Potential Continuous Electrocoagulation for The Treatment of Coal Mine Water Containing Colloidal Clays

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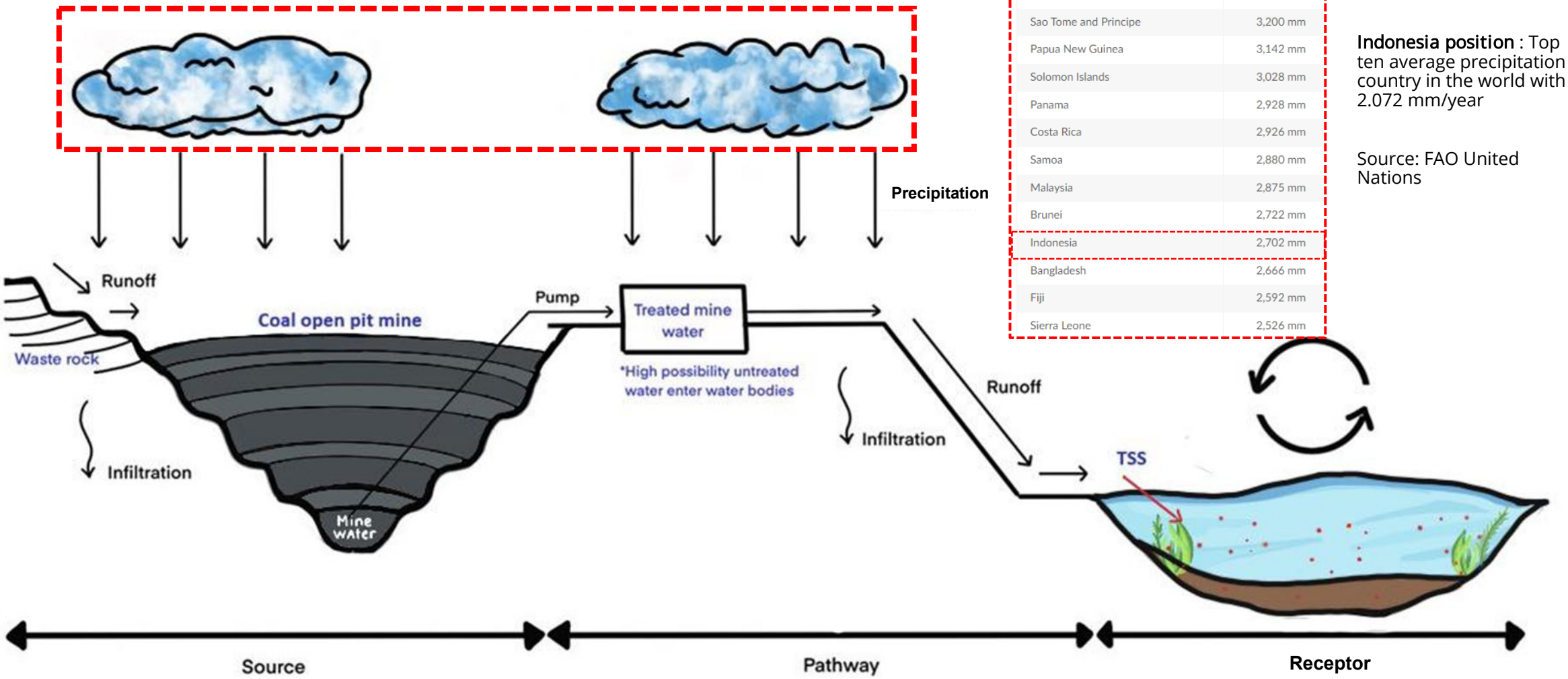
INTRODUCTION



Average precipitation in depth (mm per year) mm per year

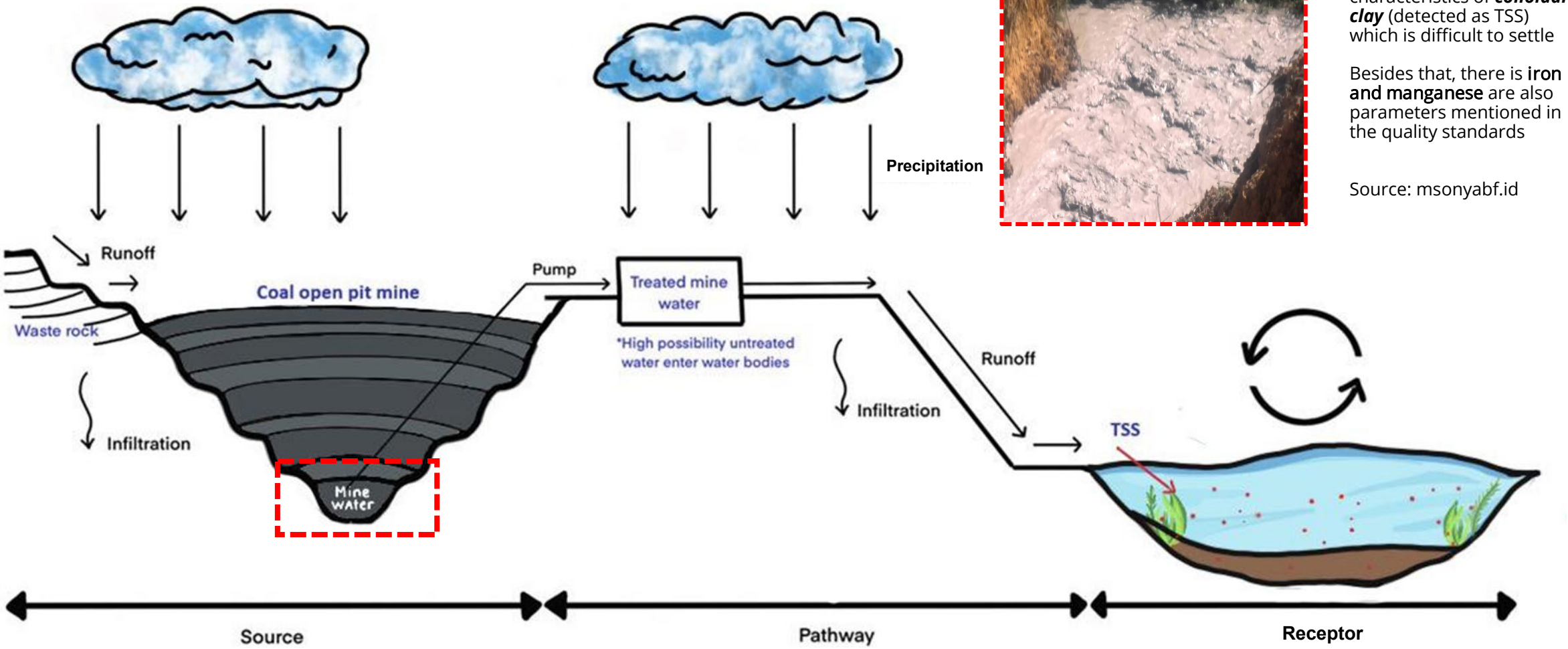
Country or region	↑ 2019
Colombia	3,240 mm
Sao Tome and Principe	3,200 mm
Papua New Guinea	3,142 mm
Solomon Islands	3,028 mm
Panama	2,928 mm
Costa Rica	2,926 mm
Samoa	2,880 mm
Malaysia	2,875 mm
Brunei	2,722 mm
Indonesia	2,702 mm
Bangladesh	2,666 mm
Fiji	2,592 mm
Sierra Leone	2,526 mm

