

Utilization of Brackish Water as a Potable Water Source through Reverse Osmosis Technology: A Case Study in Taddutan Island, Saliki Village, Kutai Kartanegara

Ansahar^{1*}, Ryan Irawan², Aldi Muhammad Miftahuddin³, Aura Nazwa^{4*}, Regita⁵, Zefanya Hosiana Cindy Prastica⁶

¹ Faculty of Engineering, Universitas Kutai Kartanegara, Tenggarong, Indonesia

² Faculty of Engineering, Universitas Kutai Kartanegara, Tenggarong, Indonesia

³ Faculty of Engineering, Universitas Kutai Kartanegara, Tenggarong, Indonesia

⁴ Faculty of Engineering, Universitas Kutai Kartanegara, Tenggarong, Indonesia

⁵ Faculty of Engineering, Universitas Kutai Kartanegara, Tenggarong, Indonesia

⁶ Faculty of Engineering, Universitas Kutai Kartanegara, Tenggarong, Indonesia

*Email Corresponding Author: ansahar@unikarta.ac.id

ABSTRAK

Air payau merupakan sumber air yang sering diabaikan karena kandungan garamnya yang tinggi, namun menjadi alternatif strategis bagi masyarakat pesisir yang kesulitan mendapatkan air tawar. Di Pulau Taddutan, Desa Saliki, Kecamatan Muara Badak, Kabupaten Kutai Kartanegara, masyarakat bergantung pada air payau yang memiliki kualitas rendah dan berpotensi menimbulkan masalah kesehatan. Penelitian ini bertujuan merancang sistem pengolahan air payau hybrid berbasis Reverse Osmosis (RO) untuk menghasilkan air minum layak konsumsi. Sampel air diambil dari dua lokasi (RT 7 dan RT 8) dan dianalisis di laboratorium DLHK Kutai Kartanegara (Desember 2023). Hasil menunjukkan bahwa air mentah memiliki salinitas 0.22–4.42‰, TDS 244.6–4.658.5 mg/L, pH 7.02–7.28, COD 18.4–46.4 mg/L, dan kontaminasi mikrobiologis ekstrem (Total Coliform hingga 87.320 MPN/100mL). Unit pengolahan air setempat (PAMSIMAS) telah berhasil menurunkan TDS menjadi 235 mg/L, tetapi masih gagal menghilangkan Total Coliform (3.232 MPN/100mL). Berdasarkan temuan tersebut, direkomendasikan sistem hybrid empat tahap: (1) pretreatment koagulasi-flokulasi (tawas + KOH), (2) filtrasi multistage (pasir cepat, mangan zeolit, karbon aktif), (3) reverse osmosis (RO) membran air payau, dan (4) disinfeksi UV. Sistem ini dirancang untuk menggunakan tenaga surya 2.500 watt guna mencapai keberlanjutan energi. Keberlanjutan operasional dijamin melalui model tata kelola BUMDes Mekar Sejati dan Willingness to Pay (WTP) masyarakat Rp50.000–Rp150.000/bulan. Penelitian ini menunjukkan bahwa air payau dapat dimanfaatkan sebagai sumber air minum tangguh bagi komunitas terpencil, selaras dengan prinsip eksplorasi sumber daya berkelanjutan dan ketahanan bencana.

Kata kunci: Kata kunci: Air payau; BUMDes; Ketahanan air; Reverse osmosis; WTP;

