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SURVEYING WATER QUALITY PARAMETERS IN SHRIMP PONDS FOR BEST AQUACULTURE PRACTICE IN BRACKISH WATERS OF SOUTH KALIMANTAN, INDONESIA

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Abstract
This study aims to survey the water quality and condition of brackish water ponds in Kotabaru Regency, South Kalimantan Province-Indonesia. The study was conducted in January 2019 initiated by the Representative Office of Bank Indonesia. The observed water quality parameters include physical (pH, temperature, oxygen etc.), chemical (nitrite, nitrate, ammonia, phosphate) and heavy metal contamination concentrations (Pb, Cd, Hg). Based on primary data from the survey results, supporting secondary data and observations of the characteristics of brackish water aquaculture ponds, it is necessary to apply good aquaculture practice methods through the application of Integrated Multi Trophic Aquaculture (IMTA) technology.

Keywords: Brackish water pond, water quality, heavy metal contamination, good aquaculture practice, IMTA

Introduction
Kotabaru Regency is one of the eleven regencies in the Indonesian province of South Kalimantan. It consists of two parts; the smaller (2,357.29 km^2) but more populated part

comprises Laut Island (Sea Island), which is the largest island off the coast of Kalimantan (Indonesian Borneo), together with the smaller Sebuku Island off Laut Island's east coast and even smaller islands nearby; the larger (7,122.88 km^2) but less populated part consists of districts on the mainland of Kalimantan (Figure 1). The economy of the regency is undergoing a restructurization with general decline of primary sector and shift to tertiary sector as with many regions in Indonesia. This was mostly seen in 2020 where combined mining, agriculture, and fishery contributed to 37.25% of the regency's Gross Regional Domestic Product (GRDP) compared to 38.51% on 2016 (GRDP, 2021). Potential land that can be developed for fisheries includes 38,490 km^2 of sea waters, 168,050 ha of public waters, 52,900 ha of land that can be used as pond aquaculture supported by brackish waters, and 269 ha of freshwater fish farming ponds. However, the land potential has not been fully organized for best utilization practices so far. The leading aquaculture commodity of Kotabaru region is from its shrimp ponds. In the past decade, many ponds have been shut down due to outbreaks of White Spot Virus (WSV) and Vibriosis. Another major issue that threatens the success and sustainability of shrimp farming is coal mining business. Environmentally, the presence of coal mining has an impact on landscape change, decreased soil fertility, threats to biodiversity, decreased water -and air quality and environmental pollution. One of the concerns regarding the food safety level of aquaculture products is heavy metal contamination. To prevent and avoid the failure of fish farming activities, it is necessary to socialize the application of good and appropriate fish farming practices for fish farmers in Kotabaru Regency. Integrated Multi Trophic Aquaculture (IMTA) technology based on the concept of "Sato Umi" is an environmentally friendly fish farming technology (green technology) because it is almost zero waste or waste-free.

In the present study, surveying of water quality parameters of pond areas in Kotabaru Regency was conducted for the understanding of the brackish water conditions providing potentials for shrimp farming activities that need continuous attention for the sustainability of aquaculture activities in Kalimantan, Indonesia. In addition to the survey, coordination and discussions were also held with the local government (Fisheries Stakeholders) and the Shrimp Farming Community. The results of the survey and discussion groups were used as a basis for formulating recommendations for the application of new technologies and best aquaculture practices in brackish waters of Kotabaru regency.

Material and Method

Determination of the location of shrimp ponds to be surveyed was based on coordination and discussion with the Fisheries Offices in Bappeda and Kotabaru Districts.

