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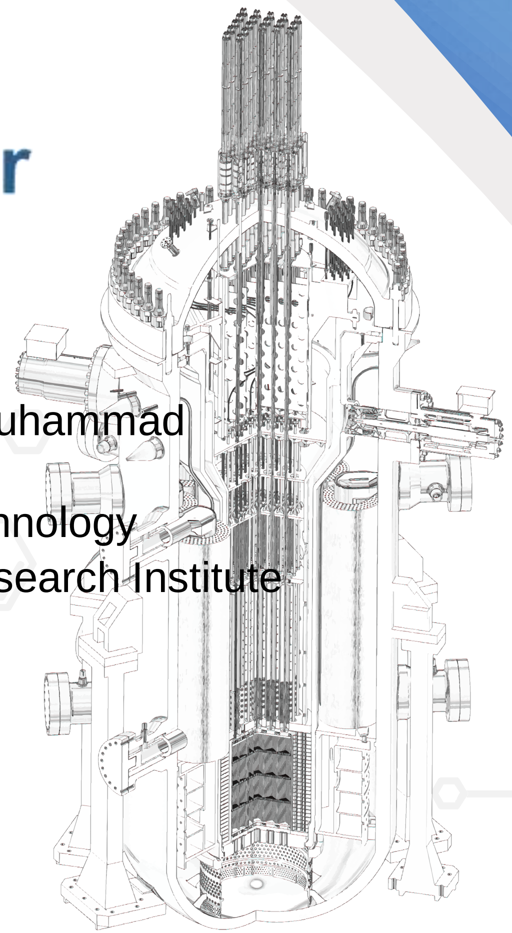
# Pretreatment laundry wastewater for removing organic surfactant



**Yessika Natalia Chelsie[a,b]**, Wang Kyu Choi[a,b], Hafiz Amir Nadeem[a,b], Muhammad Wasim Ikram[a,b], Seung Joo Lim[*a,b]

[a]Quantum Energy Chemical Engineering, University of Science and Technology

[b]Nuclear Facility Cleanup Technology Division, Korea Atomic Energy Research Institute

[*]*Corresponding author: seungjoolim@kaeri.re.kr*

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# 01 INTRODUCTION

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# 01 Characteristic of Laundry Wastewater

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- **Laundry wastewater** is generated from showering and washing activity of the workers in NPP site. This is classified as **LLW**.
- The volume can reach up to **4,000 ton/year**.

| Composition | Concentration (ppm) |
|---|---|
| $Na^+$ | 10 ~ 14.9 |
| $K^+$ | 0 ~ 1.4 |
| $Mg^{2+}$ | 1.1 ~ 2 |
| $Ca^{2+}$ | 3.4 ~ 6 |
| $Cl^-$ | 13.3 ~ 25 |
| $NO_3^-$ | 0.5 ~ 4.5 |
| $SO_4^{2-}$ | 6.8 ~ 8.8 |
| $NH_4^+$ | 12 ~ 34 |
| Surfactant | 65 ~ 200 |

| Nuclides | Activity (Ci/mL) |
|---|---|
| $^{134}Cs$ | 1.3 ~ 148.6×$10^{-14}$ |
| $^{137}Cs$ | 5.9 ~ 1.1×$10^{-14}$ |
| $^{58}Co$ | 1.5 ~ 2.32×$10^{-13}$ |
| $^{60}Co$ | 3 ~ 213.5×$10^{-13}$ |
| $^{54}Mn$ | 2.4 ~ 143.2×$10^{-13}$ |
| $^{95}Zr$ and $^{95}Nb$ | 2.7 ~ 189.1×$10^{-13}$ |
| $^{59}Fe$ | 8.1 ~ 151.4×$10^{-14}$ |

Source: Composition of Kori NPP's [1], MosNPO Radon Rusia [2], and other radioactive laundry wastewaters [3], [4], [5]

# 01 Conventional & Developing Technologies

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## Conventional technology:

- Korea, Rusia: Treated with NPP's liquid radioactive waste system → MF and evaporation [1,2,8]
- KANUPP-1 Pakistan : <4 x $10^{-7}$ nuCi/mL → Dilute and discharge to the sea [9]

## Developing treatment method:

| Reference | Treatment Method |
|---|---|
| Kursk in Rusia [7] | **Ozonizing** – Microfiltration – Sorption |
| KEPCO [1] | **UV/$H_2O_2$ photo-oxidation** – Reverse Osmosis |
| Japan [3] | Reverse Osmosis |
| Ref Fang et. al [4] | Inorganic ion exchange using zeolite 4A |
| Ref Park et. al [5] | AMP-PAN |
| Ref Yong et. al [6] | **Flocculation** – Microfiltration |

# 01 Proposed Pretreatment Method

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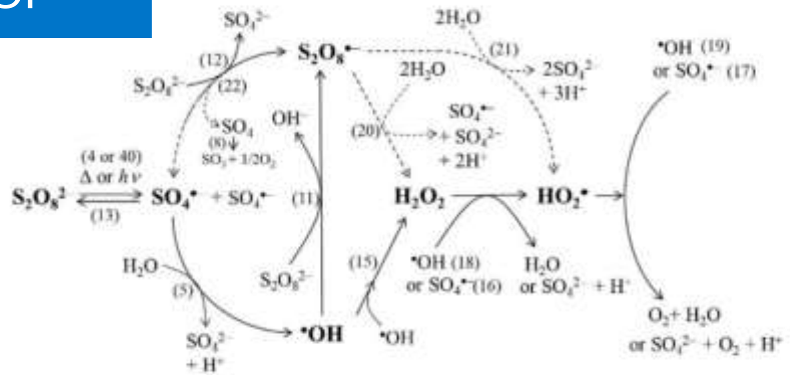
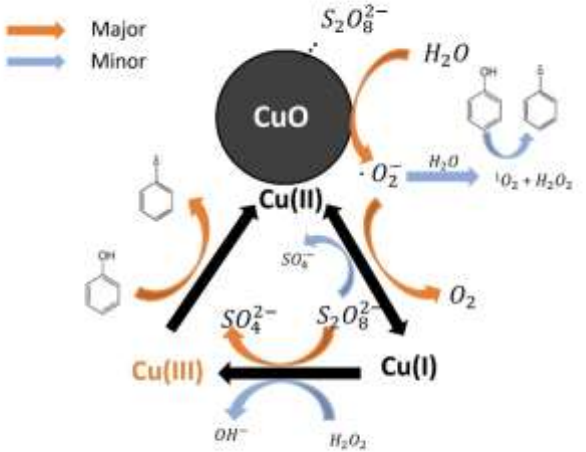
## AOP