Indonesia position : Top ten average precipitation country in the world with 2.072 mm/year

Source: FAO United Nations

Source : Modified from Farahnaz, 2024
(research maps for 2024 lead by Abfertiawan)

INTRODUCTION



Mine water has the characteristics of ***colloidal clay*** (detected as TSS) which is difficult to settle

Besides that, there is **iron and manganese** are also parameters mentioned in the quality standards

Source: msonyabf.id

Source : Modified from Farahnaz, 2024
(research maps for 2024 lead by Abfertiawan)

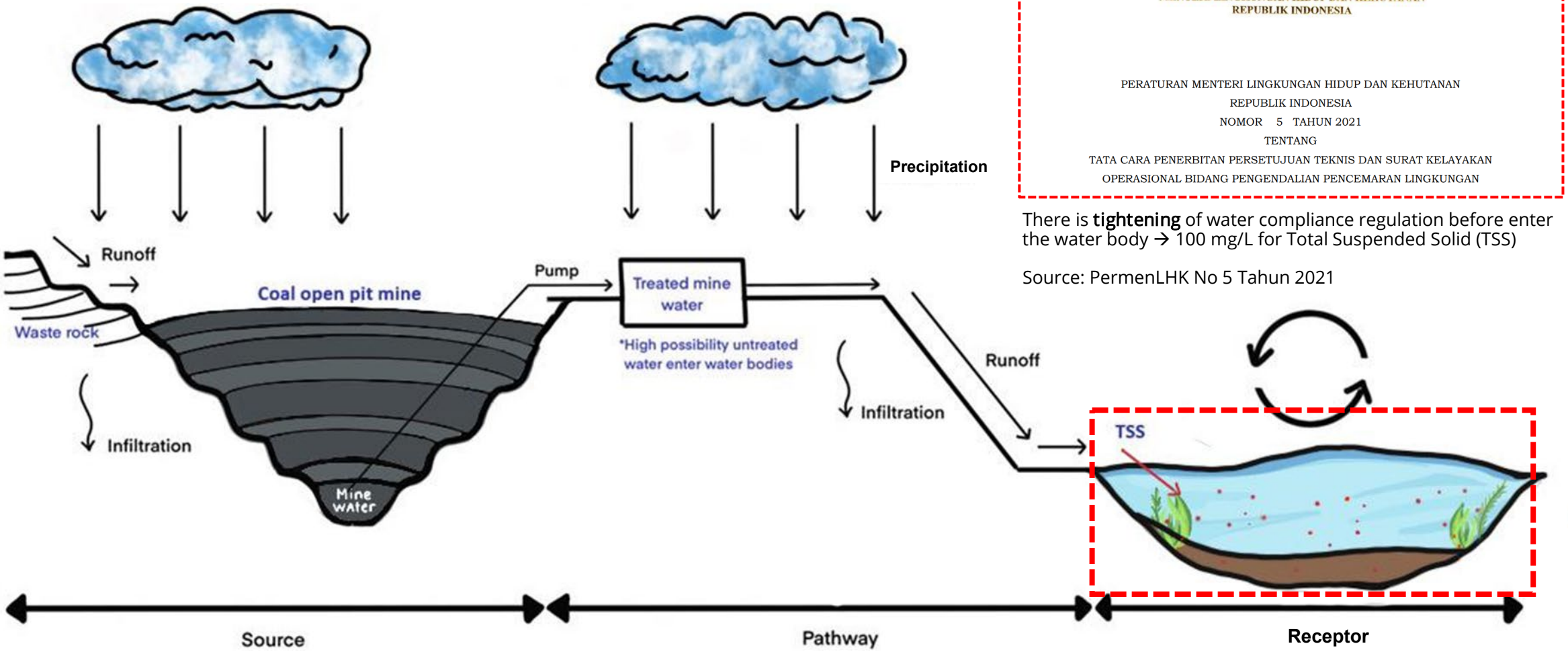
INTRODUCTION

The mine water discharge processed in the settling pond is **exceeding large** → high consumption of chemical coagulant

Source: PPT KPC – FKPLPI 2023

Source : Modified from Farahnaz, 2024
(research maps for 2024 lead by Abfertiawan)

INTRODUCTION



MENTERI LINGKUNGAN HIDUP DAN KEHUTANAN
REPUBLIK INDONESIA

PERATURAN MENTERI LINGKUNGAN HIDUP DAN KEHUTANAN
REPUBLIK INDONESIA
NOMOR 5 TAHUN 2021
TENTANG
TATA CARA PENERBITAN PERSETUJUAN TEKNIS DAN SURAT KELAYAKAN
OPERASIONAL BIDANG PENGENDALIAN PENCEMARAN LINGKUNGAN