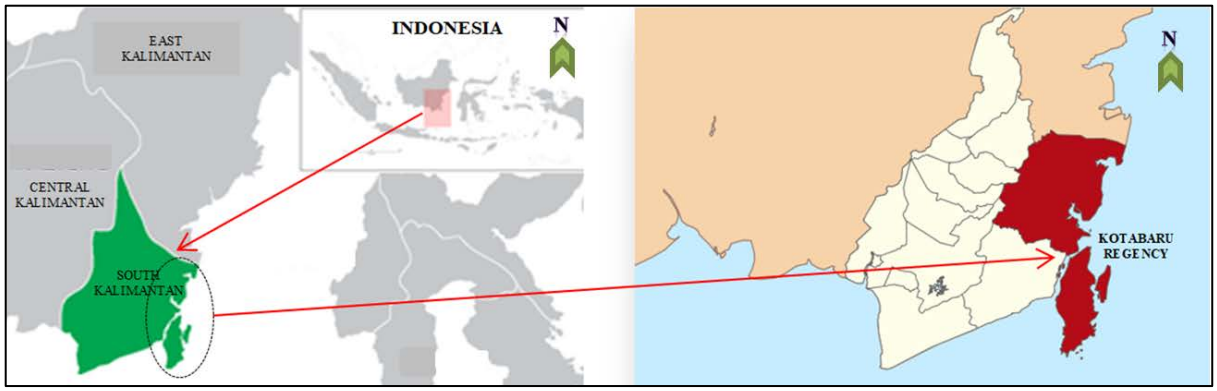

Figure 1. Map of the position of the island of Kalimantan/Borneo and the province of South Kalimantan in Indonesia (left picture), and the position of Kotabaru Regency in South Kalimantan province (right picture)

In all pond locations, several water quality parameters were measured. Surveys and observations of brackish water pond areas were conducted on January 2019, which was initiated by the Representative of Bank Indonesia, South Kalimantan.

Physical parameters (temperature, salinity, pH, turbidity) as well as dissolved oxygen (DO) were measured directly on-site by a Horiba-U10 portable water quality measurement device. Chemical parameters such as dissolved inorganic phosphorus (DIP) as phosphate (PO_4), and dissolved inorganic nitrogen (DIN) as the sum of nitrite (NO_2), nitrate (NO_3^-), and ammonia (NH_3) were measured and analyzed in the laboratory by gravimetric, titration, and spectrometric methods (APPA, 2000). All measurements and samples were taken from the outlet and inlet of the ponds. In addition, measurements were also taken on the river channel which is the source of water entering the ponds. In the presence of coal mining activities, the level of heavy metal contamination in pond water and shrimp body was measured. Heavy metal analyses of water and shrimp body samples were conducted using the method of Atomic Absorption Spectrophotometry (AAS).

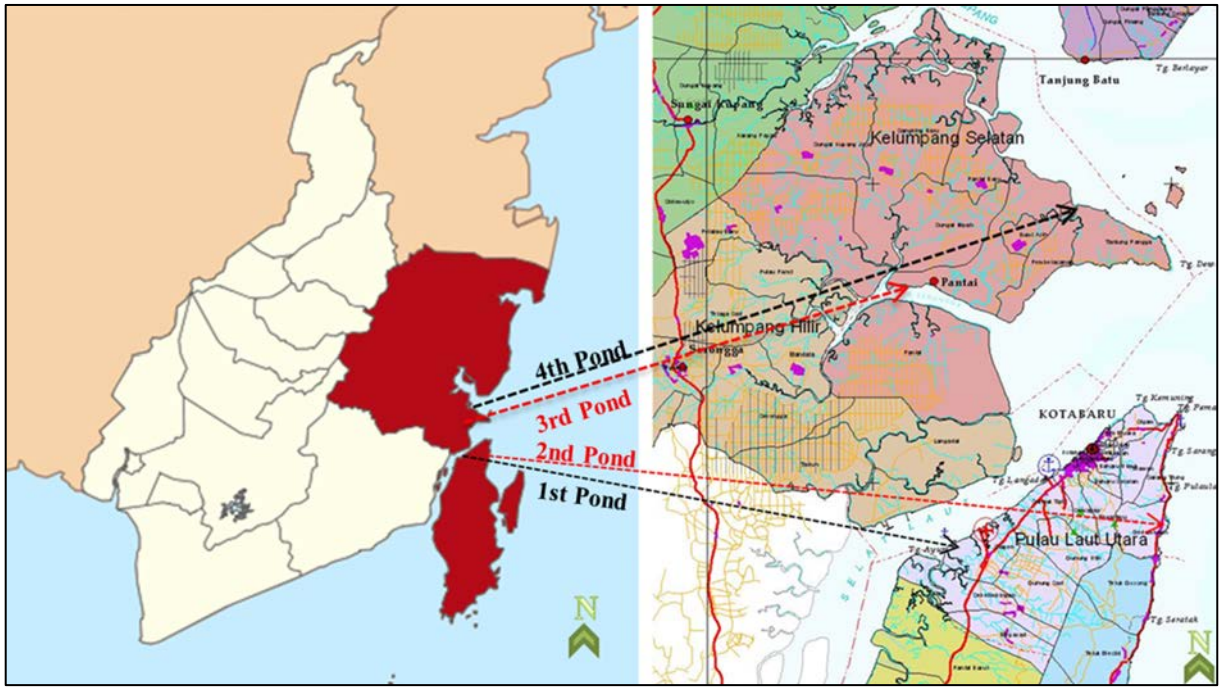

Figure 2. Four shrimp pond sites surveyed in the study; 2 ponds (1st & 2nd pond) on either side of the sea island and 2 other ponds (3rd & 4th pond) in the estuary river area.

