Risk Management of the water resources analysis: Application of Membrane technology in peat water treatment

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Abstract

The water supply system development needs to be safe and meet health requirements. Due to the expansion of the ore processing industry, water supply providers are required to identify the risks that may arise from dangerous events. The purpose of this study was to build a structured approach to drinking water risk management. We used risk assessments concerning the environmental management system, risk management, and the food safety management system. The Musi River in Palembang City is one of the most important rivers in Indonesia. This river is the source of raw water for the Tirta Musi Regional Company of Palembang City but unfortunately, the quality of this river water tends to decline due to pollution. Many things have been done by the government to manage the river water, but it has not brought positive changes to the raw water source. Problems that occur include urban development and land use changes that influence river pollution loads. The approach taken in this research is qualitative analysis and risk management by using critical review methods and regulatory studies. The results show that is in the form of policy development in river management as a source of raw water, namely land use management, separation of drainage channels with domestic sewage channels, increasing IPAL service coverage, and strengthening institutional and regulatory aspects, especially in funding commitments. Moreover, this study suggests the possibility of searching for other water resources from the peat water that collects from the peat region. As known that the South Sumatra area has many peat regions, and this might be chosen as an alternative water source. UV-ultrafiltration membrane is a promising system to produce water from peat areas.

Keywords: River Water Pollution; Land Use; Drainage; Legal & Institutional Aspects; UV-ultrafiltration membrane.

Introduction

Indonesia has a national waste management policy under Article 19 of the Law Constitution Number 18 of 2008 [1], which was followed by the Circular Letter of the Ministry of Environment and Forestry of the Republic of Indonesia Number SE.3/UM/RT/SET.1/2/2011, which prohibited the use of plastic packaging of drinking water in the mining work environment [2]. To implement these regulations, a suitable drinking water supply system must be developed that meets the basic health requirements and can be consumed directly [3].

This development aims to expand and improve the physical (technical) and non-physical systems (institutional, management, finance, community roles, and law) together to enable the provision of safe drinking water to the public [3]. The provision of safe drinking water needs to meet physical, microbiological, chemical, and radioactive requirements [4,5], which provide the minimum required and additional parameter details. To maintain a high quality of drinking water for community consumption, supervision checks are performed. Internal supervision is conducted by providers to guarantee high water quality; this includes sanitation inspection, water sampling, water quality testing, and analysis of laboratory test results, recommendations, and follow-up [3–5]. An effective method of consistently ensuring the safety of drinking water is using comprehensive risk assessments and management as they encompass all the important steps regarding water supply, from water sources to consumers [5,6]. The World Health Organization (WHO) provides a risk-based framework consisting of several components to manage the safety of drinking water [5], which involves the use of health-based targets (HBTs) to determine the level of contaminants within drinking water [4,7], use of water safety plans that include identification of hazards and necessary control measures [6], process monitoring, and system management implementation [7]

Kota Palembang is one of the most important cities in Indonesia due to its position as one of the buffers for the capital city of South Sumatera Province is strategically located, with Sultan Mahmud Badaruddin Airport as the gateway to Indonesia located in Kota Palembang. The city's economic growth is above the average of cities and regencies in South Sumatera Province, and this economic progress has made the city more densely populated. Based on data from BPS for 20 years, from 2019-2021, the population of Kota Palembang increased by 0.05 million. In 2019, the population was 1.66 million people, while at the end of 2023, it reached 1.71 million people [9]. Population growth in a city requires an increase in infrastructure needs with an increase in infrastructure needs, regional development becomes inevitable [8]. One of the infrastructure needs is a clean water supply system. In this city there is a large river that becomes a source of raw water for clean water supply, namely the Musi River, this river becomes the main river in the Musi Watershed. The Musi River is also an icon for Kota Palembang as a Waterfront City. In addition, this river is also the main source of raw water for Perusahaan Umum Daerah Tirta Musi (PTM) fulfills the need for clean water in Kota Palembang.