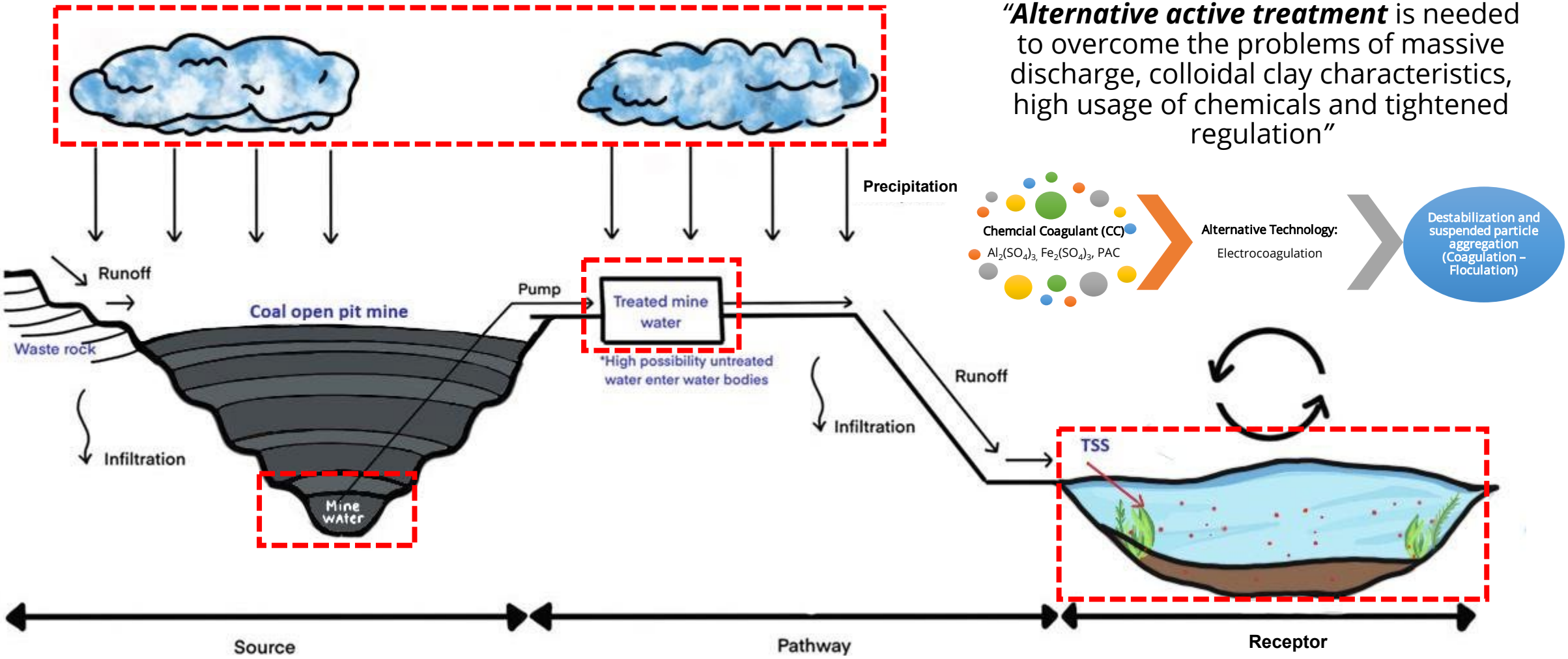
There is **tightening** of water compliance regulation before enter the water body → 100 mg/L for Total Suspended Solid (TSS)

Source: PermenLHK No 5 Tahun 2021

Source : Modified from Farahnaz, 2024
(research maps for 2024 lead by Abfertiawan)

INTRODUCTION

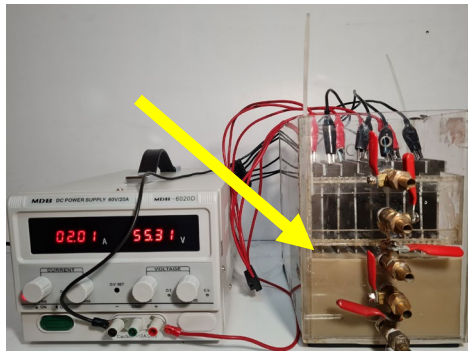
"***Alternative active treatment*** is needed to overcome the problems of massive discharge, colloidal clay characteristics, high usage of chemicals and tightened regulation"



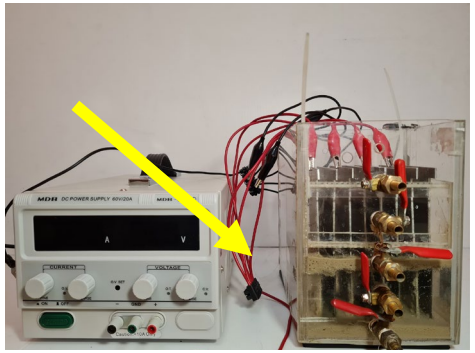
Source : Modified from Farahnaz, 2024
(research maps for 2024 lead by Abfertiawan)

INTRODUCTION

Batch Result



Before The Batch Experiment



After The Batch Experiment

The Result

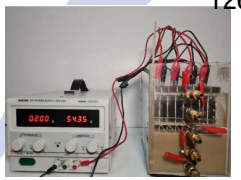
Continuous (Synthetic Mine Water) Result

Continuous Experiment

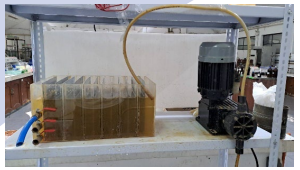
The Results
(Continuous – synthetic mine water)

RESEARCH POSITION

[2022]
Batch Operation – Lab Scale



5400 mg/L → 22.84 mg/L (99,58%)



1260 mg/L → 45 mg/L (96,43%)

[2023]
Continuous Operation – Lab Scale

[2024]
Continuous Operation – Field Scale
(Natural Mine Water)