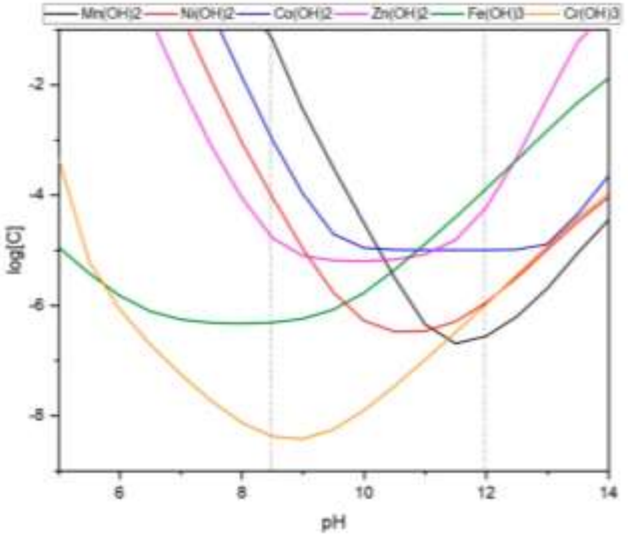


Scheme of Overall mechanism of the thermal (3<pH<13) and the photolytic decomposition of PDS [10]




Scheme of phenol transformation mechanisms in CuO/PDS system [11]

## Precipitation




Graph of Solubility of Several Metal Hydroxides as Function of pH [12]

**Research Objective:**
To investigate the pretreatment effect combining a precipitation using $Ca(OH)_2$ and AOP using peroxy disulfate at basic pH on laundry wastewater

# Comparison of Conventional and Recommended Method



## Disadvantages of conventional technologies

- Fouling effect on evaporator or membrane technologies
- Lots of secondary waste of spent IERs (ion exchange resin) → either storing in PC-HIC/PE-HIC or regenerate the resins
- High cost of ozonation process
- Longer time of conventional organic decomposition process

## Advantages of recommended method

- Degraded surfactant and/or insoluble form of Ca-surfactant
- Minimize secondary waste generation of IERs
- Cost-effective method compared to ozonation process
- Take a short time to decompose organic compound

# 02 EXPERIMENT

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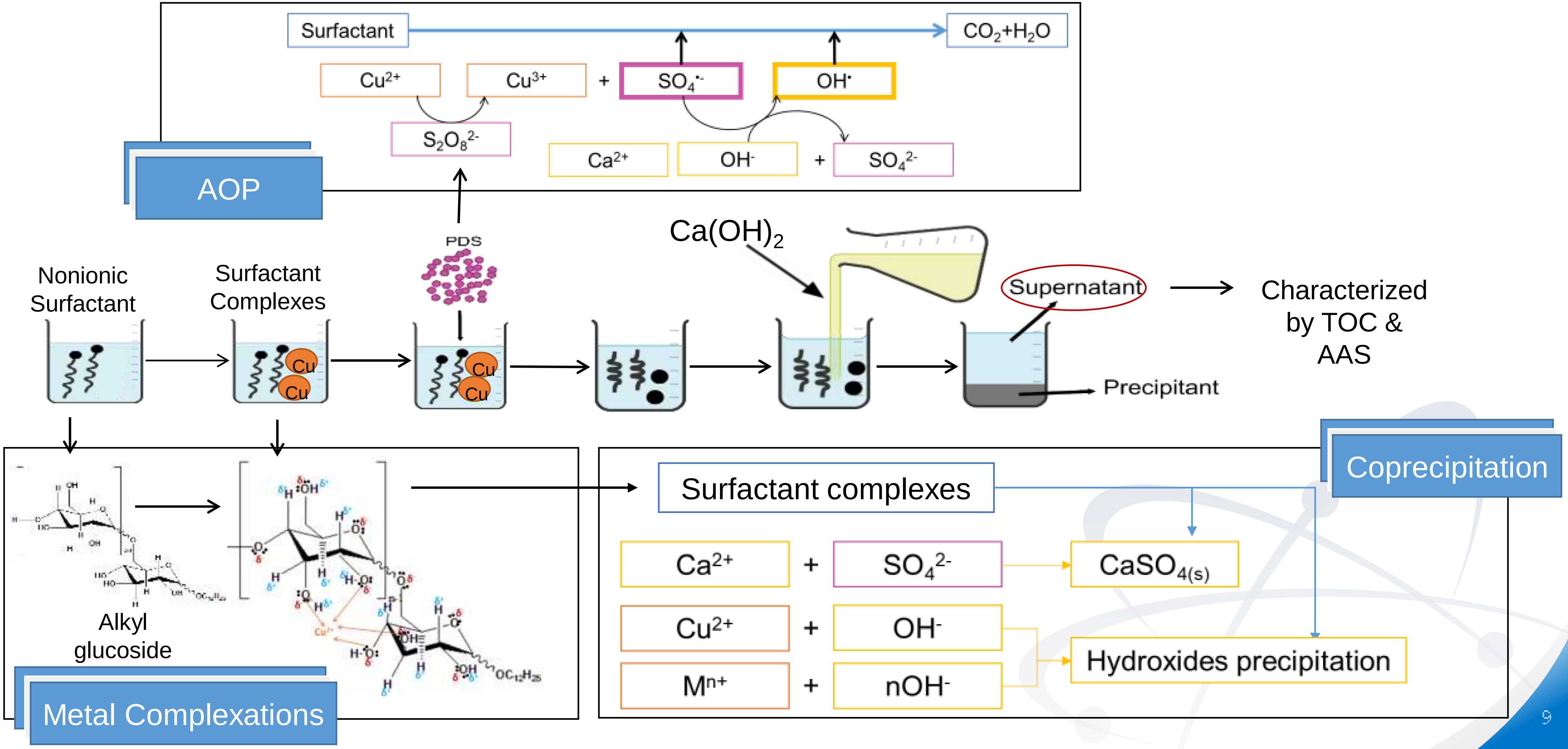
# Proposed Method





