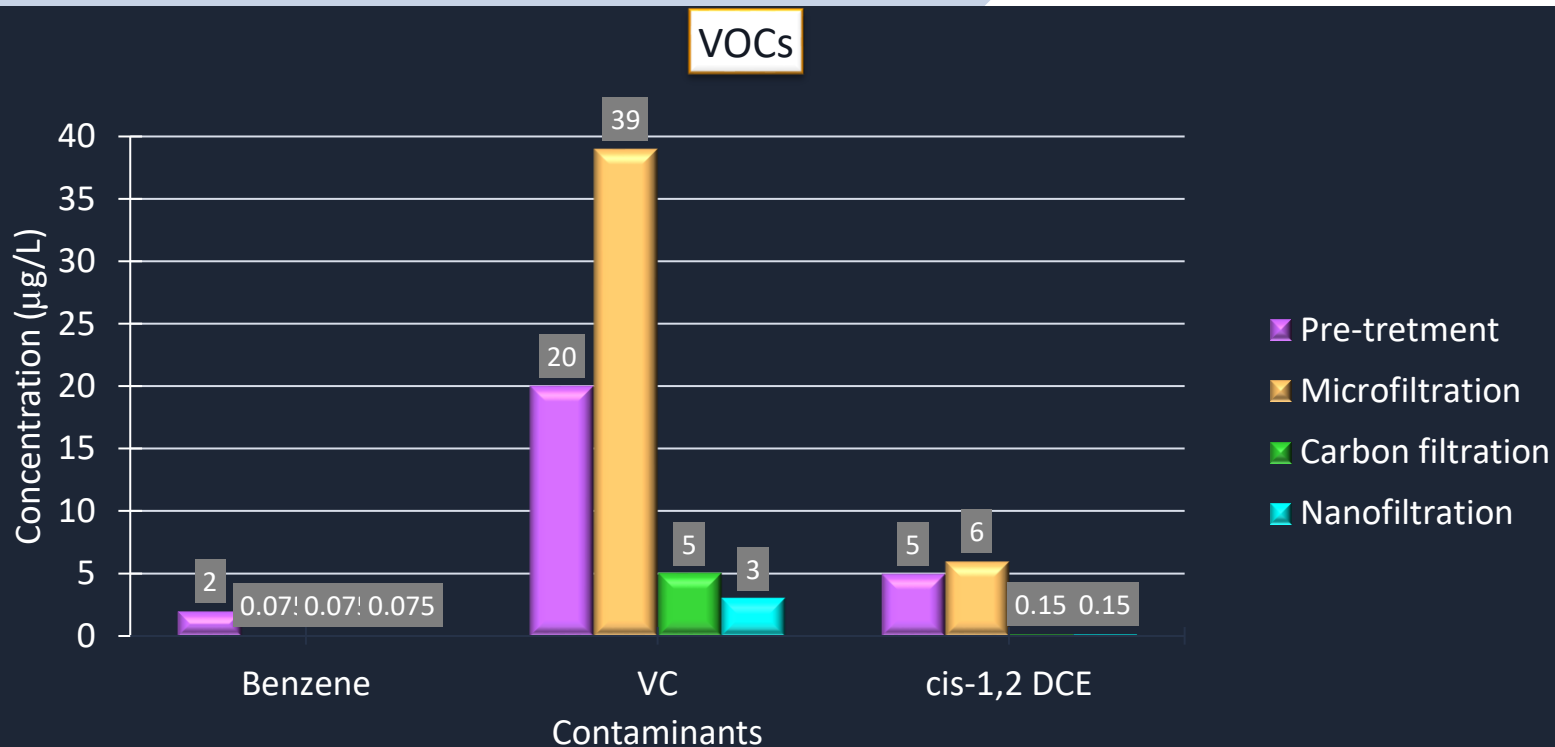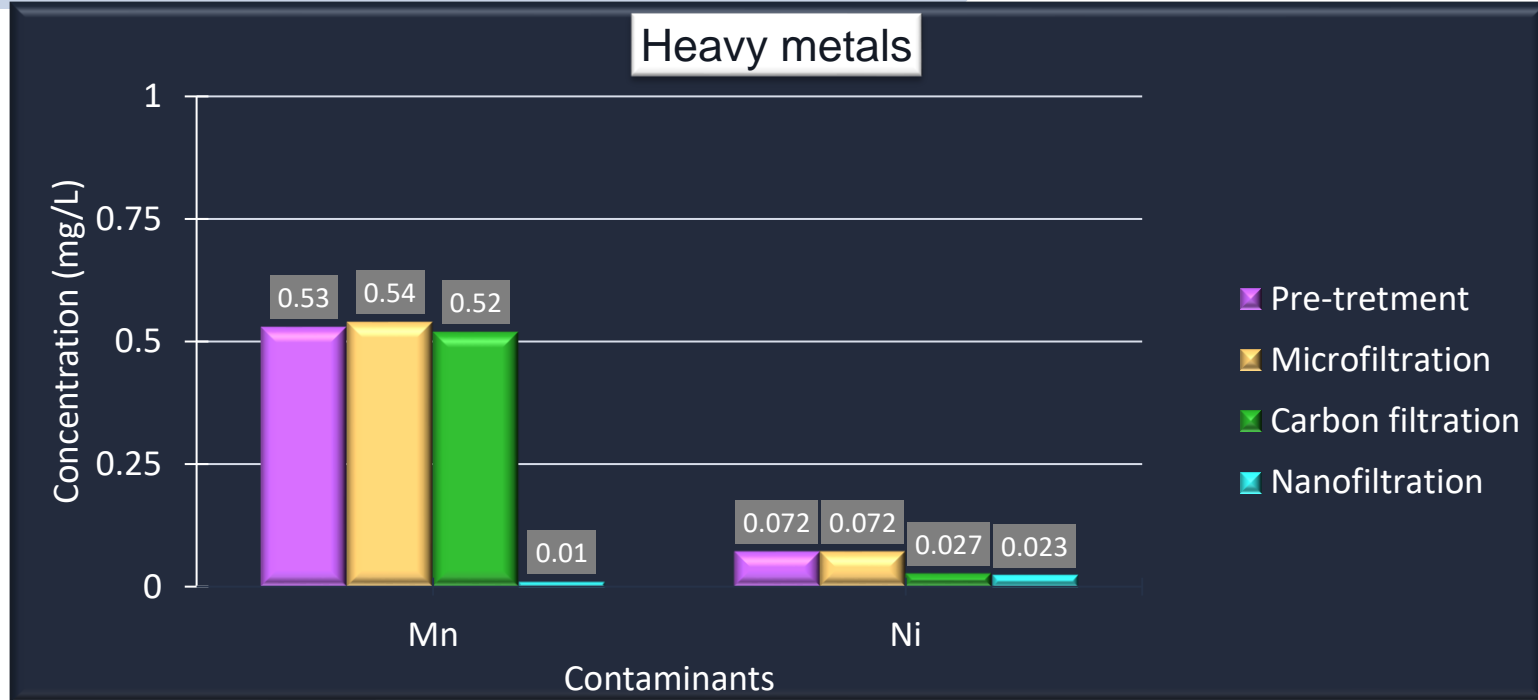
# Removal Efficiency