ABSTRACT

Brackish water, although often neglected due to its high salinity, represents a strategic water source for coastal communities facing freshwater scarcity. This study addresses a research gap in the utilization of heavily contaminated brackish water in tropical peatland areas of East Kalimantan through an integrated hybrid technology approach that combines local governance and renewable energy. Water samples were collected from two locations in Taddutan Island (RT 7 and RT 8) in December 2023 and analyzed at the accredited DLHK Kutai Kartanegara Environmental Laboratory. Results showed that raw water exhibited salinity of 0.22–4.42‰, total dissolved solids (TDS) of 244.6–4,658.5 mg/L, chemical oxygen demand (COD) of 18.4–46.4 mg/L, and extreme microbiological contamination (Total Coliform reaching 87,320 MPN/100 mL). The local PAMSIMAS unit failed to completely eliminate Total Coliform despite significantly reducing TDS. Based on these findings, a four-stage hybrid treatment system was designed: (1) coagulation-flocculation (alum + KOH), (2) multistage filtration (rapid sand, manganese zeolite, activated carbon), (3) reverse osmosis (RO) using brackish water membrane, and (4) UV disinfection. The system is operated using a 2,500-watt solar photovoltaic system (PLTS) to ensure energy sustainability, while governance by the Village-Owned Enterprise (BUMDes) Mekar Sejati and community Willingness to Pay (WTP) (IDR 50,000–150,000/month) guarantees operational sustainability. The novelty of this research lies in the integration of three pillars: (i) RO hybrid technology with adaptive pretreatment for peatland brackish water, (ii) integration of PLTS as a renewable energy source, and (iii) BUMDes-based governance. This model has

high replication potential across hundreds of coastal peatland villages in Indonesia facing similar challenges [8], [21], [30].

Keywords: brackish water; BUMDes; reverse osmosis; water resilience; willingness to pay

INTRODUCTION

Access to safe and potable drinking water remains a fundamental human right that is still unfulfilled in many coastal regions of Indonesia, particularly in peatland areas vulnerable to seawater intrusion and anthropogenic contamination [1], [5].

In Taddutan Island, Saliki Village, Muara Badak Subdistrict, Kutai Kartanegara Regency, East Kalimantan, the community relies on brackish surface water whose chemical and microbiological quality fails to meet national drinking water standards [10], [11].

Laboratory analysis of water samples from two locations (RT 7 and RT 8) in December 2023 revealed that raw water contains salinity of 0.22–4.42‰, total dissolved solids (TDS) ranging from 244.6 to 4,658.5 mg/L, turbidity of 43.4–81.3 NTU, and extreme microbiological contamination with Total Coliform reaching 87,320 MPN/100 mL—far exceeding the zero threshold stipulated in Government Regulation No. 22 of 2021 [10], [11].

This condition not only threatens public health through risks of diarrhea and gastrointestinal infections [18] but also reflects the vulnerability of water supply systems in remote areas beyond PDAM (Regional Water Company) coverage [6].

Government efforts through the PAMSIMAS program have established a water treatment facility in Saliki Village, which partially succeeded in reducing TDS to 235 mg/L and turbidity to 1.48 NTU [11]. However, laboratory findings revealed a critical weakness: Total Coliform was still detected at 3,232 MPN/100 mL, indicating failure in the final disinfection stage or possible post-treatment recontamination [18].

The system's inability to ensure microbiological safety confirms that conventional technological approaches—without adaptive design for the unique characteristics of tropical peatland brackish water—are inadequate for this local context [7], [21]. Brackish water in this region contains not only dissolved salts but also high levels of organic matter, ferrous ions (Fe^{2+}), manganese (Mn^{2+}), and complex colloids that synergistically accelerate membrane fouling and disrupt coagulation-flocculation processes.

This condition creates a significant research gap: the lack of treatment systems

specifically designed for tropical peatland brackish water that integrate adaptive pretreatment, efficient desalination technology, sustainable energy sources, and social governance models that ensure operational continuity [8], [27].

This study fills this gap by developing a hybrid reverse osmosis (RO)-based treatment system that is technically adequate and socially sustainable.

The primary novelty of this research lies in the integration of three innovative pillars: first, a multistage pretreatment design comprising coagulation-flocculation with alum and KOH, rapid sand filtration, manganese zeolite, and activated carbon—tailored to the specific contaminant profile of Taddutan water [3], [7], [12]; second, integration of a 2,500-watt Solar Photovoltaic Power Plant (PLTS) to drive the RO system without reliance on the national grid (PLN) or fossil-fuel generators [4], [8]; and third, strengthening governance through the Village-Owned Enterprise (BUMDes) Mekar Sejati, which has effectively managed the Water Supply System (WSS) since 2018 [1], [6].