During water quality measurement surveys and samplings (water and shrimp) for further analyses, informal discussions/communications were held with community farmers regarding technical constraints and problems encountered so far. Furthermore, all primary and secondary data obtained were analyzed and processed. The results of the interpretation of primary and secondary data as well as technical information from various sources are the basis for the preparation of recommendations for the application of brackish water aquaculture technology, both for the government and the cultivator community in Kotabaru district. The presentation of survey results and recommendations for the application of brackish water pond aquaculture technology was carried out at the Focus Group Discussion forum involving all stakeholders from academia, pond farmers and local governments in April 2019.

Results and Discussion

From the results of coordination with stakeholders, it was agreed and decided to survey the 4 pond locations in this study, which were considered as representatives for the conditions of all brackish water ponds in the Kotabaru region. The selected 4 ponds consist of 2 locations (1st pond and 2nd pond area) on both sides of the sea island and other 2 locations (3rd pond and 4th pond) in the river estuary area (Figure 2). Other technical considerations of the 4 selected pond sites are still doing aquaculture business. The main species cultivated in the 4 ponds was tiger shrimp (*Penaeus monodon*), while in the 4th pond a polyculture tiger shrimp with milkfish (*Chanos chanos*) was conducted.

Of the 4 ponds, only one pond that is the "2nd pond" does not receive water supply from a river. The pond water is obtained from the inlet channel directly from the sea (Makassar Strait or Sulawesi Sea). The measurement of water salinity level in the 2nd pond was 28.5 ppt (Table 1). The salinity level of the other 3 ponds that receive water through the river tends to be lower, especially in those located in the estuary area. Similarly, the turbidity level of water in pond 2 was the lowest at 8.8 NTU compared to the other 3 pond sites. In contrast, the turbidity level in the 4th pond was the highest at 18.9 NTU with the lowest salinity level of 15.9 ppt. This can be attributed to the high flow of river discharge upstream which usually carries a number of sediments. Dissolved oxygen (DO) levels in the 1st (3.56 mg/l) and 4th (4.44 mg/l) pond were below the recommended threshold. In general, other physical water quality parameters are still at the threshold according to the decision of the Minister of Environment, namely Kepmen-LH No.51 (2004) appendix III on seawater quality standards for marine biota.

Table 1. Physical parameters of water quality in shrimp ponds and rivers of Kotabaru

No.	Location	Temperature (°C)	pH	Turbidity (NTU)	DO (mg/l)	Salinity (ppt)
1	1st Pond	30.12	7.21	6.4	3.56	23.1
2	River of 1st Pond	28.50	7.20	15.3	1.66	23.9
3	2nd Pond	30.83	7.89	8.8	6.21	28.5
4	3rd Pond	29.97	7.23	14.3	6.27	22.3
5	River of 3rd Pond	29.10	7.40	9.9	3.02	22.0
6	4th Pond	30.41	7.61	18.9	4.44	15.9
7	River of 4th Pond	29.65	7.38	83.9	2.77	17.7
Standard Threshold *)		28 - 30	7.0 - 8.5	< 5	> 5	-

*) : Standard Threshold Based on Kepmen-LH No. 51/ 2004 Appendix III (Seawater Quality Standard for Marine Biota) (MERI, 2004).

The data in Table 2 show that the concentrations of ammonia, nitrite, nitrate and phosphate contained in the water samples in all 4 ponds did not exceed the thresholds set by the Government Regulations of the Republic of Indonesia No. 82 (2001) concerning Water Quality Management and Water Pollution Control.