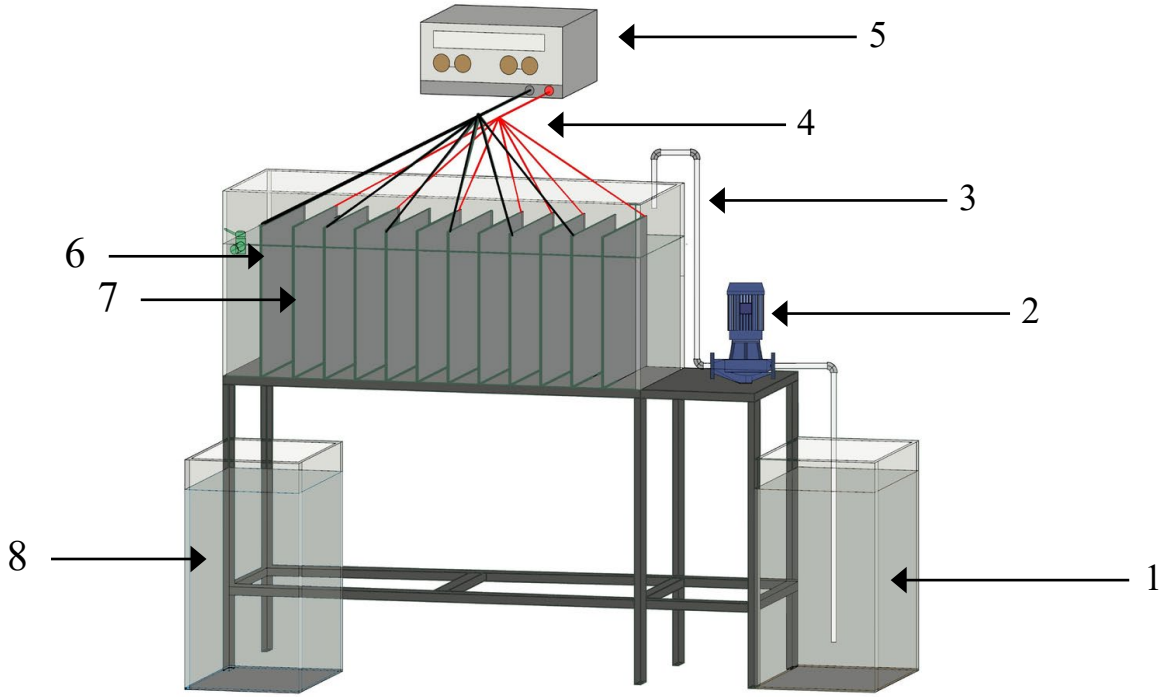
[2025]
Continuous Operation – Field Scale
(Cell arrangement & Electrode behaviour)

[2026]
Continuous Operation – Field Scale
(Reactor Design, Effect of pre/post treatment & Construction in field)

[2027]
Mine Water Treatment Plant for High Total Suspended Solid [Electrocoagulation – Implemented]

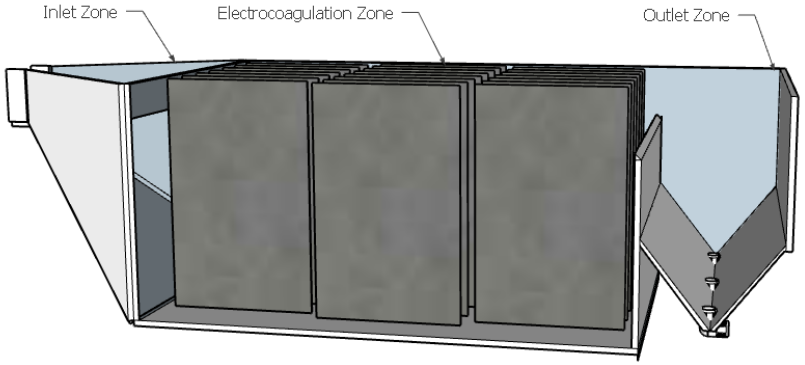
"Electrocoagulation technology provides promising results in removing Total Suspended Solid, but further understanding is needed regarding removal from natural mine water"

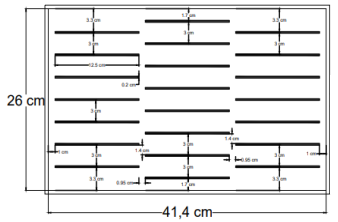
METHODS



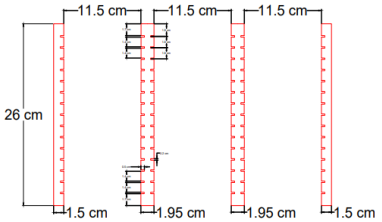
1. Raw Mine Water
2. Peristaltic Pump
3. Inlet Pipe
4. Electric Cable
5. DC Power Supply
6. Cathode Electrode
7. Anode Electrode
8. Treated Wastewater