# 03 RESULTS

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# Effects of $Cu^{2+}$ and PDS concentration

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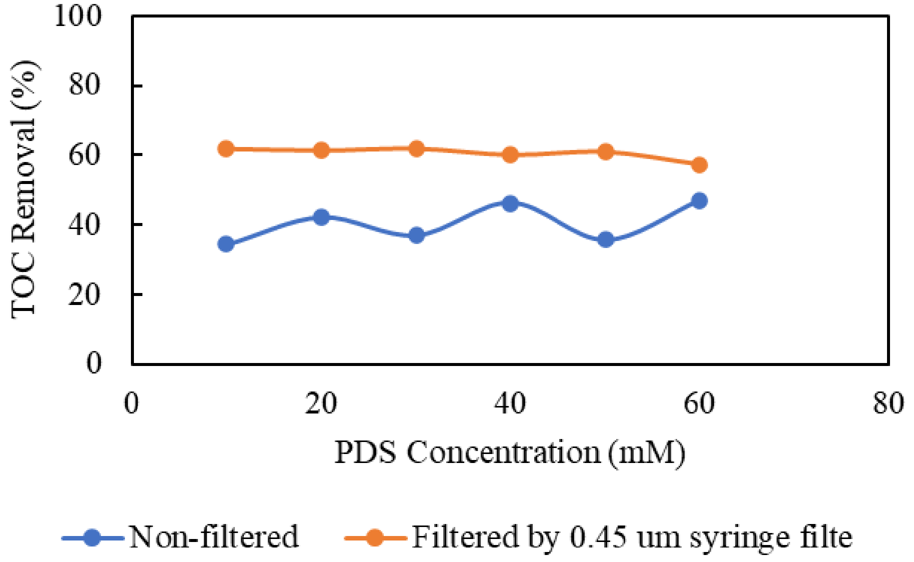
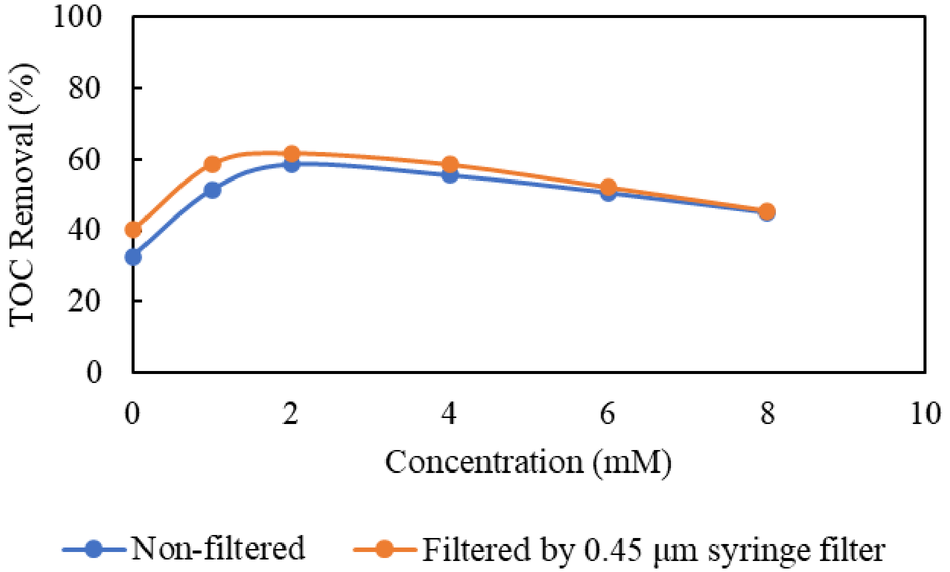
- The TOC removal of samples fluctuated around 30-45% in varied PDS concentration. After filtration, the TOC removal became higher or 57-63%.
- For the Cu experiments, the TOC removal increased sharply up to 2 mM Cu.