The data in Table 3 show that Lead (Pb) concentrations in water sample of the 2nd and 4th ponds are above the threshold, as well as Cadmium (Cd) concentrations in the 1st and 4th ponds. Meanwhile, Mercury (Hg) concentrations in all 4 ponds were still below the threshold based on

Minister of Environment Decree No. 51 (2009). Although the concentration of Pb metal in pond water has exceeded the threshold, the concentration of Pb, Cd and Hg metals contained in Tiger shrimp meat samples in both the 2nd and 4th ponds did not exceed the threshold set by the Indonesian National Standardization Agency (BSN): SNI 7387 (NSA, 2009) on the Maximum Limit of Heavy Metal Contamination in Food (Table 4). Tiger shrimp samples were only available from the 2nd and 4th ponds because the other 2 ponds (1st and 3rd pond) were still in the early stages of rearing.

Table 2. Chemical parameters of water quality in shrimp ponds and rivers of Kotabaru

No.	Location	Ammonia-N (NH_3-N) (mg/l)	Nitrite-N (NO_2^--N) (mg/l)	Nitrate-N (NO_3^--N) (mg/l)	Phosphate-P (PO_4^{3-}-P) (mg/l)
1	1st Pond	0.002	0.001	0.4	0.003
2	River of 1st Pond	0.003	0.000	0.9	0.082
3	2nd Pond	0.020	0.003	0.1	0.036
4	3rd Pond	0.005	0.002	0.4	0.049
5	River of 3rd Pond	0.005	0.004	0.5	0.078
6	4th Pond	0.020	0.000	0.7	0.085
7	River of 4th Pond	0.005	0.002	0.7	0.065
Maximum Threshold *)		≤ 0.3	≤ 0.06	≤10	≤ 0.2

*): Government Regulation No. 82/2001 on Water Quality Management and Water Pollution Control (GRRI, 2021).

Table 3. Dissolved heavy metals in water sample of tiger shrimp ponds of Kotabaru

No.	Location	Concentration (mg/l)		
		Lead (Pb)	Cadmium (Cd)	Mercury (Hg)
1	1st Pond	0.007	0.001	0.0004
2	2nd Pond	0.009	<0.001	<0.0001
3	3rd Pond	0.007	<0.001	<0.0001
4	4th Pond	0.009	0.001	<0.0001
Maximum Threshold *)		<0.008	<0.001	<0.001

*) : Standard Threshold Based on Kepmen-LH No. 51 (2004). Appendix III : Seawater Quality Standard for Marine Biota (MERI, 2004).

Table 4. Contamination of heavy metals in tiger shrimp body of 2nd and 3rd pond

No.	Sample Location of Shrimp	Lead (Pb) (mg/kg)	Cadmium (Cd) (mg/kg)	Mercury (Hg) (mg/kg)
1	Shrimp of 2nd Pond	0.06	< 0.007	< 0,005
2	Shrimp of 4th Pond	0.15	< 0.007	< 0,005
Maximum Threshold *)		≤ 0.5	≤ 1.0	≤ 1.0

*): Standard Threshold refers to SNI 7387: 2009 on the Maximum Limit of Heavy Metal Contamination in Food (NSA, 2009).

In the context of research on the utilization of water from the former coal mine excavation of PT Adaro Indonesia, South Kalimantan in collaboration with LIPI Limnology Cibinong Bogor, a trial of Tilapia fish (*Oreochromis niloticus*) and Giant freshwater prawn (GFP) (*Macrobrachium rosenbergii*) farming has been carried out in the water of coal mining excavation pond. Based on the results of the analysis of GFP and Tilapia meat, it is declared feasible and safe for consumption based on quality standards that refer to the Indonesian National Standard (SNI 7387: 2009; NSA, 2009) for the maximum limit of heavy metal contamination in food (Table 5). The positive test results obtained are due to the intensive handling of mining waste through several giant reservoirs as waste water containments, in stages such as the first reservoir, the second reservoir, and so on until the last reservoir. In the last reservoir, the water is treated so that if the water is released into the river, it will not have a negative impact on the environment (Antarakalsel, 2015).

