EEET ECOLOGICAL ENGINEERING & ENVIRONMENTAL TECHNOLOGY

Ecological Engineering & Environmental Technology, 2025, 26(2), 252–263
https://doi.org/10.12912/27197050/199326
ISSN 2719–7050, License CC-BY 4.0

Received: 2024.11.19
Accepted: 2024.12.20
Published: 2025.01.01

Actual pollution load control strategy for physical-chemical parameters in the coastal waters of Yos Sudarso Bay Jayapura City

Auldry F. Walukow[1], I Nyoman Sukarta[2*], Triwiyono[1], Albert Lumbu[1], I Dewa Ketut Sastrawidana[2], I Gusti Lanang Wiratma[2]

[1] Physics Education Study Program, Faculty of Teacher and Education, Cenderawasih University, Papua, Indonesia
[2] Chemistry Department, Faculty of Mathematics and Natural Sciences, Universitas Pendidikan Ganesha, Bali, Indonesia
* Corresponding author's e-mail: auldrywalukow@yahoo.co.id

ABSTRACT

The waters of the Youtefa Bay Nature Tourism Park have been heavily polluted with a STORET value of -99. This research aims to: analyze the existing conditions of water quality and analyze the pollution index in the waters of Yos Sudarso Bay. The location of this research is Yos Sudarso Bay, Jayapura City. The sampling points were three locations, namely Village Kayu Pulo, Taman Mesran Area, and in front of the Swiss Bell Hotel. To determine the water quality status of Yos Sudarso Bay, the STORET method and pollution index (PI) method are used. The research results show that the actual pollution load is higher than the maximum pollution load, this shows that Yos Sudarso Bay has been polluted by the parameters detergent, phenol, NH_3-N, phosphate, and TSS. The strategy model for controlling the pollution load is the implementation of land use regulations, increasing community knowledge, implementation of community income regulations, increasing coordination between OPDs, and using environmentally friendly fishing gear.

Keywords: strategy, control, pollution load, rule enforcement, Yos Sudarso Bay.

INTRODUCTION

Yos Sudarso Bay, also known as Humboldt Bay, is a small bay located in Indonesia. This bay is located on the north coast of Papua province, about 50 kilometers west of the border between the Indonesian province of Papua and Papua New Guinea. The capital of Papua province, Jayapura, is located on the edge of this bay. Since the early 20th century, both this bay and the city of Jayapura have had several different names. The name used now commemorates commodore Yos Sudarso who died in the naval battle between the Netherlands and Indonesia in 1962. During World War II, Yos Sudarso Bay was known as Humboldt Bay, and Jayapura was known as Hollandia. Humbold Bay, or better known to Indonesian people as Yos Sudarso Bay, is rich in tourism potential. The tourism potential in the bay is: beautiful seabed, white sand beaches, mangrove plants, protected forests and the animals there, and floating houses on the sea are very interesting to visit. In Yos Sudarso Bay, the Humboldt Bay Festival has been held in accordance with the agenda of the Papua Province Tourism Office, which has been taking place since 2008, every year featuring cultural tourism attractions, natural beauty, dance and artistic performances native to Humbolt Bay. Within the bay there are five villages such as Kayu Batu, Kayu Pulau, Enggros, Tobati, and Nafri which can be reached by Jayapura City Government tourist boat.

A problem that often occurs in the Gulf is cases of water pollution. Minamata Bay water pollution is caused by mercury which causes Minamata disease, such as mental disorders and neurological defects (Alfian, 2026; Farida, et al., 2021; Puspitasari, 2029; Salsabila, et al., 2023). Mercury is produced from Chiso Corporation industrial waste. Pollution of Jakarta Bay is caused by domestic liquid waste produced from household activities which is

the biggest cause of water pollution in Jakarta Bay (Suhendar, et al., 2007; Siburian, et al., 2017; Sahabuddin, et al., 2914). Pollution that has occurred in the waters of Jakarta Bay has resulted in mass fish deaths. Apart from mercury, sea waters can also be polluted by copper (Cu). The concentration of the heavy metal Cu in Dumai sea water ranges from 0.102 ppm to 0.175 ppm, the water quality in the Dumai Sea based on the concentration of Cu metal in sea water has exceeded the threshold (Febrita, et al., 2011; Cahyani, et al., 2012; Prastiwi and Kuntjoro, 2022; Sekarwati, et al., 2022; Sumarlin and Hartono, 2020). The waters of the Dumai Sea directly border the Malacca Strait, which is a lowland area where part of the area still consists of swamps and mangrove forests. Apart from being used as a port area, industry and shipping route, Dumai's coastal waters are also a place for fishing by residents who live on the coast. The port and waters are used by several companies operating in Dumai, one of which is PT. Patra Dock is engaged in the shipbuilding industry, where Cu metal is used as a preservative mixture. The passenger ferry port also uses Dumai waters for loading and unloading facilities. These conditions make these waters a busy shipping route between islands and countries, so they can contribute heavy metals including Cu. This shows that pollution in marine waters can be caused by heavy metals. Heavy metals that enter the water system, both in rivers and oceans, will be removed from the water bodies through three processes, namely deposition, adsorption and absorption by aquatic organisms.