# 03 Effects of $Ca(OH)_2$ Injection

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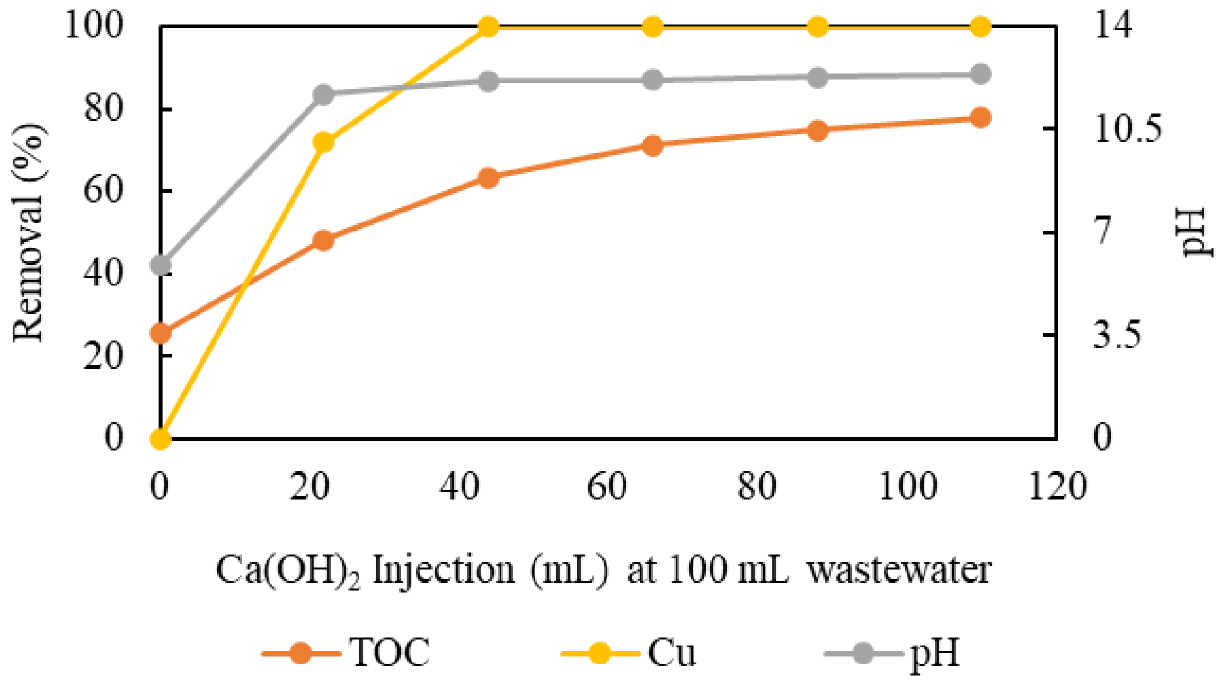
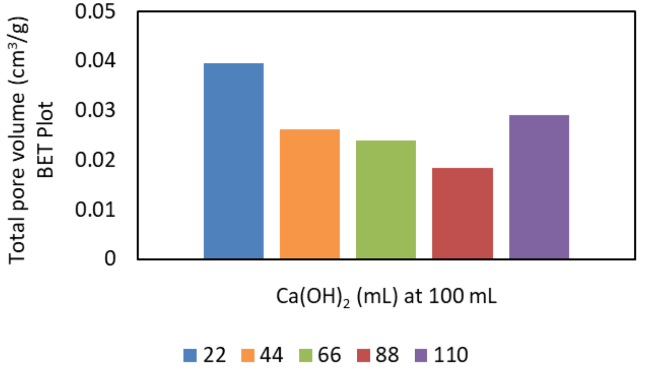
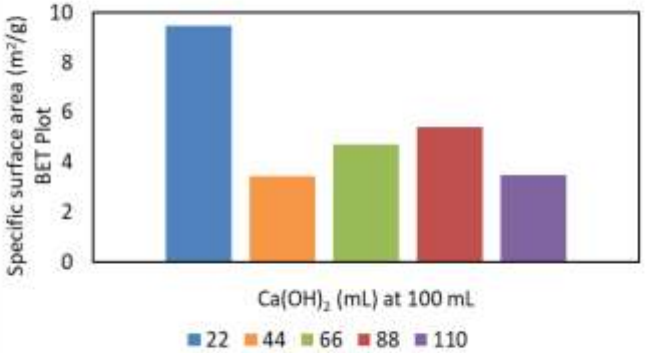
- As the volume injection of $Ca(OH)_2$ increased, the TOC removal also increased.
- Cu was almost completely removed at 44 mL $Ca(OH)_2$ earlier than TOC.
- The dominant reaction that control the overall methods is precipitation.