| Parameters | Removal Rate (%) | | |
|---|---|---|---|
| | NF | MF | Carbon |
| Benzene | 97.5 | 96.2 | 96.2 |
| cis-1,2 Dichloroethylene | 97.0 | - | 97.0 |
| Vinyl Chloride | 85.0 | - | 75.0 |
| Manganese | 96.5 | - | 1.8 |
| Nickel | 82.8 | - | 62.5 |

# Conclusion

### Hydrochemistry

**1**

Groundwater in the study area has been contaminated by VOCs (benzene, cis-1,2 DCE, vinyl chloride) and heavy metals (Mn, Ni)

### Nanofiltration Performance

**2**

The nanofiltration maximum removal rates for pollutants were higher than 97%

### Performance Comparison

**3**

Nanofiltration membrane performs better with contaminant removal than the activated carbon filter
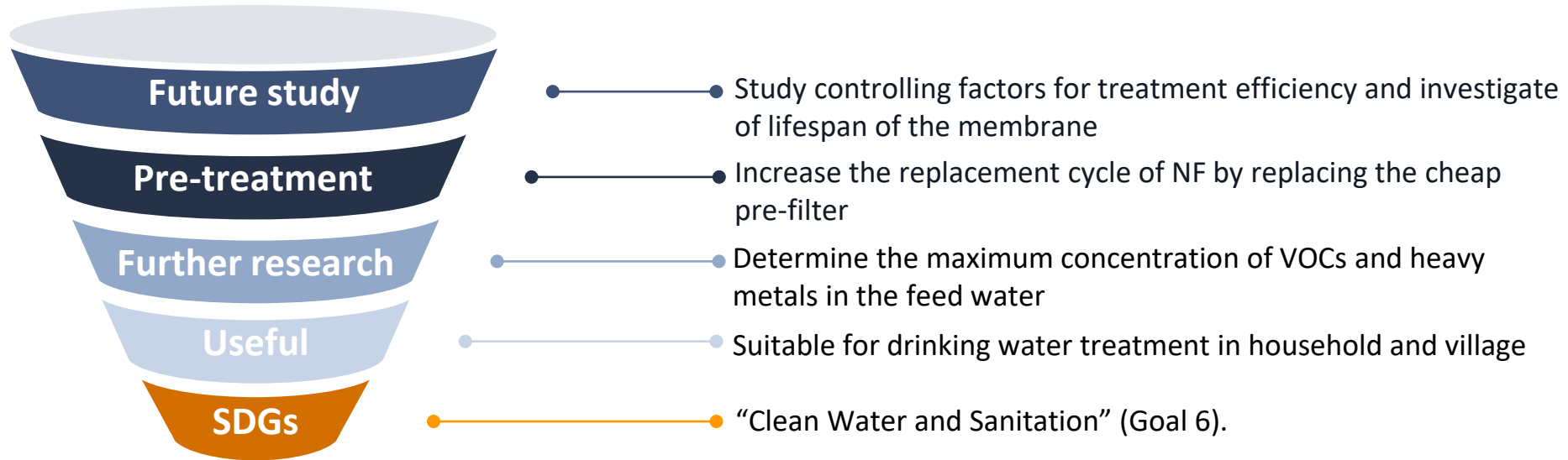
### Treatment Factors

**4**

The treatment efficiency is dependent on pretreatment requirements, influent water quality and the lifespan of the membrane

# Recommendations

**Future study** — Study controlling factors for treatment efficiency and investigate of lifespan of the membrane

**Pre-treatment** — Increase the replacement cycle of NF by replacing the cheap pre-filter

**Further research** — Determine the maximum concentration of VOCs and heavy metals in the feed water

**Useful** — Suitable for drinking water treatment in household and village

**SDGs** — "Clean Water and Sanitation" (Goal 6).

# THANKS!

**Any questions?**
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