Other factors that pollute the marine environment are: tailings (mining) waste, sediment, cyanide and heavy metals (Santosa, 2013; Rachmawati and Sugiarto, 2023; Syarifuddin, 2022) and cases of tailings dumping have occurred in Buyat Bay. Marine pollution due to mining and industrial waste results in disruption of the marine resource ecosystem, for example the death of fish and damage to coral reefs. The effect of Hg pollution in Buyat Bay is the occurrence of skin diseases (Setiyono and Djaidah, 2012; Widodo, 2008; Suryani, et al., 2021; Putranto, 2011; Prihantini and Hutagalung, 2018). Mercury (Hg) is toxic to living creatures and causes permanent body damage if consumed in sufficient quantities and for a long time. Pollution of the marine environment can also occur due to contamination by toxic chemicals such as heavy metals and persistent organic pollutants (POPs), but there are other forms of marine pollution due to the phenomenon of harmful algae blooms (HABs) which are known as algae or phytoplankton explosions. The increasing incidence of phytoplankton explosions recently is due to the influence of anthropogenic substances which are increasingly entering marine waters and changes in climate variables can be quite important contributors in triggering phytoplankton explosions. Whether we realize it or not, changes in climate variables have occurred and will continue, such as global warming which causes the melting of polar ice and has a huge impact on the environment (Dale, et al., 2006). Global warming will increase the temperature of sea water, upwelling will occur which can raise organic substances from the lower levels to the surface of sea water, including causing increased evaporation and precipitation (rain and snow) which have the potential to bring organic substances from land to sea waters, thus triggering the growth of phytoplankton. fast. Because the main parameters for phytoplankton growth are water temperature, light and organic substances, global warming will trigger phytoplankton growth. The impacts of phytoplankton explosions include disrupting public health and economically disrupting marine fisheries. Another ecological impact is changes in marine habitat and damage to the coastal structure. Phytoplankton explosions apart from causing fish deaths due to very dense populations can kill fish and invertebrates due to the secondary impact of lack of oxygen, but also produce toxins which if they enter the food chain will be dangerous for the health of humans who consume them (Kim, 2006; Mustarruddin, et al., 2018).

In Papua, water pollution has occurred in Lake Sentani and Youtefa Bay where the water quality status of the waters of the Nature Tourism Park of Youtefa Bay has been heavily or badly polluted with a STORET value of (-99) (Walukow, et al., 2022). Sources of water pollution are industrial waste, residential waste, agricultural waste, floating net cage waste and sea transportation activities. The increase in critical land area results in increased erosion and sediment in rivers and waters. The extinction of sawfish (Pristis microdon) in waters is possibly caused by increasing water pollution (Walukow, et al., 2023; Walukow and Sukarta, 2021; Suwewla, 2003). Heavy metal pollution in water must receive serious attention, because if absorbed and accumulated in the human body it can harm health and in some case cause death. Based on the description above, it can be

concluded that the source of water pollution is caused by activities upstream and downstream. This requires real action from policy makers to minimize environmental degradation. The government must be able to control and manage the bay's aquatic environment so that the bay remains sustainable and beautiful. The tourist beauty and wealth of natural resources of Yos Sudarso Bay need to be managed, however, the condition of the waters has been polluted by careless dumping of rubbish, disposal of household waste, feces and sedimentation which has resulted in shallowing of the coast. Protection and management of Yos Sudarso Bay includes: planning, utilization, control, maintenance, supervision and law enforcement. Therefore, it is necessary to investigate the extent of pollution in the coastal waters of Yos Sudarso Bay.

Previous studies have studied water pollution problems upstream and downstream caused by Mercury, Copper, tailings, cyanide, sediment and persistent organic pollutants (POPs), but previous studies have not studied model-based strategies. local wisdom in controlling sea water pollution. This strategy model based on local wisdom in controlling pollution is important to study so that mass fish deaths do not occur in Yos Sudarso Bay. The people who live around Yos Sudarso Bay are Kayu Batu Village, Kayu Pulo, Tobati, Enggros, Holte Kamp, and the Skow area, most of whose livelihoods are fishermen. The people who live on the coast of Yos Sudarso Bay have local wisdom and unique customs such as traditional houses, carvings, dances, inauguration procedures, tribal chief weddings, and mourning ceremonies, and the people have wisdom in preserving the environment because water is a source of life.

MATERIALS AND METHODS

The research site is in the coastal waters of Yos Sudarso Bay (Figure 1).

SWOT method steps

Analyzing the water quality status of Yos Sudarso Bay

To determine the water quality status of Yos Sudarso Bay, the STORET method is used. Water quality is assessed based on the provisions of the STORET system issued by the EPA (environmental protection agency) which classifies water quality into four classes, namely:

1. Class A: very good, score = 0 meets quality standards
2. Class B: good, score = -1 to -10 slightly contaminated
3. Class C: moderate, score = -11 to -30 moderately polluted
4. Class D: poor score ≥ -31 heavily contaminated

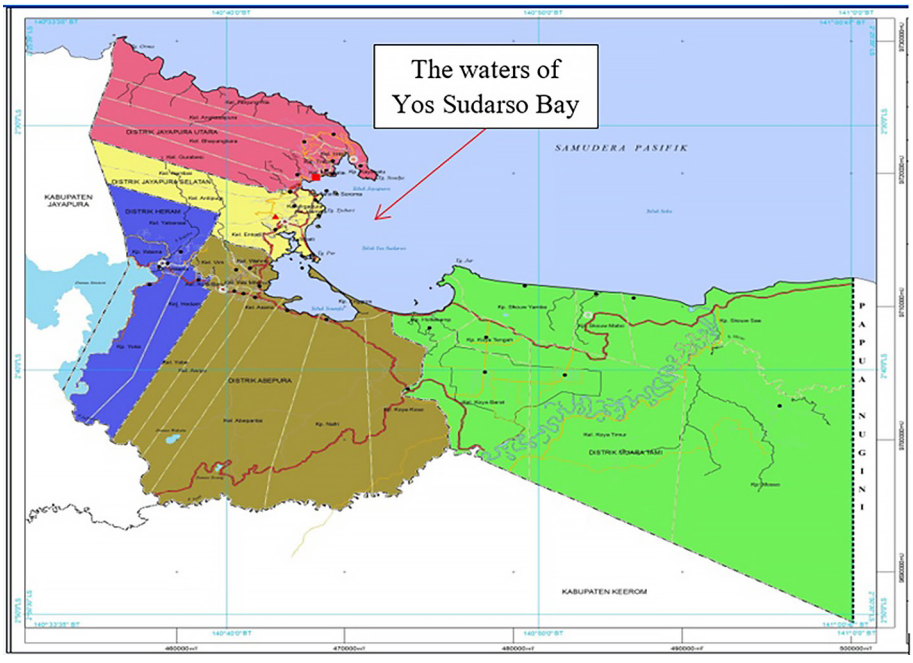

Figure 1. Location of Yos Sudarso Bay beach waters

Determining water quality status using the STORET method is carried out in the following steps:

a) Comparing the measurement data for each water parameter with the quality standard value corresponding to the water class;
b) If the measurement result meets the quality standard value (measurement result <quality standard) then it is given a score of 0,
c) If the measurement result does not meet the water quality standard (measurement result > quality standard) then it is given a score (Table 1),
d) The negative number of all parameters is calculated and the quality status is determined from the total scores obtained using the value system.