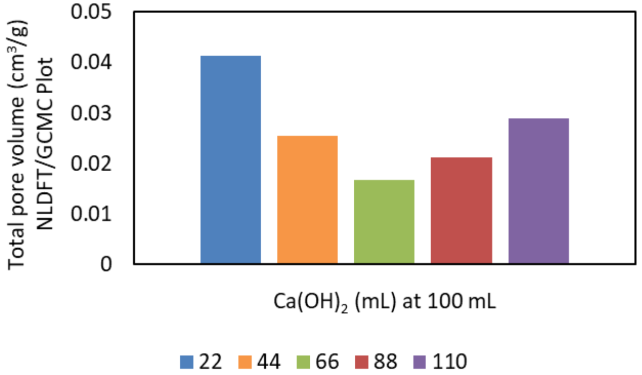


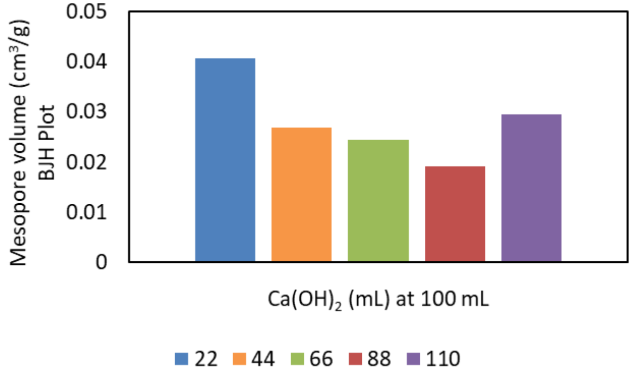
# 03 Characterization: XRD and BET

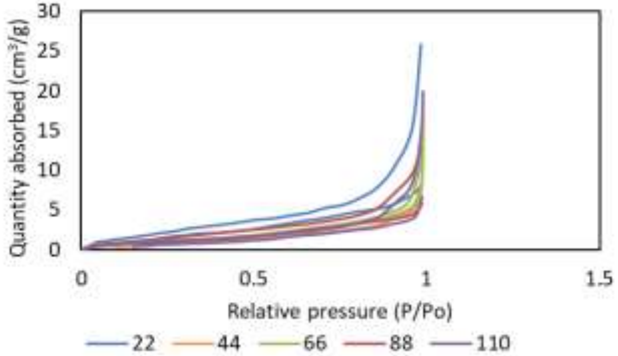


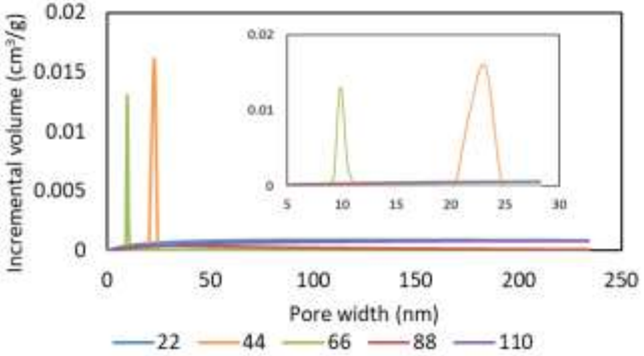


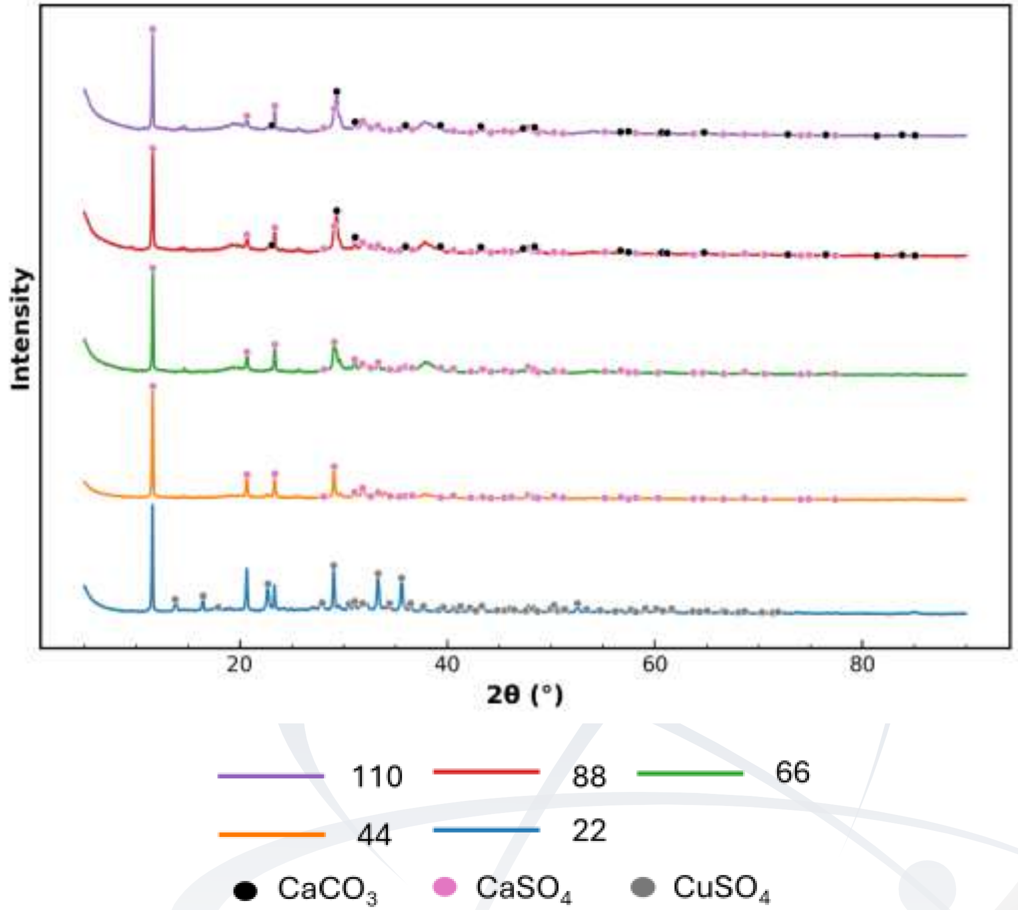



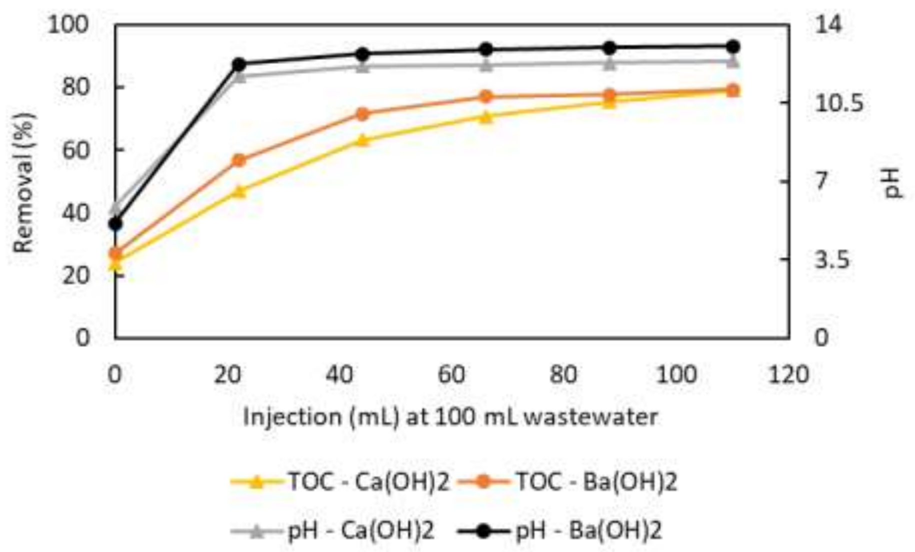



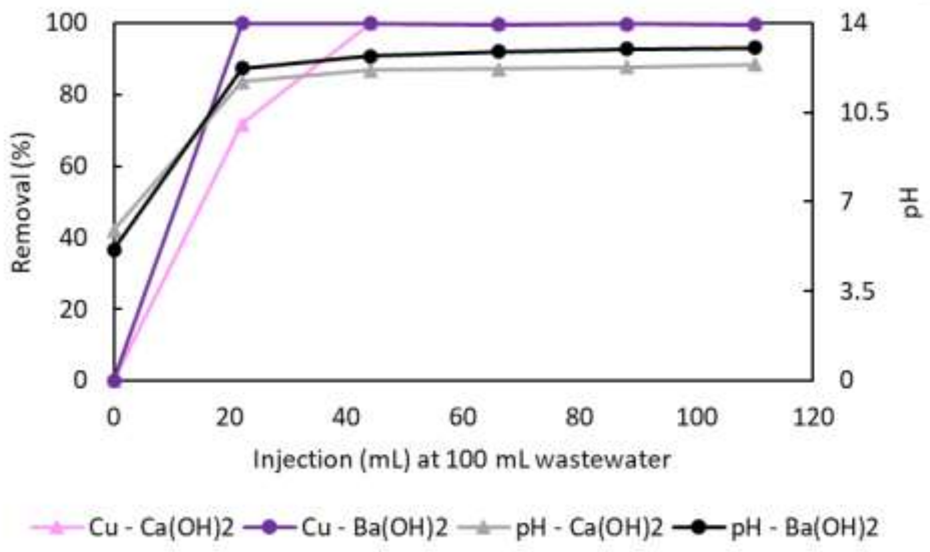



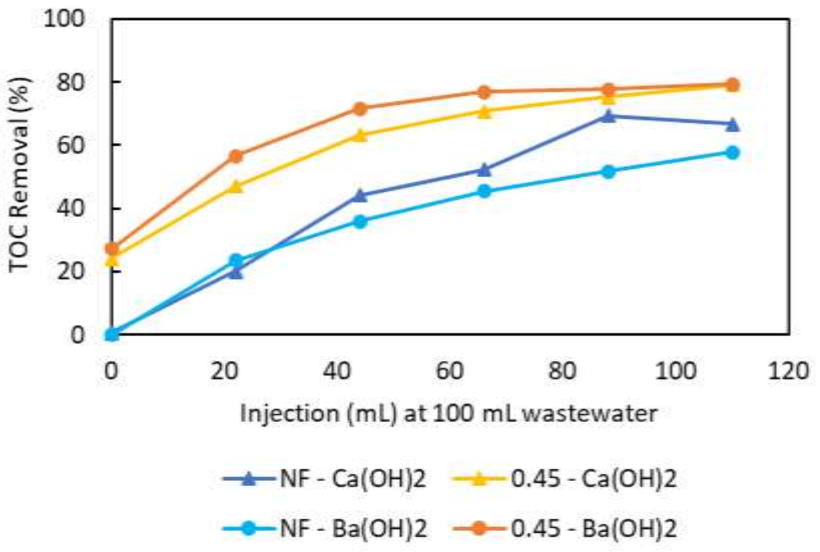