Field surveys showed that 78% of respondents are willing to pay between IDR 50,000 and IDR 150,000 per month for safe and accessible drinking water—an indicator of strong willingness to pay (WTP) that forms the financial sustainability foundation [1], [10]. This integrated approach not only addresses the technical challenges of complex water treatment but also strengthens local capacity through community institution empowerment, in accordance with the principles of community-based water governance [8].

Thus, this study provides not only a measurable technical solution but also offers a replicable model applicable to hundreds of coastal peatland villages in Indonesia facing similar challenges: freshwater scarcity, dependence on unsustainable energy sources, and the presence of capable village-level institutions as water system managers [4], [21], [28]. These findings contribute to the scientific literature on sustainable desalination in tropical regions [21] and enrich policy discourse on the integration of technology, renewable energy, and local governance in coastal community water resilience [8].

METHODOLOGY

This research adopts a multidisciplinary approach combining technical, environmental, and socio-economic aspects to design a sustainable brackish water treatment system in Taddutan Island, Saliki Village, Muara Badak Subdistrict, Kutai Kartanegara Regency. Guided by the principles of Integrated Water Resources Management (IWRM), the methodology was structured in stages to ensure data validity, technical feasibility, and operational sustainability.

2.1. Water Sampling Method

Water sampling was conducted on December 3, 2023, at two representative locations in Taddutan Island: RT 7 (coordinates E: 117°29'02.8", S: 00°27'04.0") and RT 8 (E: 117°30'15.5", S: 00°25'41.5"). Site selection was based on salinity variation and community water usage patterns, ensuring representation of the brackish water spectrum in the study area.

Grab sampling was performed according to Indonesian National Standard SNI 6989.57:2008, using 5 liters of water per site collected in sterilized HDPE bottles pre-rinsed three times with sample water. Samples were immediately stored in a cooler box with dry ice to preserve microbiological and chemical stability and delivered to the UPTD Environmental Laboratory of the Department of Environment and Forestry (DLHK) of Kutai Kartanegara Regency on December 4, 2023.

This procedure ensures sample integrity in accordance with chain-of-custody principles for surface water quality analysis, as recommended by Standard Methods for the Examination of Water and Wastewater [29].

2.2. Laboratory Analysis

Water quality was analyzed for 13 key parameters encompassing physical (temperature, TDS, TSS, color, EC, odor, turbidity), chemical (pH, BOD₅, COD, salinity), and microbiological (E. coli and Total Coliform) aspects.

All analyses were conducted at the ISO/IEC 17025-accredited DLHK Kutai Kartanegara Laboratory using methods aligned with national (SNI) and international (Standard Methods) standards. Accredited parameters—including TDS, TSS, pH, BOD₅, and microbiology—were prioritized in technical interpretation due to their direct implications for pretreatment design.

Analytical results were compared against Class II standards of Government Regulation No. 22 of 2021 as a reference for raw water suitability for drinking water treatment [11]. Additionally, laboratory data were evaluated against feedwater

quality standards for reverse osmosis (RO) units, which require turbidity <20 NTU, Fe and Mn <0.1 mg/L, and absence of biological contaminants—critical prerequisites determining the necessity of multistage pretreatment [17], [30].

This approach ensures that technical recommendations are grounded in valid and technically relevant empirical evidence.

2.3. Social Analysis (Willingness to Pay/WTP)

The socio-economic aspect was evaluated through a field survey of 30 household heads selected via purposive sampling, with primary criteria: (1) active users of local water sources, (2) permanent residents of Taddutan Island for over two years, and (3) participants in the Saliki Village Water Supply System (WSS) program.

The survey instrument included structured questionnaires and in-depth interviews to assess Willingness to Pay (WTP), water quality perception, distribution preferences (piped vs. bottled), and trust in managing institutions. Data were analyzed using descriptive quantitative methods to identify payment willingness ranges and factors driving financial sustainability.

Findings were linked to the institutional role of the Village-Owned Enterprise (BUMDes) Mekar Sejati, which has managed WSS since 2018 with support from village funds and PT Pertamina Hulu Sanga Sanga's CSR program [1], [6].

This approach aligns with the community-based water governance framework emphasizing local participation and participatory financing mechanisms [8], thereby addressing non-technical sustainability questions often overlooked in community-scale water system design.

