7 Steps of Process Research for Problem Solving

Re-use of Drainage Water as Cooling Tower Water Make-up

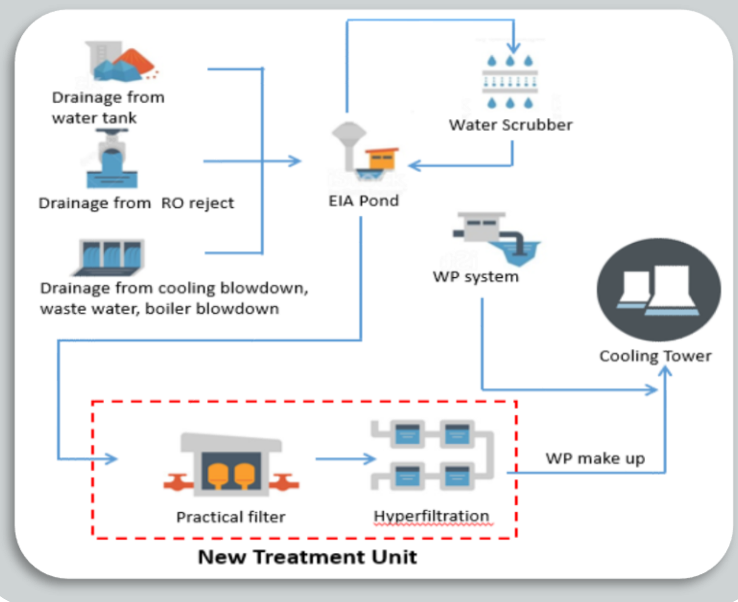
Research can be defined as the search for knowledge, or as any systematic investigation, with an open mind, to establish novel facts, solve new or existing problems, prove new ideas, or develop new theories. In a recent project, PTTES has used a "seven steps holistic approach" to process research to help a client investigate how they can re-use drainage water collected in their EIA pond as make-up water for their cooling tower system. A brief explanation of each step with key activities is given hereafter.

Project goal:

1. Re-use drainage water as make-up water for cooling tower system.
2. Utilize existing gravel filter. Determine what additional measures would be required in case the gravel filter cannot be re-used.

1. Define Problem

- Currently, drainage water from the EIA pond is discharged to sea, which impacts on the environmental and public concern.
- The quality of the drainage water collected in the EIA pond does not allow the water to be re-used internally.



2. Investigate and Collect Data

- Investigate and collect data in order to check whether the existing gravel filter can be used to treat the drainage water collected in the EIA pond to achieve the required treated water specification for use as potable water (WP) make-up in the cooling tower system.
- Collect data and compare treated water quality at outlet of the gravel filter with the required specification for cooling tower water make-up.

Details on data comparison are given below:

Parameter	Units	Drainage water from EIA Pond	WP Required quality for Cooling Tower make up	Remark
pH	-	7.0-8.9	5.5-9.0	
Temperature	C	24-34	25-35	
Turbidity	NTU	4-137	<2	To be removed suspend solid
Conductivity	uS/cm	730-2,380	<250	To be removed metal ion
Total Dissolved Solid	mg/l	<1184	<125	To be removed metal ion
Ca-Hardness	ppm as CaCO3	168.29	<50	To be removed metal ion
Mg-Hardness	ppm as CaCO3	33.03	<20	To be removed metal ion
Total Hardness	ppm as CaCO3	201.33	<70	To be removed metal ion
Chloride (Cl)	ppm	289.9	<50	To be removed metal ion
Silica (SiO2)	ppm	43.15	<20	To be removed metal ion
Total Iron (Fe)	ppm	0.159	<0.1	To be removed metal ion
p-Alkalinity	ppm as CaCO3		<0.05	To be removed metal ion
m-Alkalinity	ppm as CaCO3			
Total Alkalinity	ppm		<45	
Sulfate (SO4)	ppm	184.6	<40	To be removed metal ion

Conclusion from the data collection step:

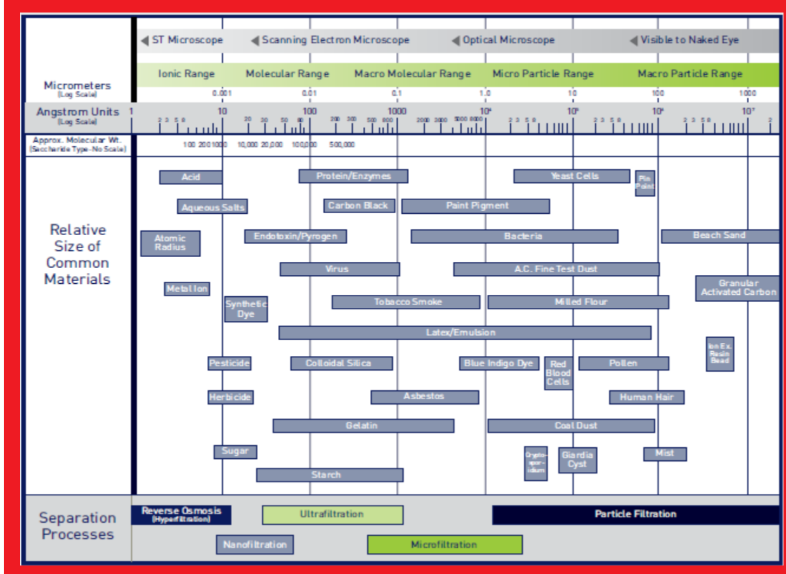
"The existing gravel filter can only reduce turbidity of water".

It cannot remove total dissolved solid from the drainage water to make it meet potable water quality for use as make-up water in the cooling tower system.

3. Review Literature

Since the existing gravel filter is not able to meet the required water quality, a literature review was carried out in order to find which technologies are available to help to meet the required water quality:

- Review literature to find appropriate technologies which can treat the recycled drainage water to meet the make-up potable water quality.
- Prepare and set-up pre-screening criteria with client to pre-screen technologies.
- Select the potential and appropriate technologies with the client.



Membrane Technology VS relative size of common materials

4. Select the way to Improvement

Based on the selected potential appropriate technologies, a questionnaire was developed to submit to potential technology providers to ask for more detailed technological information in order to perform a more detailed technology evaluation.

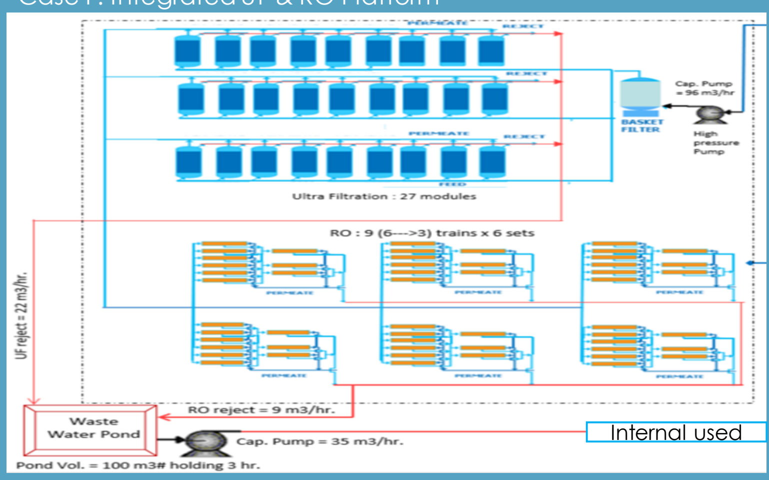
- Provide the necessary and relevant process information and limitations as well as a questionnaire to tech-providers for their proposal development etc.
- Jointly develop detailed technology evaluation criteria with the client.
- Prepare the technology comparison and evaluation to select the most appropriate technology for treating drainage water to meet required specification as target.