Analyzing the pollution index (IP)

$$PI_j = \sqrt{\frac{\left(\frac{C_i}{L_{ij}}\right)_m^2 + \left(\frac{C_i}{L_{ij}}\right)_R^2}{2}} \quad (1)$$

Pollution index class categories:

- $0 \leq PI \leq 1.0$ = good
- $1.0 \leq PI \leq 5.0$ = slightly polluted
- $5.0 \leq PI \leq 10$ = fairly polluted
- $PI > 10$ = heavy polluted

RESULTS AND DISCUSSION

Existing water quality conditions in Yos Sudarso Bay

Evaluation of the existing conditions in the sea waters of Youtefa Bay is carried out by comparing the results of the analysis of physical and chemical water parameters from sea water samples taken with the applicable water quality criteria, namely referring to the Decree of the Minister of the Environment number 51 of 2004 concerning sea water quality standards (Fig. 2), So, based on this decision, in this research, water quality criteria for marine biota

Table 1. Determination of value system to determine water quality status

Number of examples	Mark	Parameter		
		Physics	Chemistry	Biology
< 10	Maximum	-1	-2	-3
	Minimum	-1	-2	-3
	Average	-3	-6	-9
≥ 10	Maximum	-2	-4	-6
	Minimum	-2	-4	-6
	Average	-6	-12	-18

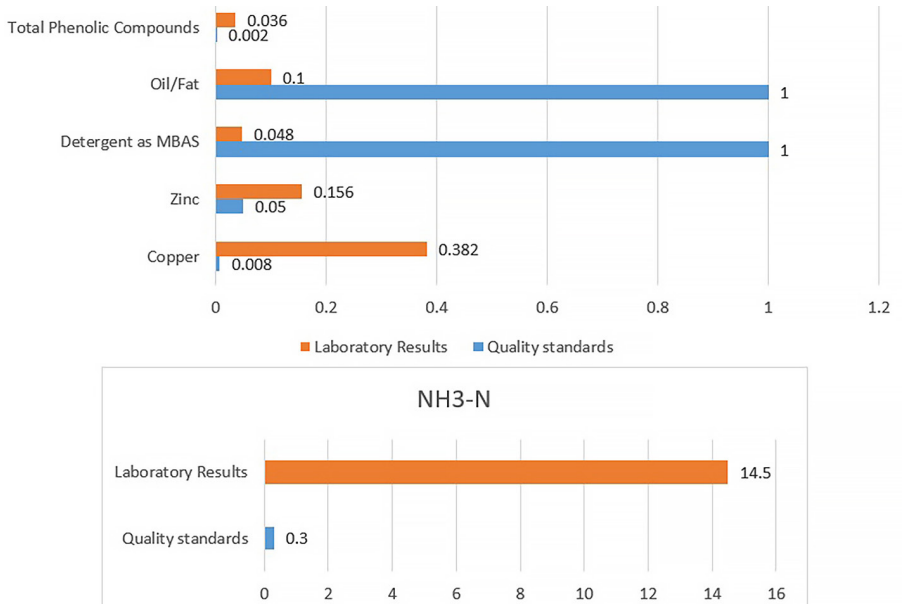

Figure 2. Water quality analysis results

Table 2. Sea water quality status at Dok II Beach, North Jayapura District

No	Parameter	Unit	Quality standards	Laboratory analysis results		Max	Min	Average	Score
				2010	2012				
1	Brightness	m	Natural						
2	Turbidity	NTU	<5	2.2	0.6	2.2 (0)	0.6(0)	1.4(0)	0
3	Temperature	°C	• Corals 28-30 • Mangroves 28-32 • Seagrass 28-30	–					
4	TSS	mg/L	• Corals 20 • Mangroves 80 • Seagrass 20	545	37.0	545(-1)	37.0(-1)	291(-3)	-5
5	pH		7–8.5	7.65	7.63	7.65(0)	7.63(0)	7.64(0)	0
6	NH_3	mg/L	0.3	–	6.9				
7	BOD_5	mg/L	20	10.2					
8	Cyanide	mg/L	0.5						
9	DO	mg/L	>5						
10	NO_3-N	mg/L	0.008		1.1				
11	PO_4-P	mg/L	0.015		0.17				
12	Salinity	0/00	• Corals 33-34 • Mangroves s/d34 • Seagrass 33-34	926	11.2	926(-2)	11.2(0)	468.6(-6)	-8
13	H_2S	mg/L	0.01		0.004				
14	As	mg/L	0.012						
15	Cd	mg/L	0.001		0.12				
16	Cr(VI)	mg/L	0.005		0.041				
17	Hg	mg/L	0.001						
18	Ni	mg/L	0.05						
19	Pb	mg/L	0.008		0.068				
20	Cu	mg/L	0.008		3.87				
21	Zn	mg/L	0.05		0.04				
22	Detergent	mg/L	1		0.072				
23	Oil/Fat	mg/L	1						
24	Phenolic compounds	mg/L	0.002						
25	Total coliforms	MPN/100mL	1000						
	Total score							fairly polluted	-13

are used as a comparison. The values used are tabulated results of the average values for high tide and low tide conditions. The reference quality standards used refer to the Decree of the Minister of Environment Number 51 of 2004 concerning sea water quality standards for marine biota (MENKLH, 2004).