2.4. Treatment System Design

Based on the synthesis of laboratory data and social findings, a four-stage hybrid treatment system was designed, specifically adapted to the unique characteristics of tropical peatland brackish water at the study site. The design follows the multi-barrier approach principle in water treatment, emphasizing the need for layered barriers to handle contaminant complexity [7], [24].

The first stage involves coagulation-flocculation using alum (aluminum sulfate) and Potassium Hydroxide (KOH) to stabilize pH in the 7–8 range, aggregate colloidal particles, and precipitate organic compounds causing color and high COD [3], [25].

The second stage is multistage filtration comprising: (i) rapid sand filter to remove suspended particles, (ii) manganese zeolite as a

catalytic oxidant for Fe^{2+} and Mn^{2+} conversion into insoluble forms (ferric oxide and manganese dioxide) [13], [22], and (iii) activated carbon for adsorption of residual organic compounds and odor [12], [15].

The third stage is reverse osmosis (RO) using a specialized brackish water membrane (maximum TDS capacity: 12,000 mg/L), capable of removing >99% of dissolved ions [14], [21]. The final stage is UV disinfection (254 nm, 40 mJ/cm² dose) for pathogen inactivation without generating carcinogenic disinfection by-products (DBPs)—a major risk when using chlorine on organically rich water [18], [19], [32].

The entire system is designed to operate on a 2,500-watt solar photovoltaic system (PLTS) to ensure energy independence [4], [8]. Detailed Engineering Design (DED) and Budget Estimate (RAB) were developed for a capacity of 1,200 liters/hour, assuming 2 hours of daily operation, aligned with community drinking water needs [10].

RESULTS AND DISCUSSION

3.1. Raw Water Characteristics and Implications for Pretreatment Design

Laboratory analysis of surface water in Taddutan Island revealed extreme variability in water quality between the two sampling locations—RT 7 and RT 8—representing spatial variation in seawater intrusion and organic pollution load in the coastal peatland area. Analytical results are presented in **Table 1**.

Table 1. In Situ Characteristics of Brackish Water in Taddutan Island, Saliki Village

No.	Parameter	Unit	Regulatory Standard	RT 7	RT 8
A. Physical					
1	Temperature	°C	±3°C from air temp	30.1	30.1
2	Total Dissolved Solids (TDS)	mg/L	<1,000	244.6	4,658.5
3	Total Suspended Solids (TSS)	mg/L	<50	40.5	29.7
4	Color	TCU	<50	34.8	19.9
5	Electrical Conductivity (EC)	µmhos/cm	—	1,168	7,990
6	Odor	—	Odorless	Odorless	Odorless
7	Turbidity	NTU	—	81.3	43.4
B. Chemical					
8	pH	—	6–9	7.28	7.02
9	BOD ₅	mg/L	<3	2.43	2.39

No.	Parameter	Unit	Regulatory Standard	RT 7	RT 8
10	COD	mg/L	<25	18.4	46.4
11	Salinity	%	—	0.22	4.42
C. Microbiological					
12	E. coli	MPN/100 mL	Not detected	6,131.0	241.0
13	Total Coliform	MPN/100 mL	0	87,320.0	48,392.0

Source: UPTD Environmental Laboratory DLHK Kutai Kartanegara, 2023

Water at RT 7 is classified as slightly brackish, whereas at RT 8 it falls into the category of heavily brackish to early saline water, with TDS reaching 4,658.5 mg/L and salinity of 4.42‰—values approaching tropical seawater salinity (3.5–5‰). More concerning, Total Coliform was detected at 87,320 MPN/100 mL at RT 7, indicating severe fecal contamination from unmanaged domestic waste. Turbidity of 81.3 NTU and COD of 46.4 mg/L reflect high organic load typical of tropical peatland water, where natural degradation produces significant concentrations of humic and fulvic acids.

Scientifically, these parameters violate the safety thresholds established for RO feedwater, which require turbidity below 20 NTU and iron and manganese concentrations each below 0.1 mg/L [17], [30].

Under such conditions, RO membranes are highly susceptible to colloidal fouling and scaling by metal precipitates, making pretreatment not merely a supportive step but an absolute technical prerequisite [21].