# Comparison with $Ba(OH)_2$ Performance



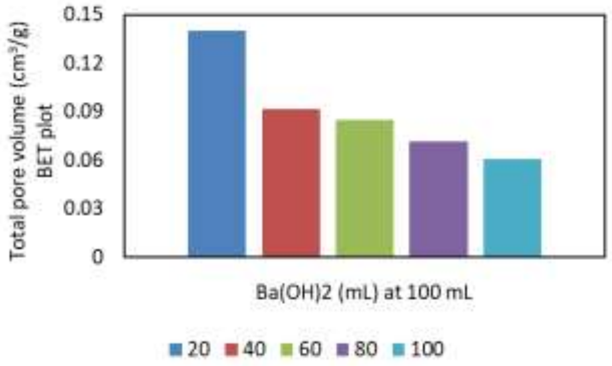



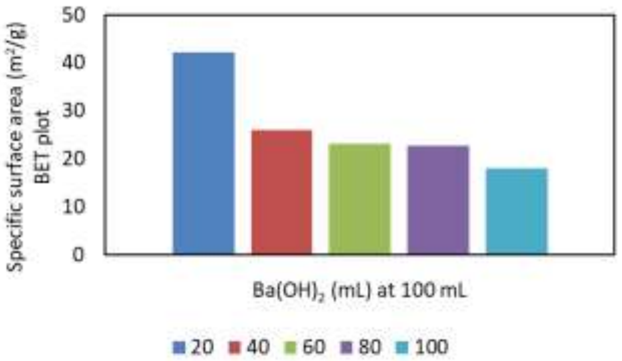



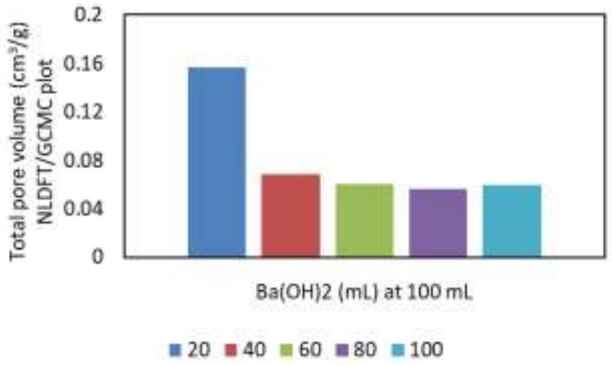

- TOC removal of $Ba(OH)_2$ was slightly higher $Ca(OH)_2$.
- Cu removal was almost complete with $Ba(OH)_2$ already at 20–40 mL

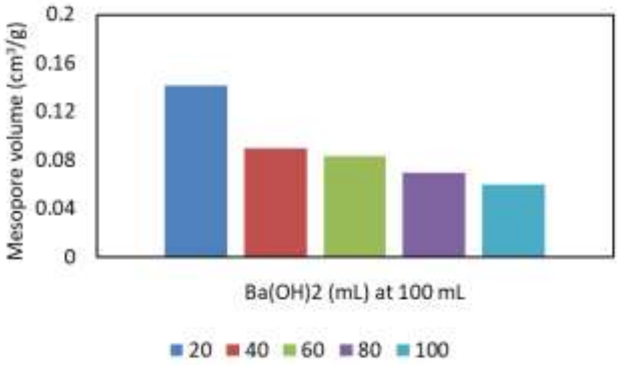
# Comparison with $Ba(OH)_2$ Characterization