The phenol level in observation data in Kayubatu Village in 2017 was 0.036 mg/L, this result is above the quality standard. The results of observations of detergent levels in Kayubatu village were 0.048 mg/L, laboratory results showed that detergent levels were still below the detergent quality standard, namely 1 mg/L. The results of laboratory analysis of Zn levels in Kayubatu village were 0.156 mg/L, the Zn concentration has exceeded the Zn quality standard, namely 0.05 mg/L. The results of laboratory analysis of the NH_3-N concentration were 14.5 mg/L, this NH_3-N level has exceeded the quality standard of 0.3 mg/L. The results of laboratory analysis of Cu levels in Kayubatu village were 0.382 mg/L, the Cu concentration has exceeded the Cu quality standard, namely 0.008 mg/L.

Water quality status in Yos Sudarso Bay waters

Dok II Beach has been moderately polluted with a value of (-13), this value was obtained using the STORET method. This is caused by

several parameters that have exceeded quality standards, namely the parameters TSS, NH_3, NO_3-N (nitrate), salinity, Cd, Cr, Pb, and Cu. Sources of pollution for the parameters TSS, NH_3, NO_3-N (nitrate), salinity, Cd, Cr, Pb and Cu come from domestic waste and erosion (Table 3). Erosion is carried through runoff and enters rivers. Activities in the river affect water quality in Yos Sudarso Bay. This is in line with research by Chi, et al which states that river hydrodynamic activity influences the improvement of bay water quality (Chi, et al., 2024). This domestic waste will have an impact on water quality and ultimately have a negative impact on human health. The results of this study are in line with research by Gutberlet, et al which states that the risks of household waste and health have an impact on scavengers and the environment in low and middle-income countries (Gutberlet and Uddin., 2017; Manna, et al., 2017; Nica, et al., 2016). High TSS will

Table 3. Sea water quality status around North Jayapura District

No.	Parameters	Unit	Quality standards	Laboratory analysis results			Max	Min	Average	Score
				KPV	MPA	SBH				
Physical										
1	Brightness	m	Natural	Typical	Typical	Typical				
2	Turbidity	NTU	<5	–	–	–	–	–	–	–
3	Temperature	°C	• Corals 28-30 • Mangroves 28-32 • Seagrass 28-30	30.5	30.6	30.6	30.6(0)	30.5(0)	30.57(0)	0
4	TSS	mg/L	• Corals 20 • Mangroves 80 • Seagrass 20	356	434	327	434(-1)	327(-1)	372.33 (-3)	-5
5	pH		7–8.5	8.20	8.13	8.26	8.26(0)	8.13(0)	8.20 (0)	0
6	NH_3	mg/L	0.3	10	9.25	8.50	10(-2)	8.5 (-2)	9.25 (-6)	-10
7	BOD_5	mg/L	20	17.2	11.20	4.2	17.2(0)	4.2 (0)	10.87 (0)	0
8	Cyanide	mg/L	0.5	-	-	-	-	-	-	-
9	DO	mg/L	>5	8.57	7.24	7.2	8.57(0)	7.2 (0)	7.67 (0)	0
10	NO_3-N	mg/L	0.008	2	1	3	3(-2)	19-2)	2.00 (-6)	-10
11	PO_4-P	mg/L	0.015	0.07	1.33	0.47	1.339 (-2)	0.07(-2)	0.62 (-6)	-10
12	Salinity	0/00	• Corals 33-34 • Mangroves s/d34 • Seagrass 33-34	12.13	12.1	12.3	12.3(0)	12.1(0)	12.18 (0)	0
13	H_2S	mg/L	0.01	0.001	0.002	0.002	0.002 (0)	0.001(0)	0.00 (0)	0
14	As	mg/L	0.012	-	-	-	-	-	-	-
15	Cd	mg/L	0.001	0.008	0.011	0.005	0.011 (-2)	0.005 (-2)	0.01 (-6)	-10
16	Cr(VI)	mg/L	0.005	0.006	0.007	0.003	0.007 (-2)	0.003 (0)	0.01 (-6)	-8
17	Hg	mg/L	0.001	0.000	0.000	0.000	0.000 (0)	0.000 (0)	0.00 (0)	0
18	Ni	mg/L	0.05	-	-	-	-	-	-	-
19	Pb	mg/L	0.008	0.075	0.154	0.018	0.154 (-2)	0.018 (-2)	0.08 (-6)	-10
20	Cu	mg/L	0.008	0.446	0.791	0.562	0.791(-2)	0.446 (-2)	0.60 (-6)	-10
21	Zn	mg/L	0.05	0.021	0.034	0.023	0.034 (0)	0.021 (0)	0.03 (0)	0
22	Detergent	mg/L	1	0.024	0.042	0.113	0.113 (0)	0.024 (0)	0.06 (0)	0
23	Oil/Fat	mg/L	1	0.164	0.338	1.042	1.042 (-2)	0.164 (0)	0.51(0)	-2
24	Phenolic compounds	mg/L	0.002	0.040	0.016	0.003	0.040 (-2)	0.003 (-2)	0.02 (-6)	-10
25	Total coliforms	MPN/100mL	1000	8	50	8	50 (0)	8 (0)	22.0 (0)	0
	Total score									-85 (heavily polluted)

Note: KPV – Kayu Pulo Village, MPA – Mesran Park Area, SBH – In front of the Swiss Bell Hotel.

increase turbidity. High turbidity values can disrupt the osmoregulation system of aquatic organisms. Nitrite levels in waters are relatively small, smaller than nitrate because they are immediately oxidized to become nitrate. Sources of nitrite come from industrial waste and domestic waste. High ammonia levels can indicate organic material contamination originating from domestic waste, industrial waste, or agricultural fertilizer waste. Likewise, pollution by nitrogen fertilizers, including anhydrous ammonia as well as organic animal and human waste, can increase nitrate levels in water. Compounds containing nitrate in the soil are usually soluble and easily migrate with underground water. Consuming well water with high nitrate levels will cause several health problems such as goiter, methemoglobinemia, and so on. Nitrate that enters the body, 6% will be reduced to nitrite which is carcinogenic. Ammonia in surface water comes from urine and feces; also, from the microbiological oxidation of organic substances (HaObCcNd) originating from natural water or industrial and residential wastewater.