Electrocoagulation *set-up*
Modified from : Ghazali, 2023

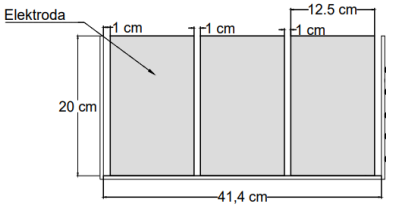




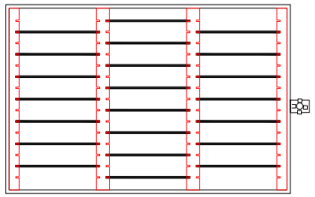
Top View



Frame



Side View



Top View + Frame

Reactor Illustration

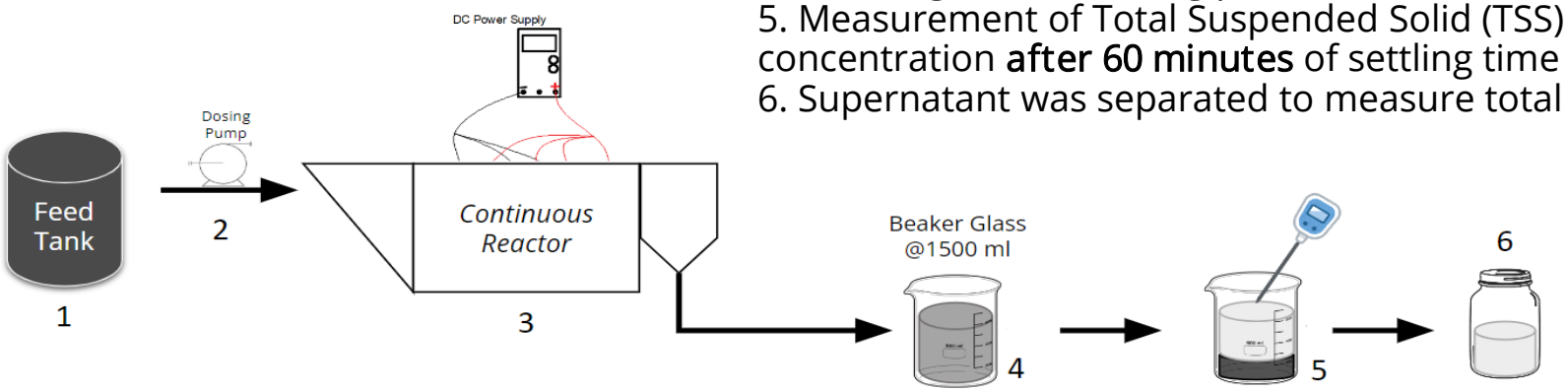
METHODS

Electrocoagulation and Chemical Coagulation

Design	Sample	Electrodes	Variable
Acrylic Reactor, 15 L Continuous Operation	Actual mining water from one of the settling ponds of coal mines in East Kalimantan	39 alumunium electrodes, 12.5 x 20 x 0.2 cm, Effective area (anode) 0.0175 m^2	Discharge variation (0.3, 0.5, 0.7 L/min) Current Density (16.3, 19, 21.7 A/m^2)

Operation Scheme

1. Feed tank
2. Peristaltic pump
3. Continuous reactor
4. Beaker glass for settling process
5. Measurement of Total Suspended Solid (TSS) concentration **after 60 minutes** of settling time
6. Supernatant was separated to measure total iron



Chemical Coagulation

400 – 700 mg/L

$Al_2(SO_4)_3$
Poly Aluminium Chloride
Polyacrylamide

INITIAL CONCENTRATION

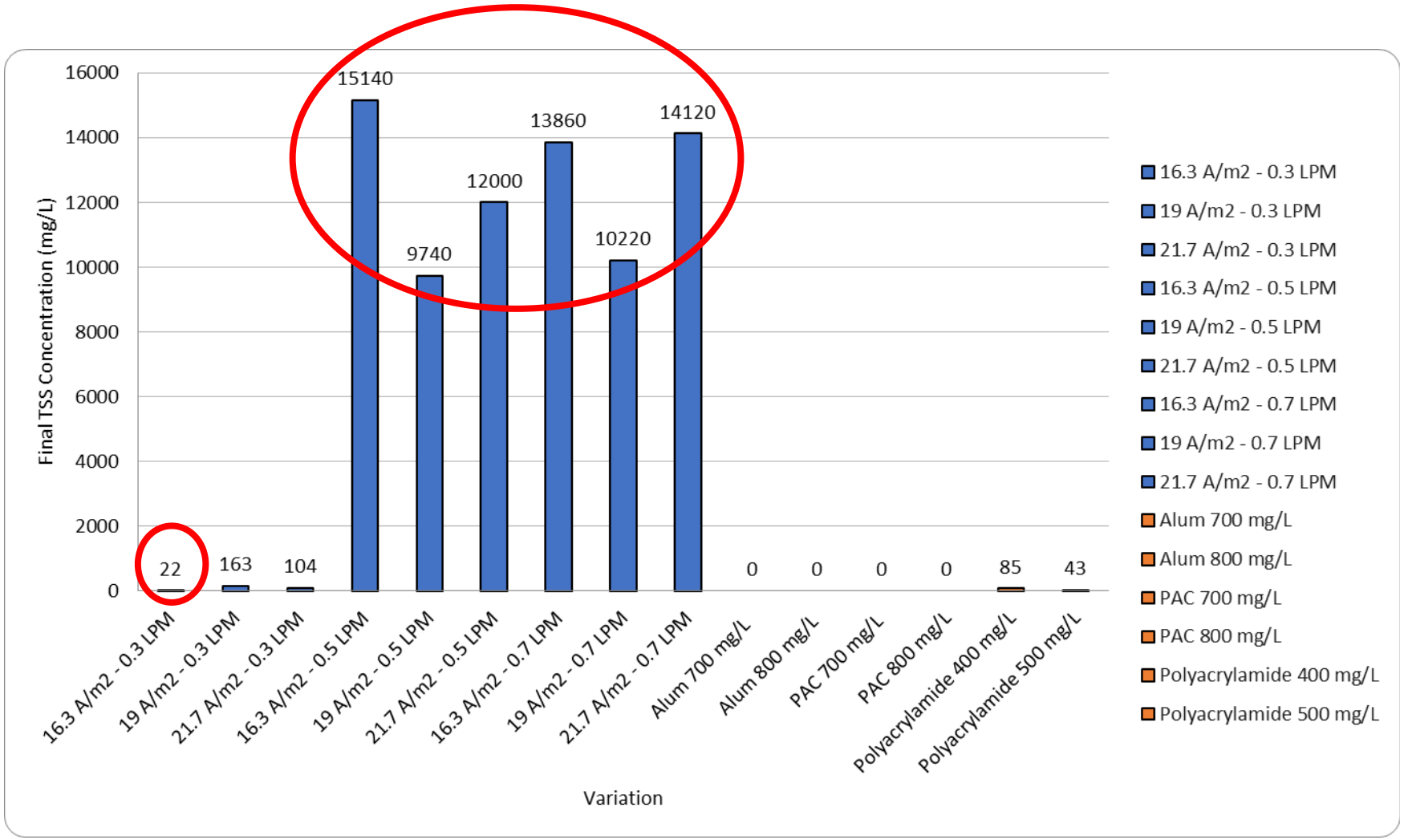
No	Parameters	Unit	Value	Quality Standard *)	Analysis Method
1	pH	-	**7.46**	6-9	pH Meter
2	Conductivity	µS/cm	**905**	-	Conductivity Meter
3	ORP	mV	**-43.88**	-	Thermometer
4	TDS	mg/L	**440.3**	1000	TDS Meter
5	TSS	mg/L	**15,730**	300	Gravimetry
6	Fe (total)	mg/L	**14.65**	7	*Atomic Absorption Spectroscopy* (AAS)