The proposed pretreatment design—combining coagulation-flocculation, multistage filtration, and adsorption—is hierarchically structured to address this contaminant complexity in stages, consistent with the internationally recognized multi-barrier approach in drinking water treatment [7], [24].

3.2. Performance of the PAMSIMAS System

The PAMSIMAS unit in Saliki Village demonstrated impressive technical performance in reducing chemical and physical parameters but failed in the microbiological aspect—a critical weakness that threatens consumer safety. Analytical results of treated water from this unit are presented in **Table 2**.

Table 2. In Situ Characteristics of Treated Water from PAMSIMAS Unit, Saliki Village.

No.	Parameter	Unit	Regulatory Standard	Lab Result (Treated Water)
A. Physical				

No.	Parameter	Unit	Regulatory Standard)	Lab Result (Treated Water)
1	Temperature	°C	±3°C from air temp	27.7
2	Total Dissolved Solids (TDS)	mg/L	<1,000	235
3	Total Suspended Solids (TSS)	mg/L	<50	2.93
4	Color	TCU	<50	1.34
5	Electrical Conductivity (EC)	µmhos/cm	–	212.7
6	Odor	–	Odorless	Odorless
7	Turbidity	NTU	–	1.48
B. Chemical				
8	pH	–	6–9	7.36
9	BOD ₅	mg/L	<3	2.41
10	COD	mg/L	<25	1.26
11	Salinity	%	–	0.1
C. Microbiological				
12	E. coli	MPN/100mL	Not detected	1
13	Total Coliform	MPN/100mL	0	3,232

Source: UPTD Environmental Laboratory DLHK Kutai Kartanegara, 2023

The system successfully reduced TDS from 4,658.5 mg/L to only 235 mg/L and turbidity from 43.4 NTU to 1.48 NTU, suggesting the probable use of a hidden RO membrane configuration. However, Total Coliform was still detected at a concentration of 3,232 MPN/100 mL, indicating failure of the final disinfection system or post-treatment recontamination. In tropical environments with high temperature and humidity, distribution systems without residual disinfection are highly vulnerable to biofilm growth and pathogen ingress.

Scientifically, this failure has serious implications, as the presence of Total Coliform is a primary indicator of exposure to enteric pathogens such as *E. coli*, *Salmonella*, and *Shigella*, which are responsible for diarrhea and other gastrointestinal disease outbreaks [18].

Therefore, terminal UV disinfection—which produces no toxic by-products and is effective against a broad spectrum of pathogens [9]—becomes a non-negotiable final safeguard in the proposed hybrid system design.

3.3. Willingness to Pay Analysis and the Role of BUMDes in Sustainability

The sustainability of the water treatment system depends not only on technical aspects but also on social validation and local institutional capacity. A survey of 30 household heads in Saliki Village showed that 78% of respondents are willing to pay between IDR 50,000 and IDR 150,000 per month for safe, clean, and easily accessible drinking water.

This amount is sufficient to cover the system's monthly operational cost of IDR 1,766,725, thus opening opportunities for sustainable, community-based financing. The Village-Owned Enterprise (BUMDes) Mekar Sejati has proven its capacity as a WSS manager since 2018, supported by village budget allocations and PT Pertamina Hulu Sanga Sanga's corporate social responsibility (CSR) program.

This institution serves not only as a technical operator but also as an empowerment agent that understands local dynamics, can implement fair tariff collection, and reinvests operational surpluses into infrastructure maintenance. This governance model aligns with the principles of community-based water governance that emphasize local involvement in ensuring the sustainability of water supply systems [8], [30].

3.4. Water Treatment System Design

Based on the synthesis of technical data and social findings, a four-stage hybrid treatment system was designed that is scientifically adequate and socially sustainable. The first stage involves coagulation-flocculation using alum and potassium hydroxide (KOH) to aggregate colloidal particles, stabilize pH in the neutral range, and precipitate organic compounds causing color and high COD.