Figure 1 Musi River at Kota Palembang

Research by Hermana explained that land use change can have a negative effect in the form of high pollution loads [10]. The results of another study related to urban development in Vietnam also confirmed the influence of urban development on the decline in surface water quality, and the more the population the more the amount of waste produced. According to Huang et al., it is explained that the faster land use change leads to a decrease in river water quality [11]. Efforts made by the government have been quite diverse, but still have not shown good results. Construction-based approaches have been carried out, with the construction of embankments, retaining walls, river normalization, and park construction, but have not been able to improve river water quality. Other approaches include the issuance of regional regulations on water quality management, strengthening the institutional aspects that deal with river issues, and waste management in the watershed area. All of these have yet to show positive results on changes in water quality. This problem is made even more

complex by the lack of Wastewater Treatment Plan (WWTP) service coverage in the watershed area, which has just been built and in operation since February 2024 and the domestic waste disposal channels were flown through drainage channels to the Musi River directly. This study aims, to identify important factors in the management of raw water resources to improve the quality of water and use the membrane technology to produce raw water from peat water recourses.

Previous studies have mentioned the relationship or important links between land use and river water pollution, including land use type and population density; management in controlling land use change; human activities that affect the quality and quantity of river water; the influence of waste and residues on the land surface; and population growth and the influence of development, competition to explore water resources, and lack of land use planning will contribute to the decline in the quality of water resources [12] The relationship model between land use and river water quality, including the hydrological model, is closely related, which also confirms that there is a positive and negative relationship between the type land use and river water quality variables [13]. Land use change can also affect the quality of raw water sources and have implications for the allocation of water use for the community [14]. The Musi watershed area of Kota Palembang showed that the change of open land into built-up land, as well as the increase in industrial land, influenced the decline in the water quality of the Musi River. Other important aspects of river management as a source of raw water are regulatory and institutional aspects. Studies conducted by Ananto showed that the river's regulatory and institutional aspects are important in managing the river as a raw water source [12].

As an alternative raw water, this study has searched for the possibility of peat water as a raw water resource. This study has been initiated with the application of an ultrafiltration membrane process for water disinfection. This is studied in continuous operation to remove total suspended solids, biological oxygen demand, iron, colour, pH, and bacteria Escherichia coliform that present in urban wastewater.

Figure 2 Peat water area

Based on this composition below , we can tabulated the peat water composition in south Sumatera (Table 1)

Table 1. Peat Water Composition

Parameter	Range value
Organic (mg/L)	25.64 – 37.92
Iron (mg/L)	13.56 – 46.89
TSS (mg/L)	172 – 168
Color (TCU)	802 - 3390
Turbidity (NTU)	86 – 365
pH	3.4 – 3.6

METHODS

This research uses various approaches, starting with identifying important factors in water quality management, using the critical review method and regulatory studies, and then assessing the management that has been carried out while developing management scenarios based on the important factors identified through a risk management approach. The management strategy was organized into Risk Management-Based Raw Water Source Management Policy Development. The following Figure 3 explains the stages in the research conducted.