The source of ammonia in waters is the breakdown of organic nitrogen (protein and urea) and inorganic nitrogen found in soil and water, which comes from the decomposition of organic material (dead plants and aquatic biota) by microbes and fungi. High concentrations of ammonia on the surface of the water will cause the death of fish found in the water.

The waters of Yos Sudarso Bay beach which is located on Village Kayu Pulo beach, the beach in the Taman Mesran area and the beach in front of the Swiss Bell Hotel have been heavily polluted with a value of (-85) (Table 4). This is caused by several parameters that have exceeded the quality standards, namely the parameters TSS, NH_3, NO_3-N, PO_4-P, Cd, Cr, Pb, Cu, Zn, Oil/Fat, and Phenolic Compounds. The TSS range is from 327 – 434 mg/L, the highest TSS levels in the coastal waters of the Taman Mesran area and the lowest in the coastal waters of the Swiss Bell Hotel Front. The range of NH_3 levels is 8.5–10 mg/L, where the highest NH_3 concentration is in Village Kayu Pulo and the lowest is in the coastal waters of the Swiss Bell Hotel Front. The NO_3-N concentration range is from 1–3 mg/L, where the highest concentration is in the waters of the beach at the Front of the Swiss Bell Hotel and the lowest is at the beach in the Taman Mesran area. The range of PO_4-P levels is 0.07–1.33 mg/L, where the highest concentration is in the coastal waters of the Taman Mesran area and the lowest is in Village Kayu Pulo. The Cd concentration range is 0.005–0.011 mg/L, where the highest concentration is in the coastal waters of the Taman Mesran area and the lowest is in the coastal waters of the Swiss Bell Hotel Front. The range of Cr levels is 0.003–0.007 mg/L, where the highest is in the coastal waters of the Taman Mesran area and the lowest is in the coastal waters of the Swiss Bell Hotel Front. The Pb concentration range is 0.018–0.154 mg/L, where the highest concentration is in the coastal waters of the Taman Mesran area and the lowest is in the coastal waters of the Swiss Bell Hotel Front. The range of Cu levels is 0.446 – 0.791 mg/L, where the highest concentration is in the coastal waters of the Taman Mesran area and the lowest is on the Village Kayu Pulo beach. The Zn concentration range is 0.021 – 0.034 mg/L, where the highest concentration is in the coastal waters of the Taman Mesran area and the lowest is on the Village Kayu Pulo beach. The concentration range for Oil/Fat is 0.164–1.042 mg/L, where the highest concentration is in the waters of the Front Hotel Swiss Bell beach and the lowest is at Village Kayu Pulo beach. The concentration range of phenolic compounds is 0.003–0.040 mg/L, where the highest concentration is at Village Kayu Pulo beach and the lowest is in the waters of the Front Swiss Bell Hotel beach.

The results of the analysis using the IP method showed that the water quality status or pollution index in the coastal waters of Kayubatu village was heavily polluted with a value of (30.21). This is caused by several parameters that have exceeded quality standards, namely: NH_3-N, Cu, Zn, and Phenol.

Based on the study above, it shows that the water quality status in the coastal waters of Yos Sudarso Bay is mildly polluted, moderately polluted and heavily polluted. Therefore, it is necessary to control water pollution. The aspect of controlling water pollution involves the role of government, the role of society, the role of industry, the role of customs, and the role of religion, this is a manifestation of the Co-Management approach. The government's role is the need to inventory and identify sources of river and coastal pollution. The government's role must also be to control environmental documents and environmental permits for the types of businesses or industries in the city of Jayapura. Types of business or industry that do not yet have environmental documents such as AMDAL, UKL, UPL or SPPLH and environmental permits must be reprimanded and given sanctions

Table 4. Status of Sea Water Quality at Base-G Beach in Kayubatu Village

No.	Parameter	Unit	Lij	Ci	Ci/Lij	(Ci/Lij) baru	Information
A. Inorganic chemicals are not metals							
1	pH		7-8.5 (7.75)	8.02	1.03483871	0.36	Lij which has a range. and Ci>Lij
2	NH_3-N	mg/L	0.3	14.5	48.3333333	9.42123374	(ci/Lij)>1 then Formula (ci/Lij) new=1+5log(ci/Lij) measurement results
3	Salinity	mg/L	• Corals 33-34 • Mangroves s/d34 • Seagrass 33-34 (33.5)	12.4	0.37014925	42.2	Lij which has a range. and Ci>Lij. and Ci≤Lij
4	Sulfide (H_2S)	mg/L	0.01	0.004	0.4	0.4	
B. Inorganic chemistry of metals							
5	Cadmium (Cd)	mg/L	0.001	0.001	1	1	
6	Mercury(Hg)	mg/L	0.001	0	0	0	
7	Copper (Cu)	mg/L	0.008	0.382	47.75	9.39486688	(ci/Lij)>1 then Formula (ci/Lij) new=1+5log(ci/Lij) measurement results
8	Zinc(zn)	mg/L	0.05	0.156	3.12	3.47077297	(ci/Lij)>1 then Formula (ci/Lij) new=1+5log(ci/Lij) measurement results
C. Inorganic chemistry							
9	Detergent as MBAS	mg/L	1	0.048	0.048	0.048	
10	Oil/Fat	mg/L	1	0.1	0.1	0.1	
11	Total phenolic compounds	mg/L	0.002	0.036	18	7.27636253	(ci/Lij)>1 then Formula (ci/Lij) new=1+5log(ci/Lij) measurement results
					Amount (Ci/Lij) new	73.6712361	
					(Ci/Lij) new average	6.6973851	
					(Ci/Lij) maximum	42.2	
					Pij^2	912.85	
					Pij	30.21 (heavily polluted)	