*) Government Regulation of The Republic of Indonesia, Water Quality Management and Water Pollution Control

pH, ORP, TDS and Conductivity Measurement

Total Iron (Fe) Measurement

RESULTS AND DISCUSSION



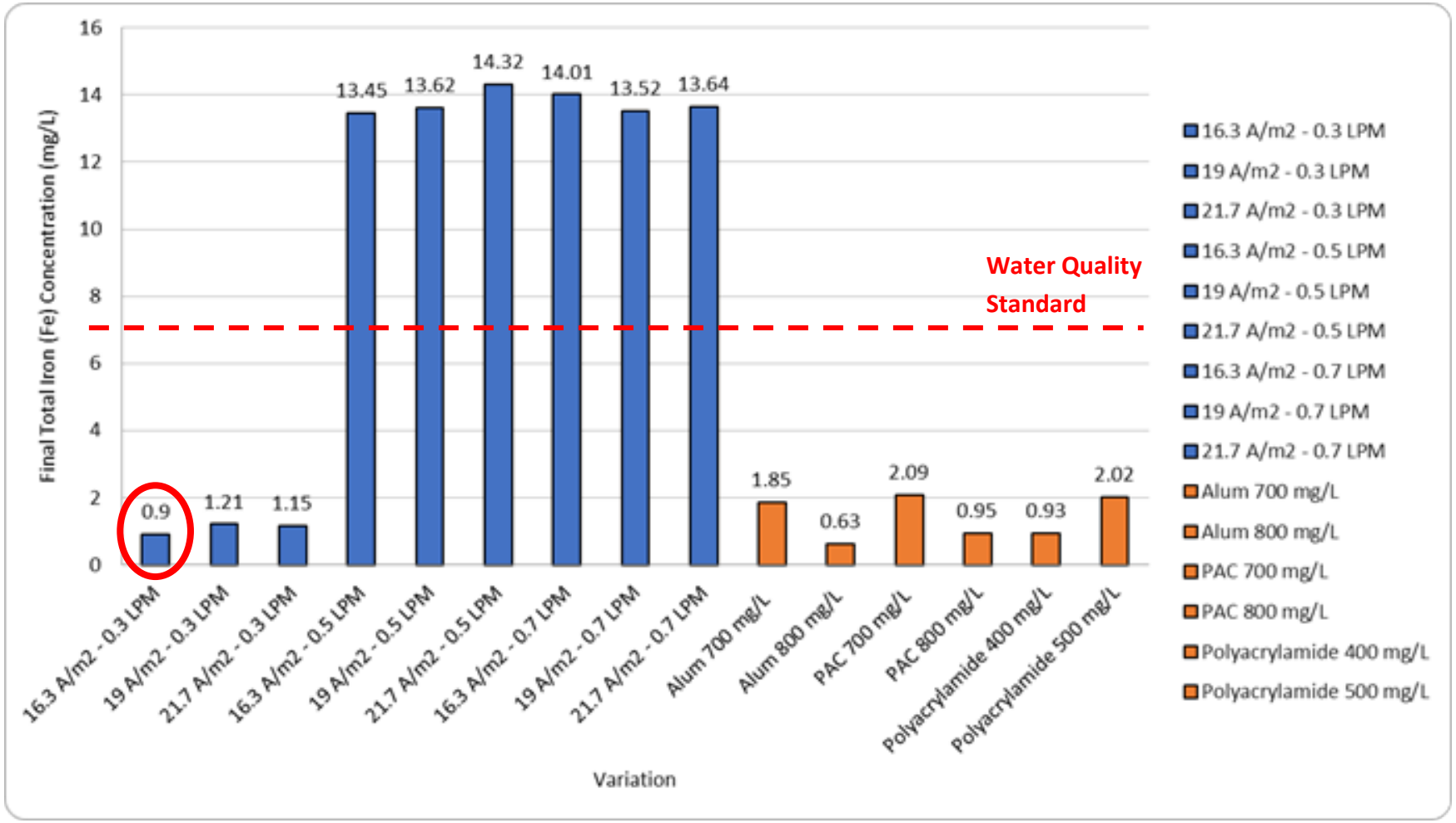
15,730 mg/L

22 mg/L

Highest Percentage of TSS Removal (Electrocoagulation)

99.87%

RESULTS AND DISCUSSION



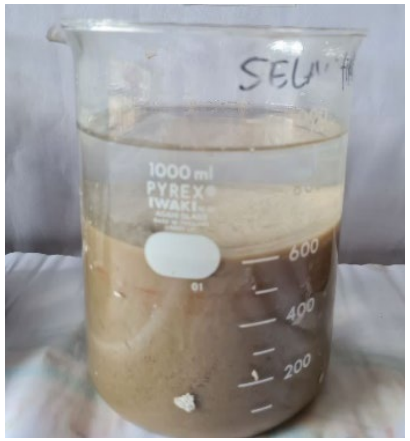
14.65 mg/L

0.9 mg/L

Highest Percentage of Total Iron Removal (Electrocoagulation)

93%

RESULTS AND DISCUSSION



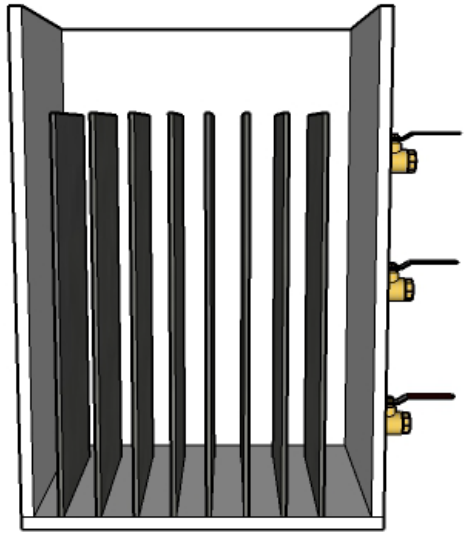
Electrocoagulation after 60 minutes of settling time in 16.3 A/m^2 – 0.3 L/min variation