Table 5. Results of heavy metal contamination analysis in the body of Tilapia and Giant Freshwater Prawn reared in the Cibinong-Bogor Limnology pond and PT Adaro coal mine excavation pond, South Kalimantan

No	Parameters	Unit	Animal & Location				Maximum Threshold**	
			Giant Freshwater Prawn (GFP)		Tilapia			
			Cibinong	Adaro	Cibinong	Adaro	GFP	Tilapia
1	**Lead (Pb)**	mg/kg	<0.048	<0.048	< 0.048	<0.048	**0,50**	**0,30**
2	**Cadmium (Cd)**	mg/kg	0,160	<0.003	<0.003	<0.003	**1,00**	**0,10**
3	**Mercury (Hg)**	mg/kg	<0.005	<0.005	<0.005	<0.005	**1,00**	**0,50**
4	**Arsenic (As)**	mg/kg	<0.003	<0.003	<0.003	<0.003	**1,00**	**1,00**

** Standard Threshold refers to SNI 7387: 2009 on the Maximum Limit of Heavy Metal Contamination in Food (NSA, 2009).

Referring to the survey results and secondary data as well as the characteristics of brackish water aquaculture conditions in Kotabaru regency, the Team of Research Center for Fishery, recommended the application of good fish farming methods through the application of IMTA technology based on the Sato Umi concept.

A new concept for sustainable fisheries called "Sato-Umi", is defined as "High productivity and biodiversity in the coastal sea area with human interaction" as shown in Figure 3. To establish Sato-Umi, it is necessary to realize comprehensive material cycling in coastal sea area. In order to achieve high aquatic biodiversity, human activity have to keep nutrients concentrations moderate within coastal sea area to provide good habitats for marine biota. Proper management of aquatic resources is important to obtain high fish productivity in Sato-Umi (Sachoemar et al., 2016).

The Integrated Multi Trophic Aquaculture (IMTA) technology based on Sato Umi concept and a sustainable fish farming technology is environmentally friendly, the so-called green technology, because it is “Zero Waste” or “Waste-free” (Figure 4). With this technology, the productivity of coastal brackish water and marine aquaculture can be enhanced through the

business development of aquaculture in an integrated and intensive cultivation of various commodities such as shrimp, finned fish, seaweed and shellfish reared in an area with water quality maintenance. In this system, organic waste of food remains and fish feces will be used by shellfish and sea cucumber for growth, while the seaweed will utilize inorganic nutrients for growth to create a balance of the ecosystem (Chopin, 2006; Neori et al., 2001). Mussels and seaweed, in addition to functioning as bio-filters, can also be used as bio-indicators of the level of pollution in the aquaculture environment.

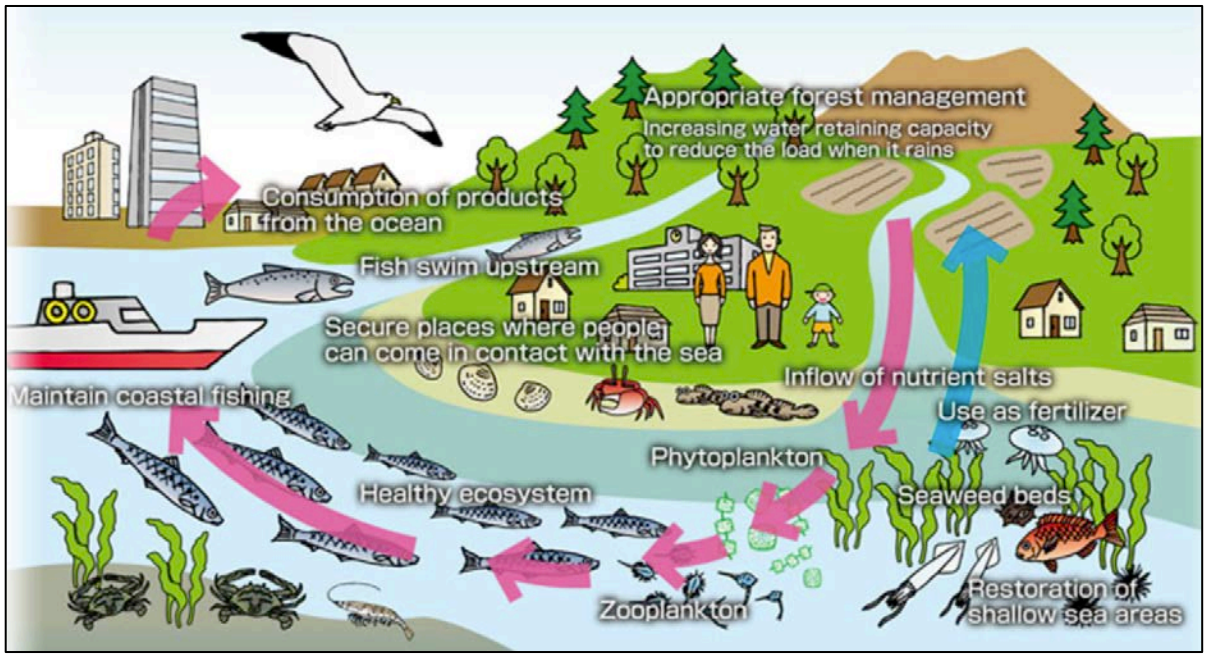

Figure 3. A new concept for sustainable fisheries called "Sato-Umi" (Sato-umi Net, n.d.)