in accordance with applicable legal regulations. The role of religious leaders and community leaders together must continue to voice the importance of preserving the environment or being environmentally conscious in religious lectures or religious pulpits, because preserving the environment is part of faith. The community figures in question are the leaders of village associations in Jayapura City, such as the Leadership of Kawanua Harmony, the Leader of the Javanese Community Association, the Leader of the South Sulawesi Family Association, and others. The role of these figures must continue to speak out against throwing rubbish and waste water carelessly, must throw it in the trash and must have an IPAL for industry. The role of traditional leaders in Jayapura City must be to prevent land conversion that is not in accordance with the function of space. The land use change in question is: land use change in the Abe Protected Forest, CA Cycloop and the catchment area as a buffer layer. Utilization activities that are not in accordance with the function of space in the Abe Protected Forest, CA Cycloop and catchment areas as a buffer layer are settlements, housing, tree

felling, agriculture and plantations. The role of traditional leaders is also to supervise environmental documents and environmental permits for types of business or industry in the city of Jayapura. Types of business or industry that do not yet have environmental documents such as AMDAL, UKL, UPL or SPPLH and environmental permits must be reprimanded by traditional leaders. The role of traditional leaders and the government must be to jointly monitor the existence of IPALs in types of business or industry. Those who do not have IPALs must be reprimanded and given sanctions in accordance with applicable government regulations.

Pollution load

The Figure 3 shows that the actual pollution load is higher than the maximum pollution load, this shows that Yos Sudarso Bay has been polluted by the parameters Detergent, Phenol, NH_3-N, Phosphate, and TSS. The highest river pollution load entering Yos Sudarso Bay is the TSS parameter and the lowest is NH_3-N. TSS pollution loads can cause sedimentation in the Anafre River Estuary and increase turbidity in the Yos Sudarso River and Bay. The pollution load in Yos Sudarso Bay resulted in mass deaths of fish, eels and turtles. Hundreds of small white fish-eating birds also died.

The pollution control strategy in Yos Sudarso Bay is the Weakness – Threats (WT) strategy with a position value of (-0.2; -0.3). The WT strategy is:

1. Implement land use regulations to avoid degradation of natural resources around Yos Sudarso Bay and avoid silting.
2. Increase public knowledge to minimize waste in Yos Sudarso Bay.
3. Implement regulations that support fishermen's income.
4. Improve coordination between regional apparatus organizations (OPD) to minimize pollution.
5. Increase the use of environmentally friendly fishing gear.

Based on the strategy above, the strategy model is

The results of this research are in line with research by (Walukow, et al., 2023) which states that controlling water pollution requires enforcement of regulations (Walukow and Sukarta, 2021; Hapsari, et al., 2020). The occurrence of sea water pollution will result in an economic decline for fishermen. Environmental regulations influence the development of a high-quality marine economy (Wu, et.al., 2923; Agustiningsih, et al., 2012; Lubis, et al., 2018).

Yos Sudarso Bay has a wealth of natural tourism potential that is attractive to tourists, namely the beauty of the seabed, beaches, mangrove plants, protected forests, and very interesting wildlife. People enter the mangrove forest and end up polluting Yos Sudarso Bay. One effort to preserve the environment is the involvement of Indigenous Peoples through local wisdom. The local wisdom of indigenous communities is that women who can enter mangrove forests are women (mama) who are married, while girls who are not yet married cannot enter. Mothers will

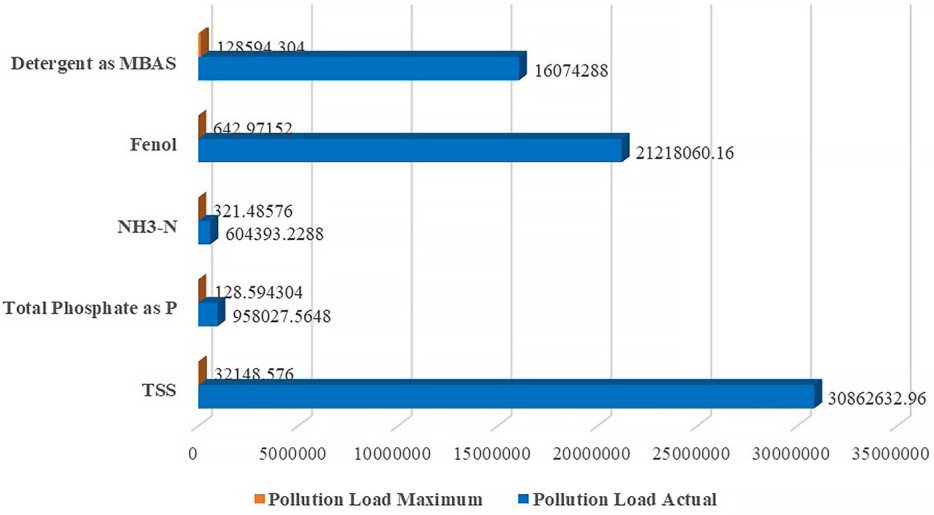

Figure 3. Maximum pollution load (tons/month)