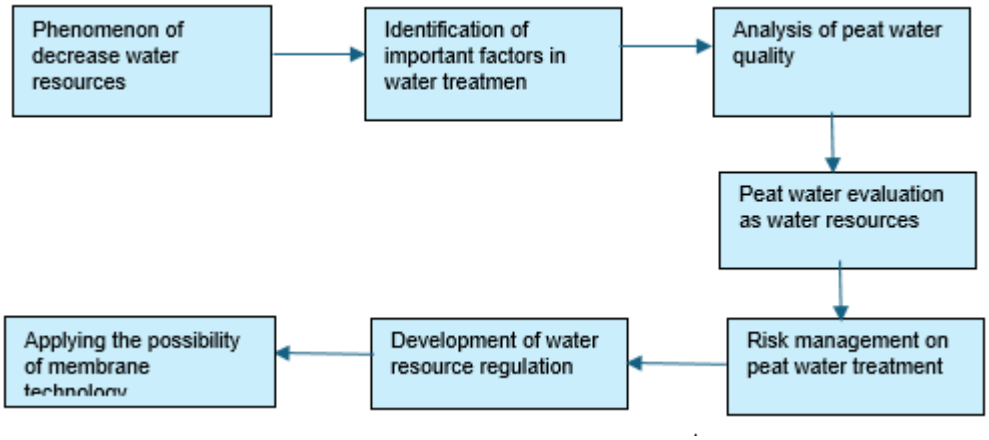

Figure 3. Research Stages

RESULTS AND DISCUSSION

Identification of Important Factors Identification of important factors in river water quality management, based on 3 relevant regulations that are compared with 15 previous relevant studies. The regulations are Government Regulation of the Republic of Indonesia No. 42 of 2008 on Water Resources Management; Government Regulation No. 38 of 2011 on Rivers; Government Regulation No. 82 of 2001 on Water Quality Management and Water Pollution Control [15]. Through the study conducted, there are 5 important factors in managing rivers as raw water sources. Figure 4 below explains these five important factors.

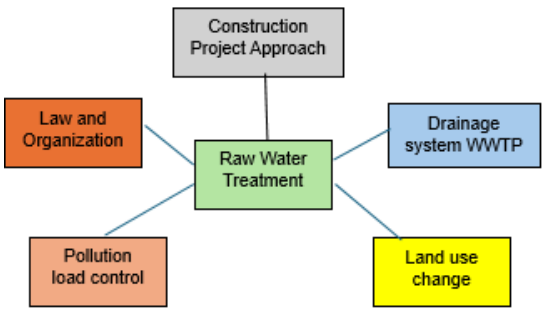

Figure 4. Five Important Factors as a Sources of Raw Water

Based on the figure above, there are 5 important factors in river management as a source of raw water, these five factors will become variables in the preparation of risk management-based governance. Risk Management Based on the discussion above, 5 main variables are obtained in managing river water quality related to land use change. These five variables are interrelated and strongly support the success of river water quality management. To support success in river water quality management, the five variables will be analyzed through risk management to maximize positive value and anticipate failure in managing river water quality. The Risk Management study and assessment was conducted with 4 resource persons, namely, the Head of the Musi River, the Head of Technical Operations of the Musi River Basin Directorate General of Natural Resources of the Ministry of PUPR, the Head of Engineering of the Kota Palembang Environmental Agency, and the Section Head of Water Quality Standards of the Directorate of Pollution Control of the Ministry of Environment and Forestry of the Republic of Indonesia. The initial step was to identify risks that could occur based on 5 important variables. The results of risk identification in these

variables are 34 identification of risks that may occur. Identification is also carried out to anticipate and find solutions to these risks, the analysis is carried out through a risk register.

The prioritized risks are shown in Table 1 Prioritized Risks below.

Table 1 Prioritized Risks No Risk Description Severity

No	Risk Priority	Remarks
1	Development of built-up land has a decreasing impact on river water quality	0.56
2	Population growth increases pollution	0.56
3	Related regulations have not been maximally socialized to the community	0.56
4	City-scale WWTP service coverage	0.00
5	Pollution load from upstream and South Kota Palembang is very influential	0.49
6	Land use for settlements creates waste	0.49
7	River Water Quality in 2016-2019 is categorized as the poorest	0.49
8	The change of open land into residential areas influences the decline in water quality	0.49
9	The conversion of open land into industrial areas influences the decline in water quality	0.49
10	Construction sector development reduces open land	0.49
11	Land use for industry creates waste	0.40
12	Liquid waste disposal from drainage affects river water quality	0.40
13	River management dominated by PUPR	0.40
14	High Domestic pollution load	0.30
15	Embarkment buildings are not functioning optimally	0.24

The responses obtained can be in the form of preventive or corrective actions validated by experts. Risks with similar causes, namely the conversion of open land into built-up land, will result in similar responses, namely by strengthening related regulations, including strengthening the implementation and attention to the RT and RW, the obligation to build waste treatment facilities in developed areas, and strengthening community participation which is also outlined in the regulations. Activities related to the construction project approach are responded to by accelerating the construction so that it can be completed. In addition, it is necessary to routinely normalize rivers, arrange river boundary lines, and increase the construction of parks around the river. This construction project approach must also go hand in hand with legal and institutional aspects, and community participation. The response to the risk of pollution from primary drainage is to involve the community to play an active role in controlling the discharge of liquid waste into drainage channels. The government is obliged to build an area-scale WWTP or increase the coverage of city-scale WWTP services and increase supervision of industries that do not carry out liquid waste treatment.