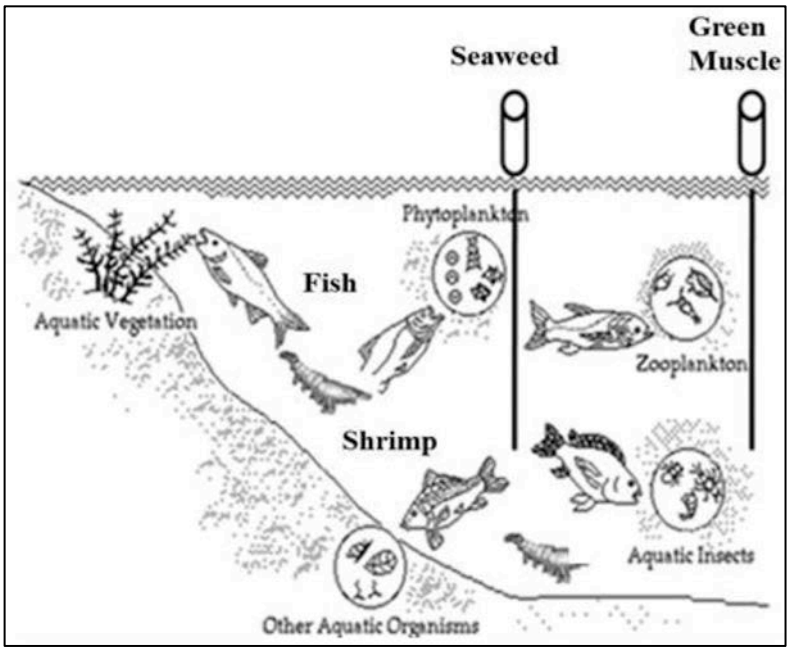

Figure 4. Sustainable model of IMTA for brackish water aquaculture (Sachoemar et al., 2014

The criteria for the choice of species were based on high market demand, high market price, existing culture technology, readily available or constant supply of seed stock, and compatibility of species to the pond environmental requirements in Kotabaru regency. Furthermore, the combination of species in the IMTA farming system aims to help improve the pond environment by utilizing aquaculture species that control and recycle nutrients available and abundant. Extractive species such as mussels and seaweed have been reported to have promising bioremediation potential. As recommendation, culture integration with finfish as a co-cultured organism, mussels as filter feeders, and seaweeds as the primary producers are operative in achieving a sustainable Tiger shrimp (*P. monodon*) aquaculture (Arriesgado et al., 2022).

Conclusion

Based on primary data from the survey results, supporting secondary data and observations of the characteristics of brackish water aquaculture ponds in Kotabaru Regency, it is suggested to apply good aquaculture practice methods through the application of IMTA technology based on the concept of Sato Umi. Integration of IMTA farming with finfish as co-cultured organisms, mussels as filter feeders, and seaweed as primary producers can be used to achieve sustainable Tiger shrimp (*P. monodon*) farming.

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Ethical approval

The author declares that this study complies with research and publication ethics

Informed consent

Informed consent has been obtained from all individual participants involved in the study.

Data availability statement

The authors declare that data can be provided by corresponding author upon reasonable request.

Conflicts of interest

There is no conflict of interests for publishing this study.

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Contribution of authors

Dedy Yaniharto: Conceptualization, Data interpretation, Formal analysis, Writing original draft
Fauzan Ali: Formal analysis, Fact finding data, Investigation, Methodology, draft review.
Iding Chaidir: Project administration, Resources, Supervision, Validation, draft review.
Ratu Siti Aliah: Recommendation resources, Supervision, Validation, draft review.
M. Kholik Firmansyah: Data gathering, analysis contribution, supervision, editing.
All authors have read and agreed to the final version of the manuscript.

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