5. Clarify and Make Clear

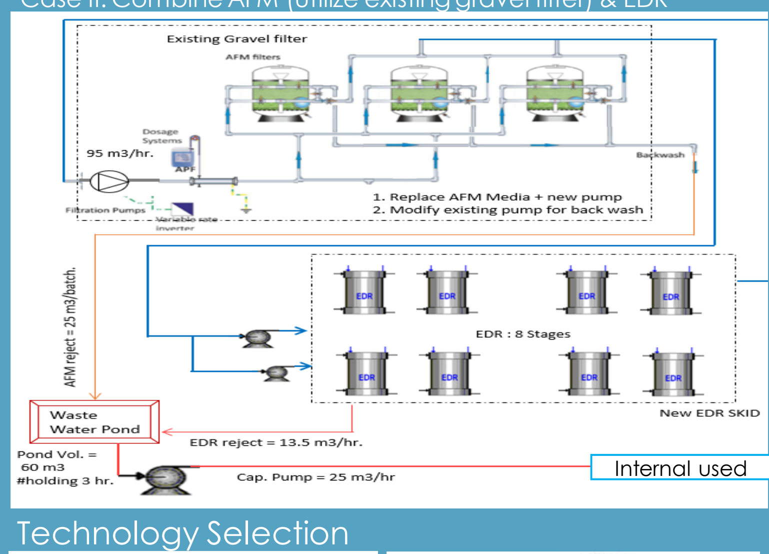
Perform technical proposal clarification sessions with the technology providers in order to clarify unclear points from their proposal, and to have discussion to thoroughly understand the technology provider's proposal.

UF = Ultrafiltration
RO = Reverse Osmosis
AFM = Activated Filter Media
EDR = Electrodialysis Reversal

Case I : Integrated UF & RO Platform



Case II: Combine AFM (utilize existing gravel filter) & EDR



Technology Selection

Case I : UF + RO

Case II : AFM + EDR

6. Analyze and Evaluate Data

Evaluate and select the most appropriate technology according to the proposal information. List the Pros and Cons, and possible risks of each technology.

	Pros.	Cons.
UF+RO	1. Lower investment cost than AFM + EDR 2. Excellent control and product efficiency 3. Capable of handling various TDS loads (high/med./low) 4. Capable of Silica removal 5. More plant references (conventional technology) 6. Common spare part for existing RO unit	1. Lower production of WP product than EDR process (lower %recovery) 2. Higher volume of waste water 3. Shorter life time (4-5 Years) than AFM+EDR 4. Higher energy consumption (due to higher Operating Pressure) 5. Not suitable for fluctuations of inlet (This will shorten the life time of the RO/UF media)
AFM+EDR	1. Able to cover full range of Total suspended solids (TSS) as specified in feed inlet condition 2. Capable of handling inlet process fluctuations 3. Lower transition time (higher availability) 4. Longer life time: (8-10 Years) 5. More robust and stable than RO system 6. Lower volume of waste water 7. Lower energy consumption (due to lower operating pressure)	1. Higher investment cost than UF+RO 2. Higher chance of silica ingress in WP make-up (due to incapable of removing silica) 3. Incapable of handling high TDS peak load 4. Required Step-up rectifier unit (DC power supply) 5. Less plant references (new technology)

- ISBL and OSBL requirement
- Estimated CAPEX (± 50%) and OPEX
- Plot space required vs. available plot space

7. Conclusions and Recommendations

Propose/recommend the most appropriate technology based on the technology evaluation results.

- At the end of this work process, PTTES recommended client on the most appropriate technology that can be used to treat the recycled drainage water to meet the cooling tower make-up water quality.
- PTTES also recommended to review/modify some equipment associated with the water treatment system and the way forwards on cost estimation and conceptual design.

Now the project is under approval in order to have a budget for performing FEED (basis of design for ± 30% CAPEX)

Want to learn more or get more details ? Great! How about a nice -

CALL-TO-ACTION

For more information, *please contact*
Ms. Jariya Oonmechai, at Jariya.o@pttes.com
Mr. Artit Wiwatwisansakul , at Artit.w@pttes.com
Mr. Teerapat Matchimapiro, at Teerapat.m@pttes.com