The second stage is multistage filtration comprising rapid sand filter to remove suspended particles, manganese zeolite as a catalytic oxidant to precipitate iron and manganese, and activated carbon to adsorb residual organic compounds and odor. The third stage is reverse osmosis (RO) using a specialized brackish water membrane with a TDS handling capacity up to 12,000 mg/L, capable of removing more than 99% of dissolved ions. The final stage is UV disinfection at a dose of 40 mJ/cm² for pathogen inactivation without forming toxic by-products.

The main finding of this research lies in the integration of three mutually reinforcing innovative pillars. First, adaptive technology specifically designed for the unique characteristics of tropical peatland water rich in organic matter and dissolved metals; second, integration of a 2,500-watt Solar Photovoltaic Power Plant (PLTS) that ensures energy independence and eliminates dependence on

unstable grid electricity or expensive fossil fuels; third, a BUMDes-based governance model that ensures financial and operational sustainability through active community participation.

Scientifically, this integration not only addresses the technical challenges of complex water treatment but also strengthens system resilience against external disruptions such as energy supply instability or climate change. Although the initial investment for the PLTS system is slightly higher than grid-based alternatives, its monthly operational cost is lower and offers long-term resilience that cannot be ignored in the context of sustainable development in remote areas [8].

CONCLUSION

This study demonstrates that brackish water in Taddutan Island, Saliki Village—previously considered problematic due to salinity of 0.22–4.42‰, TDS up to 4,658.5 mg/L, and extreme microbiological contamination (Total Coliform up to 87,320 MPN/100 mL)—can be transformed into potable water through an integrated and sustainable technological approach.

The local PAMSIMAS unit, although capable of significantly reducing TDS to 235 mg/L, failed to ensure microbiological safety due to persistent Total Coliform detection at 3,232 MPN/100 mL, revealing a critical imbalance between technical desalination and final sanitation in community water distribution systems.

The core contribution of this research lies in an integrative framework combining three pillars of innovation: first, a hybrid treatment system comprising multistage pretreatment (coagulation-flocculation, manganese zeolite filtration, activated carbon) and brackish water reverse osmosis (RO) membrane, specifically designed to handle the complexity of tropical peatland water rich in organic matter and dissolved metals; second, integration of a 2,500-watt Solar Photovoltaic Power Plant (PLTS) that ensures energy independence, eliminates dependence on unstable grid or fossil fuel infrastructure, and positions the system within the green water technology framework; third, a governance model based on the Village-Owned Enterprise (BUMDes) Mekar Sejati, supported by community willingness to pay (WTP) of IDR 50,000–150,000 per month, which guarantees long-term operational, maintenance, and distribution sustainability.

This system possesses high replication potential for communities facing similar challenges—limited freshwater access, brackish water dominance, unreliable energy dependence

on generators or PLN, and the presence of established BUMDes as local managing institutions. Replication can be achieved through scalable adaptation, site-specific pretreatment modification, and continuous capacity building of local human resources through training programs.

In the context of climate resilience and coastal community water security, this model not only addresses technical challenges but also strengthens community-based water sovereignty—a principle increasingly urgent in the era of climate change and resource uncertainty. Therefore, this research not only contributes technically to brackish water treatment engineering but also offers a holistic framework that can be adopted by local governments, research institutions, and communities in designing technically, economically, socially, and environmentally sustainable drinking water systems [4], [8], [21], [30].

REFERENCES

- [1] Andriani, M., & Yusuf, M. (2021). Community participation in Saliki Village: Water Supply System program in fulfilling clean water needs. *Journal of Social and Science*, 1(8), 819–826. <https://doi.org/10.59188/jurnalsosains.v1i8.178>
- [2] Wiresti, R. D. (2020). Analysis of the impact of work from home on early childhood during the Covid-19 pandemic. *Jurnal Obsesi: Jurnal Pendidikan Anak Usia Dini*, 5(1), 641.
- [3] Sudoh, R., Islam, M. S., Sazawa, K., Okazaki, T., Hata, N., Taguchi, S., & Kuramitz, H. (2015). Removal of dissolved humic acid from water by coagulation method using polyaluminum chloride (PAC) with calcium carbonate as neutralizer and coagulant aid. *Journal of Environmental Chemical Engineering*, 3(1), 770–774. <https://doi.org/10.1016/j.jece.2015.04.007>
- [4] Cahyani, R. W., Boer, C. D., Aipassa, M. I., Alam, D. F., Besar, B., Standar, P., Lingkungan, I., Jalan, H., & Wahab, A. (2022). Study on the potential development of ecotourism in Muara Enggelam Village, Muara Wis Subdistrict, Kutai Kartanegara Regency, East Kalimantan Province. *Jurnal Penelitian Ekosistem Dipterokarpa*, 8(1), 67–82. <https://doi.org/10.20886/JPED.2022.8.1.67-82>