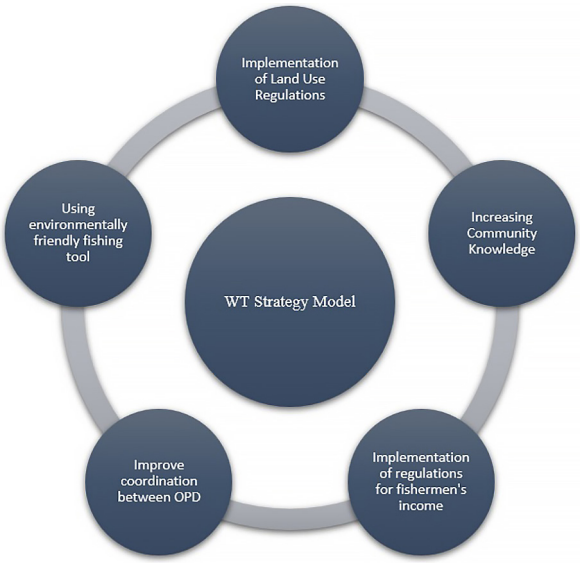

Figure 4. Pollution control strategy model in Yos Sudarso Bay

look for marine products while undressing so that men and outsiders are prohibited from entering this forest on purpose. If outsiders or men enter this forest without permission, they will receive customary sanctions in the form of payment according to the level of error. However, indigenous communities are experiencing various pressures so that the mangrove forest, which functions to prevent the risk of earthquakes, tsunamis and aberrations, has experienced damage covering an area of 222.08 ha. The main cause of damage to mangrove forests is the increase in activities that convert mangrove forests into other uses such as ponds, development of industrial and residential areas. Increasing damage to mangrove forests has resulted in increased water pollution in Yos Sudarso Bay. Therefore, the strategy model based on local wisdom is to increase the role of customary law communities, forest socialization is mothers, those who can enter the mangrove forest are women who are already married, women enter the mangrove forest by taking off their clothes, it is prohibited for men and outsiders to enter the mangrove forest and customary sanctions for men entering mangrove forests. This local keirin-based strategy model can minimize water pollution in Yos Sudarso Bay.

CONCLUSIONS

Yos Sudarso Bay water quality parameters that have exceeded quality standards are copper, zinc and ammonia. The water quality status in Yos Sudarso Bay is moderately polluted and heavily polluted. The strategy for controlling the burden of water pollution in Yos Sudarso Bay is the Weakness – Threats Strategy, namely a strategy that minimizes weaknesses to avoid the threat of pollution in the days to come. The most important strategy is the enforcement of environmental management regulations. Local people really love mothers, because mothers are the ones who give birth to offspring. The strategy model based on local wisdom is to view mangrove forests as women or mothers, so they must be preserved.

Acknowledgements

Thanks are expressed to the Institute for Research and Community Service at Cenderawasih University and the Faculty of Teacher Training and Education at Cenderawasih University for providing PNBP funding assistance for this research**.**

REFERENCES

1. Agustiningsih, D., Sasongko S.B., Sudarno., 2012. Water Quality Analysis and Water Pollution Control Strategy for the Blukar River, Kendal Regency. *Journal of Precipitation*, *9*(2), 64–71.
2. Alfian. 2006. Mercury: the benefits and effects of its use on human health and the environment. University of Northern Sumatra.
3. Cahyani, M.D., Azizah., R.T.N., Yulianto, B. 2012. Study of the heavy metal copper (Cu) content in water, sediment, and blood mussels (*Anadara granosa*) in the waters of the Sayung River and Gonjol River, Sayung District, Demak Regency. *Journal of Marine Research*, *1*(2), 73-79, http://ejournal-s1.undip.ac.id/index.php/jmr
4. Chi, Y., Zhang, W., Liu, Y., Zhang, X., Chi, W., Shi, B., 2024. Improving water quality in a sea bay by connecting rivers on both sides of a Harbor. *Journal of Marine Science and Engineering*, *12*(442), 1–19. https://doi.org/10.3390/jmse12030442.
5. Dale, B. Edwards, M. Reid, P.C. 2006. *Ecology of harmful algae: Climate change and harmful algal bloom.* Spriger-verlag. Heidelberg.
6. Djokosetiyanto. 2005. Water quality measurement and analysis. Open University. Ministry of Education. Jakarta.
7. Farida, S.S., Firmansyah, Y.W., Widyantoro, W., Fuadi, M.F., Afriana, Y., Hardiyanto, A., 2021. The impact of river pollution in Indonesia on health problems: Literature review. *Journal of Health*

Research, *13*(1), 120–133.