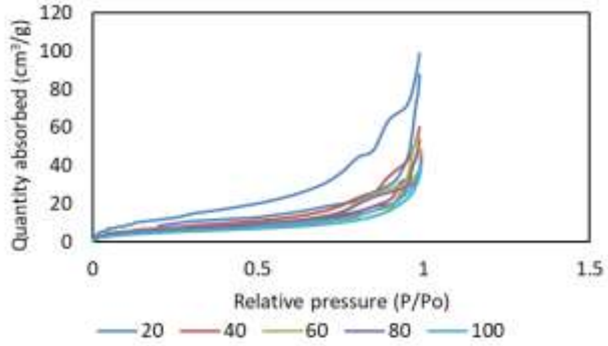


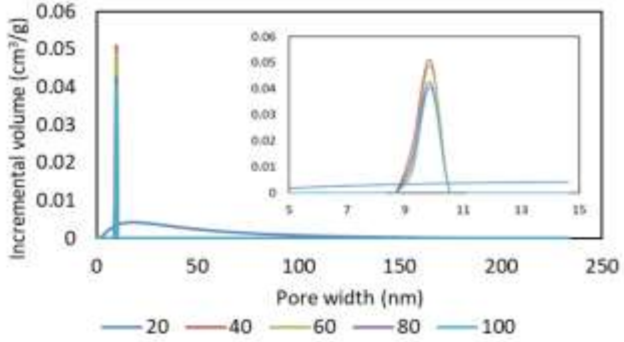


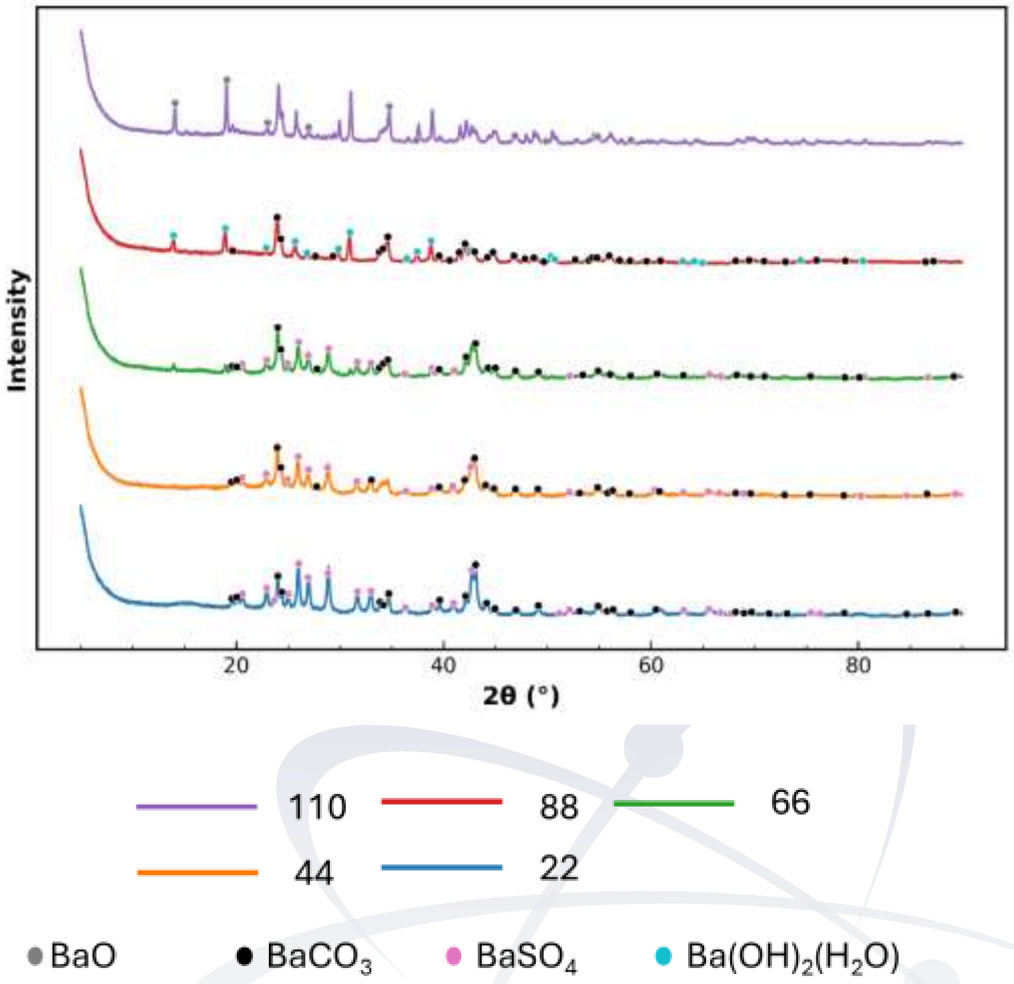



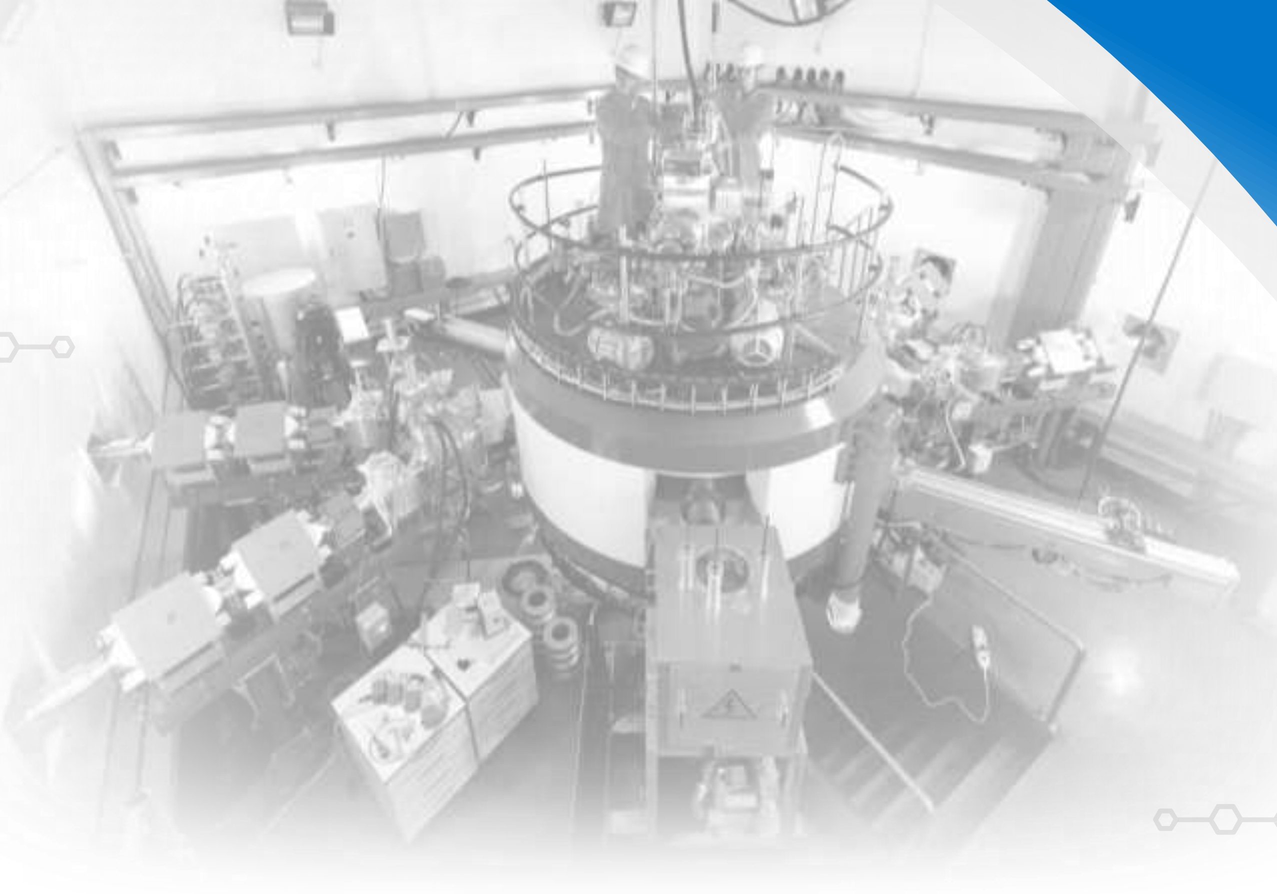





# 04 CONCLUSION

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# 04 Conclusion



- In this study, the pretreatment effect combining a precipitation using $Ca(OH)_2$ a nd AOP was investigated.
- The **surfactant decomposition** by the catalyst-persulfate and its removal through **calcium-surfactant precipitation** occurred simultaneously upon $Ca(OH)_2$ injection.
- **The highest TOC removal efficiency was 78%** by injecting 2 mM of $Cu^{2+}$, 10 mM of PDS, and 110 mL of $Ca(OH)_2$. This result can be achieved within 0-minute sedimentation time. So, the total reaction time for this process is 10 minutes.
- Based on these findings, the recommended method can be one of **the capable candidates** of laundry wastewater treatment in industrial scale. However, still there is there is the necessity to evaluate this optimum condition in other surfactant types and concentrations and also in actual laundry wastewater.

# 04 Future Plan



- Although radionuclides were not specifically targeted, in the next experiment Cs and Co will be incorporated in the simulated wastewater.
- Apply plasma treatment to the separated sludge to reduce volume and improve stability to verify compliance with disposal standards.

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Pretreatment System For Removing Surfactant

# THANK YOU

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# References

[1] J.-K. Park, S.-M. Park, J.-B. Kim, M.-C. Lee, and M.-J. Song, “Radioactive Laundry Waste Treatment System Without Secondary Waste Generation,” Mar. 2000.
[2] Y. Karlin, D. Gorbachev, A. Volkov, and A. Barinov, “Advantageous Technology For Treatment Of Laundry Waters,” Feb. 2001.
[3] M. Kikuchi, H. Sugimoto, H. Yusa, and K. Ebara, “Development of a laundry waste treatment system,” Apr. 1977.