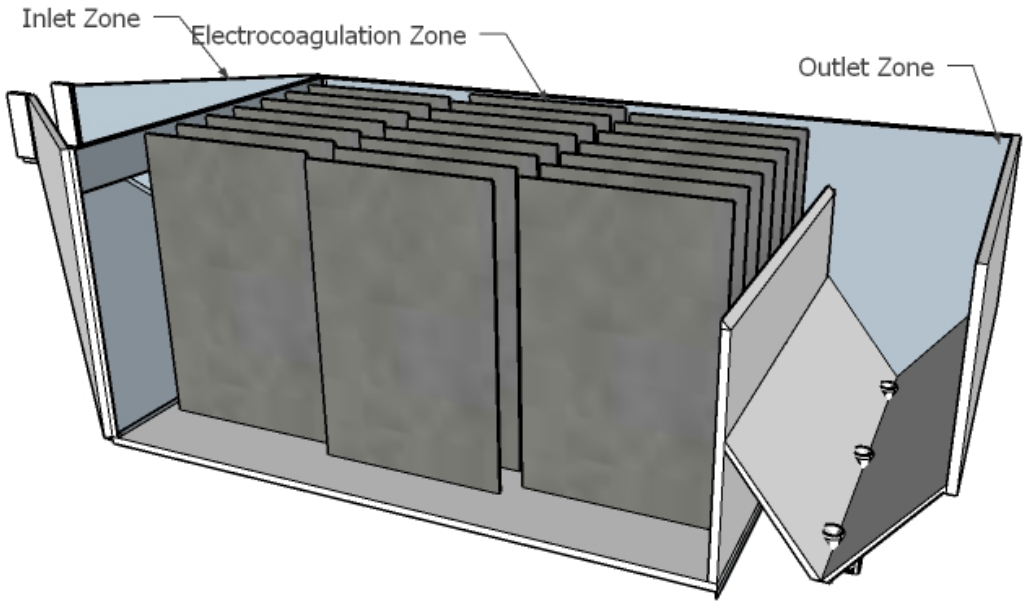
Dead zones in reactor

Dead zone causes mass transfer to be disrupted and the electrocoagulation process is not optimal.

Further research is needed on cell geometry and reactor design suitable for mine water with high colloidal clay content

FURTHER RESEARCH





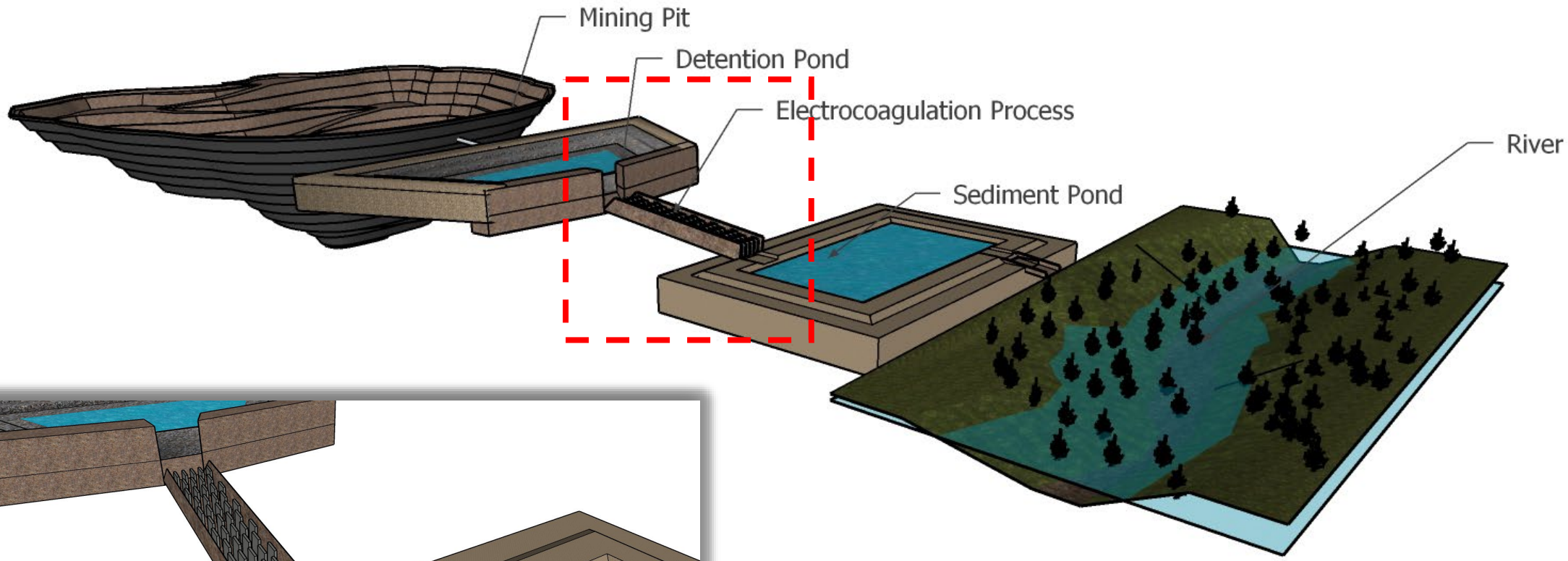
Batch Reactor (2022)