Table 2 Risk Management and Risk Management Plan

Risk Description	Risk Assessment	Mitigation Measures or Risk Management Plan	Responsibility
Financial management Inadequate cost recovery and	Moderate	The NWSDB is committed to continuing policy dialogue with the	Ministry of City Planning and Water

financial sustainability because of low water tariff		government for approval of regular tariff adjustment and the establishment of an independent regulator of water services.	Supply and National Water Supply and Drainage Board
Inadequate tariff affects cost recovery and financial sustainability due to inadequate revisions in water tariffs	Low	Awareness campaigns for consumers on improved service levels linked to marginally higher tariffs will be conducted, and continuing policy dialogue for gradual and continuous volumetric tariff increases will be implemented.	Project management, coordination, and implementation unit and Project management consultants
Procurement and implementation Lack of qualified contractors and challenges in the availability of cleared sites may lead to delays in project implementation and result in cost and time overruns	Moderate	The NWSDB has conducted several pre-bid meetings to explain the bid documents to the potential bidders. The NWSDB has taken advance actions for timely possession and securing of the land acquired for project works. The NWSDB employed a senior manager to ensure the availability of unencumbered land and minimize private land acquisition. The NWSDB obligations include ensuring the right of access for laying pipelines and construction of treatment plants and water tanks	National Water Supply and Drainage Board
Source sustainability Lack of sustained support from fishing communities for the desalination plant will cause implementation delays and cost overruns	Moderate	PMCIU has carried out the public consultation. The project design addressed concerns raised by the stakeholders through specific design requirements of the desalination plant and livelihood improvements for the local fishing communities.	Project management, coordination and implementation unit, Project management consultants
Inadequate management of environmental issues will lead to incompletion of the desalination plant	Moderate	The bidding documents have provided detailed environmental studies to help the contractor manage the risks. During the implementation stage, careful environmental monitoring and supervision will be carried out by an independent third party.	National Water Supply and Drainage Board, Project management, coordination and implementation unit, and Project management consultants
The water treatment plant is not operated properly during the postconstruction period	Moderate	Water treatment plant implementation is through composite design–build–operate contract. The contractor's remuneration is linked to performance, with built-in incentives for nonrevenue water reduction through effective network management. Sufficient O&M funding is included in the project cost.	National Water Supply and Drainage Board and Project management, coordination and implementation unit
Non-revenue water results in low-cost recovery and low-demand satisfaction levels	Moderate	The NWSDB will continue to encourage the maintenance of low water losses and high-performance efficiency. Training and capacity	National Water Supply and Drainage Board and Project

		building will be provided to NWSDB operational staff in continuously checking and monitoring the level of losses in the networks.	management consultants
Climate change-related risks adversely affect the construction schedule and longevity of infrastructure components of the project due to extreme events	Low	Risk screening will be done to identify the type and intensity of climate risks the project will face. If risks are found to be relevant, adaptation or resilience measures to protect the investments from pre-identified risks will be incorporated into the project design.	National Water Supply and Drainage Board and Project management consultants
Overall	Moderate		

MCPWS = Ministry of City Planning and Water Supply, NWSDB = National Water Supply and Drainage Board, O&M = operation and maintenance, PMC= Project management consultants, PMCIU=Project management, coordination and implementation unit, TA = technical assistance.

Based on that risk management and risk management plan, we studied the peat water has an inland peat swamp and south Sumatra is one of them that has a lot of peat swamp areas. As known, peat soil has a high organic matter with the main components being humic acid, lignin, and carbohydrate with acidic pH. Peat water is water created by a mixture of plant starch and water. It is brown in color and contains a lot of organic substances, which come from the decomposition of organic matter such as leaves, trees, and wood. In processing peat water becomes clean water, it can be done by chemical, biological, and filtration. The ultrafiltration membrane photoreactor is based on porous stainless-steel membranes coated with a TiO_2 layer (1.5 and 2.5 %) and illuminated by a UV lamp (254 nm) [16,17]. The outlet of the UV stream allows the operation of the system under conditions of constant transmembrane pressure (TMP) keeping the UV-contact time in a few seconds, significantly lower than the typical irradiation time employed in TiO_2 photocatalytic processes. An E. coli removal in the UV outlet was achieved with a 0.2 μm membrane operating with a TMP of 0.5 bar and a UV contact time of 2- 6 hr. The microbial balance data from the cells recovered from the membrane confirmed that the removed microorganisms died due to the UV action over the membrane surface. Modification of the membrane with TiO_2 has shown to be a suitable way to improve both UV inactivation and filtration efficiency.