8. Febrita, E., Darmadi, Trisnani, T., 2011. Content of the heavy metal copper (Cu) in red snails (*Cerithidea sp*) in Dumai Sea Waters. Riau Province. *J. Biogenesis*, *8*(1), 36–40.
9. Gutberlet, J., Uddin, S.M.N. 2017. Household waste and health risks affecting waste pickers and the environment in low- and middle-income countries. *International Journal Of Occupational and Environmental Helth*, *23*(4), 299–310. https://doi.org/10.1080/10773525.2018.1484996.
10. Hapsari, I.A., Dawud, J., Sufianti, E., Lestari, E.W., Nurliawati, N., 2020. Implementation model of industrial waste water pollution control policy in Purwakarta regency using a systems thinking approach. *Journal of State Administration*, *26*(3), 249–266.
11. Kim, H.G. 2006. Mitigation and control of HABS, Ecological studies: Analysis and synthesis. 189. Springer. Netherland. 327-338.
12. Lubis, A.I.F., Nasution, D.P., Sembiring,R., 2018. Analysis of the impact of environmental pollution on socio-economic factors in coastal areas in Pahlawan Village, Tanjung Tiram District, Batubara Regency. *Abdi Ilmu Scientific Journal*, *2*(1), 94–116.
13. Manna W., Subari Y., Kadirman. 2017. Analysis of water quality and heavy metal contamination of mercury (Hg) and lead (Pb) in fish in the hertasning regional canal, Makassar City. *Journal of Agricultural Technology Education*, *3*(2017): S197-S210.
14. MENKLH. 2004. Decree number: Kep 51/MENKLH/2004 concerning Guidelines for Determining Environmental Quality Standards. Secretariat of the state minister for Population and Environment. Jakarta.
15. Mustarruddin, Wiyono, E.S., Khotib.M., Asnil, Bahri, S. 2018. pollution patterns of fishing locations and fish caught due to the development of economic activities around lake Maninjau. *Journal of Natural Resources and Environmental Management*, *8*(2), 134–142.
16. Nica C., Djamar T.F.L.B., Sulistiono. 2016. Content of heavy metals Pb, Hg, Cd, and Cu in the flesh of bamboo shoot fish (*Sillago Sihama*) in the Donan River Estuary, Cilacap, Central Java. Indonesian. *Journal of Fishery Product Processing*, *19*(3): 267–276. DOI: 10.17844/jphpi.2016.19.3.267. journal.ipb.ac.id/index.php/jphpi
17. Prastiwi, A.D., Kuntjoro, S. 2022. Analysis of heavy metal copper (Cu) content in water spinach (*Ipomea aquatica*) in the Prambon River, Sidoarjo. *Bio Lantern*, *11*(3), 405–413. https://journal.unesa.ac.id/index.php/lenterabio/index
18. Prihantini, N.N., Hutagalung, P., 2018. Health problems due to mercury exposure to workers in the cosmetics industry. *Widya Scientific Journal*, *5*(1), 56–61.
19. Puspitasari, D.E. 2009. The impact of water pollution on environmental health from an environmental law perspective (Case Study of the Code River in Wirogunan Village, Mergangsan District and Prawirodirjan Village, Gondomanan District, Yogyakarta). *Legal Pulpit*, *21*(1), 23–34.
20. Putranto, T.T. 2011. Heavy metal mercury (Hg) pollution in ground water. *Technique*, *32*(1), 62–71.
21. Rachmawati, A., Sugiarto, D.W. 2023. Systematic review: Effects of contamination from mining tailings on public health. *Public Health Bulletin*, *42*(1), 40–51. https://ejournal.poltekkes-smg.ac.id/ojs/index.php/keslingmas/issue/archive
22. Sahabuddin, H., Harisuseno, D., Yuliani, E., 2014. Analysis of water quality status and capacity for the pollution load of the Wanggu River, Kendari City. *Journal of Water Engineering*, *5*(1), 19–28.
23. Salsabila, N.F., Raharjo, M., Joko, T. 2023. River water pollution index and the distribution of (waterborne diseases): A Systematic Study. *Environmental Occupational Health and Safety Journal*, *4*(1), 24–34.
24. Santosa. 2013. Impact of marine environmental pollution by mining companies on traditional fishermen. *J. Lex Administratum*, *1*(2), 2013.
25. Sekarwati, N., Murachman, B., Sunarto. 2015. The impact of heavy metals Cu (copper) and Ag (silver) in silver industry liquid waste on well water quality and public health and control efforts in Kota Gede Yogyakarta. *Ecoscience Journal*, *VII*(1), 64-76.
26. Setiyono, A., Djaidah, A., 2012. Consumption of fish and agricultural products on blood Hg Levels. *J. Public Health*, *7*(2), 110–116. Siliwangi University, Tasikmalaya.
27. Siburian, R., Simatupang, L., Bukit, M., 2017. Analysis of sea water quality on activities in the Port of Waingapu-Alor, East Sumba. *Journal of Community Service*, *23*(1), 225-232.
28. Suhendar,I., Sachoemar, Wahjono, H.D.W. 2007. Conditions of water environmental pollution in Jakarta Bay. *J. JAI*, 3(1), 2007.
29. Sumarlin, S., Harsono, B. 2020. Analysis of the heavy metal copper (Cu) in the Pampang River, Pampang Village, North Samarinda District. *Agrocomplex*, *20*(2), 12–18. https://ppnp.e-journal/agro_ppnp
30. Suryani, D., Darmawan, Sriwahyuni, S., Yarmaliza. 2021. Analysis of the impact of mercury metal content (Hg) in river water on public health in Paya Ateuk Village, Pasie Raja District, South Aceh Regency. *Jurmakemas Journal*, *1*(2), 203–215.
31. Suwelo, I.S., 2005. Rare and endangered fish species need to be protected by law. *Journal of Indonesian Aquatic and Fishery Sciences*, *12*(2), 153–160.
32. Syarifuddin, N. 2022. The influence of the nickel mining industry on maritime environmental

conditions in Morowali Regency. *Journal of Maritime Applied Research & Technology*, *1*(2), 19–23.

33. Walukow, A.F., Triwiyono, Sukarta, I.N. 2022. Conceptual model of water pollution control strategies in the lower Sentani watershed post flash flood using the SWOT method. *Ecological Engineering & Environmental Technology*, *22*(3), 120–129. https://doi.org/10.12912/27197050/135528
34. Walukow, A.F., Triwiyono, Lumbu A., Gultom M., and Sukarta I.N., 2023. Policy priority model for management of lake sentani waters degradation after flash floods using the A'WOTMIC method. *Journal of Ecological Engineering*, *24*(6), 239–248. https://doi.org/10.12911/22998993/162953.
35. Walukow, A.F., Sukarta, I.N. 2021. Analysis of carrying capacity and water pollution in the Simporo Strait Area After a Flash Flood. *Ecological Engineering & Environmental Technology*, *22*(3), 120–128. https://doi. org/10.12912/27197050/135528.
36. Widodo. 2008. Mercury (Hg) pollution as an impact of gold ore processing in the Ciliunggunung river, Walura, Sukabumi Regency. *Indonesian Geological Journal*, *3*(3), 139–149.
37. Wu, F., Cui, F., Liu, T. 2023. The influence of environmental regulation on high-quality development of marine economy from different subjects' perspectives. *Frontiers in Marine Science*, *10*(1107666), 1–24. doi:10.3389/fmars.2023.1107666.