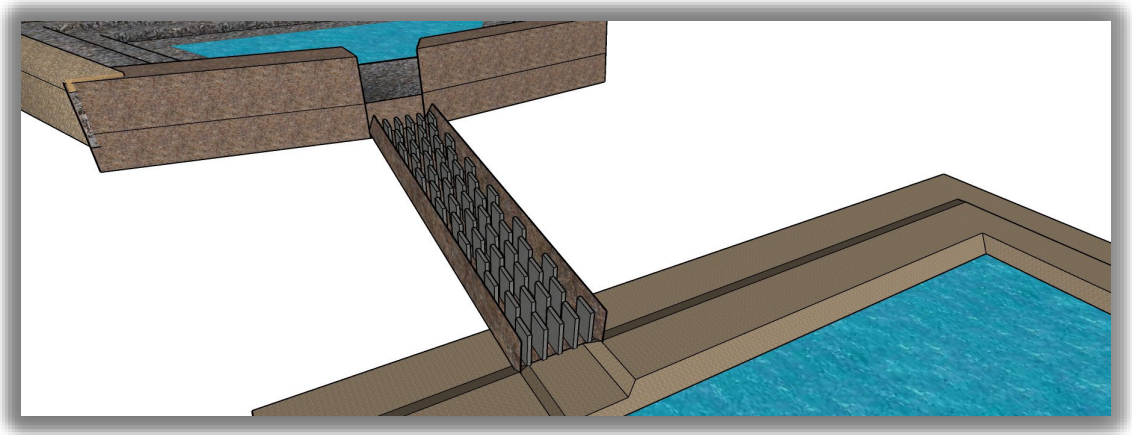
Continuous Reactor

(2023-2025)

(This Research Position)

FURTHER RESEARCH

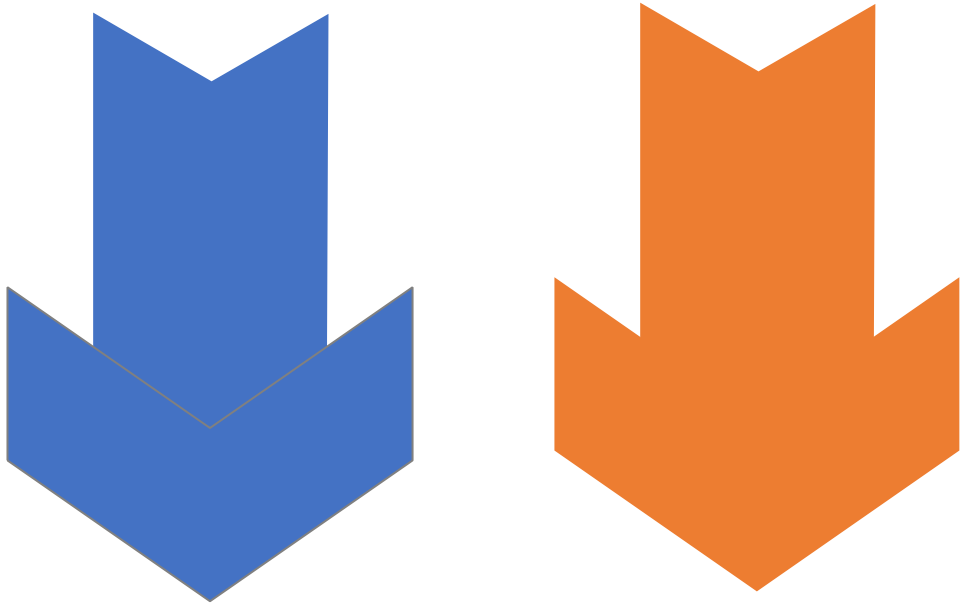




Scale up Illustration

(2026-2027)

CONCLUSION



Optimum variation **16.3 A/m²**
with a discharge of **0.3 Liter/min**

99.87 % → TSS Removal

93 % → Total Iron Removal

Electrocoagulation method to remove colloidal clay in mine water still requires exploration to find the

“optimum design”

REFERENCES

ACKNOWLEDGMENT

This study was supported by the Bandung Institute of Technology through the Water and Wastewater Engineering Research Group (KK-RALC) and the Environmental Department of PT. Kaltim Prima Coal.

REFERENCES

Abfertiawan, M. S., Gautama, R. S., Kusuma, S. B., & Notosiswoyo, S. (2016). Hydrology Simulation of Ukud River in Lati Coal Mine. Evergreen, 3(1), 21–31. https://doi.org/10.5109/1657737

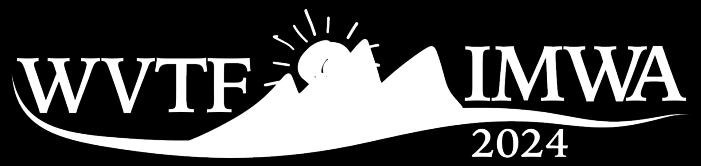
Abfertiawan, M. S., Hasan, F., Handajani, M., Syafila, M., Gunawan, F., Djali, F., Stanley, P. ;, Wolkersdorfer, C. ;, & Wolkersdorfer, K. (2023). High Total Suspended Solid (TSS) Removal for Coal Mining Water Using Electrocoagulation.

Badan Pusat Statistik Republik Indonesia. (2022). Statistical Yearbook of Indonesia 2022.

López-Guzmán, M., Flores-Hidalgo, M. A., & Reynoso-Cuevas, L. (2021). Electrocoagulation Process: An Approach to Continuous Processes, Reactors Design, Pharmaceuticals Removal, and Hybrid Systems—A Review. Processes, 9(10), 1831. https://doi.org/10.3390/pr9101831

Nur'utami, M. N., & Hayasaka, T. (2022). Interannual Variability of the Indonesian Rainfall and Air–Sea Interaction over the Indo–Pacific Associated with Interdecadal Pacific Oscillation Phases in the Dry Season. Journal of the Meteorological Society of Japan. Ser. II, 100(1), 2022–004. https://doi.org/10.2151/jmsj.2022-004

Qiao, P., Wang, S., Li, J., Zhao, Q., Wei, Y., Lei, M., Yang, J., & Zhang, Z. (2023). Process, influencing factors, and simulation of the lateral transport of heavy metals in surface runoff in a mining area driven by rainfall: A review. Science of The Total Environment, 857, 159119. https://doi.org/10.1016/j.scitotenv.2022.159119



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