- [5] Sukarman, S., & Haryati, U. (2021). Peatland and carbon reserve estimation in Kutai Kartanegara Regency, East Kalimantan. *Jurnal Agroekoteknologi Tropika Lembab*, 4(1), 20–28. <https://doi.org/10.35941/JATL.4.1.2021.5792>
- [6] Final Report Unikarta. (2023). Final report: Development and engineering in the field of technology and innovation of water treatment technology to produce clean and potable water (Research Report). Center for Environmental Research and Management, Faculty of Engineering, Universitas Kutai Kartanegara Tenggarong.
- [7] Elma, M., Pratiwi, A. E., Rahma, A., Rampun, E. L. A., Mahmud, M., Abdi, C., Rosadi, R., Yanto, D. H. Y., & Bilad, M. R. (2021). Combination of coagulation, adsorption, and ultrafiltration processes for organic matter removal from peat water. *Sustainability*, 14(1), 370. <https://doi.org/10.3390/su14010370>
- [8] Khayan, K., Sutomo, A. H., Rasyid, A., Puspita, W. L., Hariyadi, D., Anwar, T., Wardoyo, S., Sahknan, R., & Aziz, A. (2021). Integrated water treatment system for peat water treatment. *CLEAN – Soil, Air, Water*, 50(3), Article 2100404. <https://doi.org/10.1002/clen.202100404>
- [9] Kong, J., Lu, Y., Ren, Y., Chen, Z., & Chen, M. (2021). The virus removal in UV irradiation, ozonation and chlorination. *Water Cycle*, 2, 23–31. <https://doi.org/10.1016/j.watcyc.2021.05.001>
- [10] DLHK Laboratory Report. (2023). Surface water test report (No. LHU 660.1/176–177/UPTD.Lab/LHU/DLHK) [Laboratory data]. Department of Environment and Forestry, Kutai Kartanegara.
- [11] Government Regulation of the Republic of Indonesia No. 22 of 2021 on Groundwater Management.
- [12] Matilainen, A., Vieno, N., & Tuhkanen, T. (2006). Efficiency of the activated carbon filtration in the natural organic matter removal. *Environment International*, 32(3), 324–331. <https://doi.org/10.1016/j.envint.2005.06.003>
- [13] Arifianingsih, N. N., Zevi, Y., Helmy, Q., & Notodarmojo, S. (2020). Peat water treatment using oxidation and physical filtration system and its performance in reducing iron (Fe), turbidity, and color. *E3S Web of Conferences*, 148, 07011. <https://doi.org/10.1051/e3sconf/202014807011>
- [14] Peavy, H. S., Rowe, D. R., & Tchobanoglous, G. (1985). *Environmental engineering*. McGraw-Hill.
- [15] Notodarmojo, S., Mahmud, A., & Larasati, A. (2017). Adsorption of natural organic matter (NOM) in peat water by local Indonesian tropical clay soils. *International Journal of GEOMATE*, 13(38), 111–119. <https://doi.org/10.21660/2017.38.30379>
- [16] Muhammad, J. (2020). Peat water purification by hybrid of slow sand filtration and coagulant treatment. *Journal of Environmental Science and Technology*, 13(1), 22–28. <https://doi.org/10.3923/jest.2020.22.28>
- [17] Viessman, W., & Hammer, M. J. (1985). *Water supply and pollution control* (4th ed.). Harper & Row.
- [18] Postigo, C., Gil-Solsona, R., Herrera-Batista, M. F., Gago-Ferrero, P., Alygizakis, N., Ahrens, L., & Wiberg, K. (2021). A step forward in the detection of byproducts of anthropogenic organic micropollutants in chlorinated water. *Trends in Environmental Analysis and Chemistry*, 32, Article e00148. <https://doi.org/10.1016/j.teac.2021.e00148>
- [19] Qadafi, M., Notodarmojo, S., & Zevi, Y. (2020). Effects of microbubble pre-ozonation time and pH on trihalomethanes and haloacetic acids formation in pilot-scale tropical peat water treatments for drinking water purposes. *Science of the Total Environment*, 747, 141540. <https://doi.org/10.1016/j.scitotenv.2020.141540>
- [20] Qadafi, M., Notodarmojo, S., & Zevi, Y. (2021). Performance of microbubble ozonation on treated tropical peat water: Effects on THM4 and HAA5 precursor formation based on DOM hydrophobicity fractions. *Chemosphere*, 279, 130642. <https://doi.org/10.1016/j.chemosphere.2021.130642>
- [21] Rahman, N. A., Jose Jol, C., Albania Linus, A., Dampam, F. L., Abdul Jalal, N. S., Baharudin, N., Wan Borhan, W. W. S., & Kumar, F. (2022). Desalination of Borneo tropical brackish peat water with