[4] X. Fang, Z. Xu, Y. Luo, L. Ren, and W. Hua, “Removal of radionuclides from laundry wastewater containing organics and suspended solids using inorganic ion exchanger,” 2016.
[5] Y. Park, Y.-C. Lee, W. S. Shin, and S.-J. Choi, “Removal of cobalt, strontium, and cesium from radioactive laundry wastewater by ammonium molybdophosphate-polyacrylonitrile (AMP-PAN),” Jun. 2010.
[6] G. Yong *et al.*, “Treatment of the wastewater containing low-level 241Am using flocculation-microfiltration process,” *Separation and Purification Technology*, vol. 40, no. 2, pp. 183–189, Dec. 2004, doi: 10.1016/j.seppur.2004.02.009.
[7] Y. I. Slepokon, V. V. Milyutin, E. Kozlitin, and V. M. Gelis, “Application of the Sorption-Membrane Technologies for Liquid Radioactive Waste Processing at Kursk NPP.”
[8] Ministry of Environment, Republic of Korea, “[별표 13] 수질오염물질의 배출허용기준(제34조 관련) [Annex Table 13: Standards for permission of discharge of water pollutants],” Enforcement Rules of the Water Environment Conservation Act, amended Dec. 10, 2021. (PDF).
[9] Rizvi, M.H. and Abbas, M., “Advances in implementing strategy for management of radioactive waste in Pakistan”, in *Radioactive Waste Management: Solutions for a sustainable future, proceedings of an international conference, held in Vienna, Austria, 1-5 November 2021*. Vienna: International Atomic Energy Agency. 2021
[10] C. Lee, Hak-Hyeon Kim, N.-B. Park, ”Chemistry of persulfates for the oxidation of organic contaminants in water,”.2018.
[11] C. Li, V. Goetz, and S. Chiron, “Peroxydisulfate activation process on copper oxide: Cu(III) as the predominant selective intermediate oxidant for phenol and waterborne antibiotics removal,” *Journal of Environmental Chemical Engineering*, vol. 9, no. 2, p. 105145, Apr. 2021, doi: 10.1016/j.jece.2021.105145.
[12] A. Rivonkar *et al.*, “Optimisation of the chemical oxidation reduction decontamination process (CORD) on surrogate stainless steel in regards to its efficiency and secondary wastes,” Dec. 2022, doi: 10.3389/fnuen.2022.1080954.