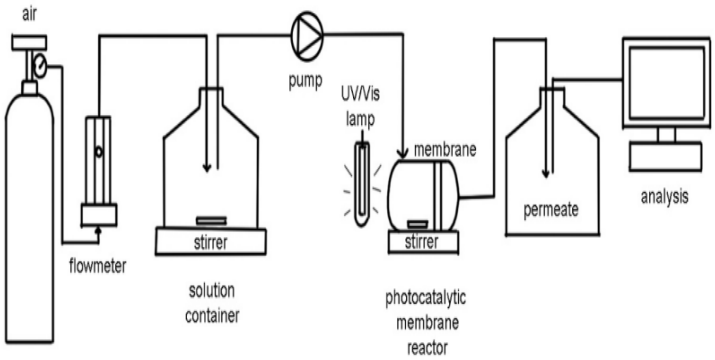

Figure 5 Initiated schematic diagram of membrane system with UV for peat water treatment

The results showed that the concept of UV membrane system can be achieved in producing the promised water resources. The composition of water from peat water by using membrane

treatment showed that the percentages of produced water fulfiled the raw water standardization. Table 3 tabulated the composition of produced water from peat water.

Table 3 The composition of produced water from peat water

TiO_2 (%)	Time (hr)	TSS (mg/L) (Std 50 mg/L)	BOD (mg/L) (Std 2 mg/L)	Fe (mg/L) (Std 0.3 mg/L)	Color (TCU) (Std 50 scale TCU)	pH (Std 6-7)	Bacteria E. Coliform MPN/100 (Std 0)
0	**0**	**55.7**	**62.7**	**24.04**	**286**	**2.46**	**106**
1.5	2	19.2	1.56	1.76	38	4.32	0
	4	17.3	1.38	1.52	25	5.78	0
	6	16.8	0.73	1.03	18	6.59	0
	2	18.3	1.96	0.68	14	5.34	0
	4	17.8	1.65	0.36	12	6.03	0
	6	17.5	1.48	0.31	2.5	7.05	0

Table 3 shows that the composition of the raw water parameters achieved the raw water standardization. UV membrane system plays a big role in treating the peat water to raw water that can be used as daily water by adding 1.5 % TiO_2 in 6 hours. Total suspended solids (TSS) decreased significantly from 55.7 mg/L to 16.8 mg/L, BOD decreased also from 62.7 mg/L to 0.73 mg/L, and the percentage of Fe, color, pH, and Bacteria E.coli form decreased also to 1.03 mg/L, 18 TCU, 6.59 and 0 MPN, respectively.

CONCLUSIONS

The concept of policy development in river management as a source of raw water based on risk management as follows.

- Strengthening the implementation of land use management or RTRW of Kota Palembang based on Law No. 26/2007, the minimum open land area (or RTH) is 30%. In 2018, the area of open land reached 29.87%, land use changes continue to occur due to population and economic growth, the commitment to the ratio of built and open land must be maintained, and the requirement to build supporting

infrastructure, especially for wastewater and waste in the development of land.

- Strengthen coordination between relevant institutions, from the central, provincial to municipal levels, to optimize and harmonize various programs in river water quality management.
- Strengthen the implementation of existing regulations, as well as make a strong legal basis for implementing work programs (related to budget or funding commitments), in addition to reinforcing the application of sanctions against parties who do not participate in river water quality management and pollution control.
- Increasing community participation in water quality management and water pollution control, existing regulations are socialized as optimally as possible so that the community increases their concern in river water quality management issues.
- The possibility of applying UV membrane for peat water treatment is a promising alternative to getting other water resources.

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