- adsorption process in continuous electrocoagulation treatment. *Desalination*, 527, 115574. <https://doi.org/10.1016/j.desal.2022.115574>
- [22] Rahman, N. Abdul, Tomiran, N. A., & Hashim, A. H. (2020). Batch electrocoagulation treatment of peat water in Sarawak with galvanized iron electrodes. *Materials Science Forum*, 997, 127–138. <https://doi.org/10.4028/www.scientific.net/MSF.997.127>
- [23] Ritson, J. P., Bell, M., Graham, N. J. D., Templeton, M. R., Brazier, R. E., Verhoef, A., Freeman, C., & Clark, J. M. (2014). Simulated climate change impact on summer dissolved organic carbon release from peat and surface vegetation: Implications for drinking water treatment. *Water Research*, 67, 66–76. <https://doi.org/10.1016/j.watres.2014.09.015>
- [24] Edzwald, J. K., & Tobiason, J. E. (1999). Enhanced coagulation: US requirements and a broader view. *Water Science and Technology*, 40(7), 63–70. [https://doi.org/10.1016/S0273-1223\(99\)00641-1](https://doi.org/10.1016/S0273-1223(99)00641-1)
- [25] Padmaja, K., Cherukuri, J., & Anji Reddy, M. (2020). A comparative study of the efficiency of chemical coagulation and electrocoagulation methods in the treatment of pharmaceutical effluent. *Journal of Water Process Engineering*, 34, 101153. <https://doi.org/10.1016/j.jwpe.2020.101153>
- [26] Amri, I., Herman, S., Fadhlah Ramadan, A., & Hamzah, N. (2022). Effect of electrode and electric current on peat water treatment with continuous electrocoagulation process. *Materials Today: Proceedings*, 63, S520–S525. <https://doi.org/10.1016/j.matpr.2022.04.873>
- [27] Sutapa, I. D. A., Prihatinningtyas, E., & Limnology Research Group. (2020). IPAG60 as alternative solution to provide clean water in peatland areas. *IOP Conference Series: Earth and Environmental Science*, 477(1), 012030. <https://doi.org/10.1088/1755-1315/477/1/012030>
- [28] Tonks, A. J., Aplin, P., Beriro, D. J., Cooper, H., Evers, S., Vane, C. H., Sjögersten, S., & 2017. Impacts of conversion of tropical peat swamp forest to oil palm plantation on peat organic chemistry, physical properties and carbon stocks. *Geoderma*, 289, 36–45. <https://doi.org/10.1016/j.geoderma.2016.11.018>
- [29] American Public Health Association (APHA). (2017). *Standard methods for the examination of water and wastewater* (23rd ed.). American Public Health Association.
- [30] Zevi, Y., Qadafi, M., & Notodarmojo, S. (2022). The presence of trihalomethanes and haloacetic acids in tropical peat water. *Journal of Engineering and Technological Sciences*, 54(3), 220314. <https://doi.org/10.5614/J.ENG.TECHNOL.SCI.2022.54.3.14>