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## Water Quality Status of Segara Anakan Cilacap Indonesia for Biota Life

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## Water Quality Status of Segara Anakan Cilacap Indonesia for Biota Life

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**Abstract.** The Segara Anakan is a fertile estuarine of Indonesian water having strategic values for various uses. Increased human activities have increased the potential risk of deteriorating environmental quality and subsequently caused a decline in organism biodiversity. The purposes of this study were to assess the quality of Segara Anakan by evaluating the pollution status biologically, whether it fulfilled the requirement for organism life or not. The research method used was a four-month survey in the eastern part of the Segara Anakan area. Sampling was done purposively in 7 sites. The parameters observed were water quality according to seawater quality standards for marine biota. The status of water quality was determined using the Coefficient of Saprobic. The results showed that ten parameters did not meet water quality standards, that were TSS, Dissolved Oxygen, Phosphate, Orthophosphate, Nitrate, PCBs, TBT, and Cr, As, Cd, and Pb. The status of water quality in all locations showed that it was lightly polluted with the status of mesosaprobic  $\beta$ . It was recommended that human activities that potentially pollute the environment, such as waste disposal, be restricted to avoid the water quality from becoming worse.

### 1. Introduction

Segara Anakan is an estuarine surrounded by mangrove forests located in Cilacap Regency, Central Java Indonesia (07°34'29.42" S - 07°47'32.39" S and 108°46'30.12" E - 109°03'21.02" E), which covers of approximately 34,018 Ha. Although those areas are protected from the Indonesian Ocean by Nusakambangan island, it is still connected with the sea through two canals of East Plawangan (Majingklak Strait) and West Plawangan (Motean Strait). Therefore, it is affected by the tidal movements of the Ocean.

Segara Anakan is one of the national conservation areas divided into Western and Eastern, for management purposes. Based on its water source, the western part obtains freshwater input from Rivers Citandui and Cikonde, which have a very high sedimentation rate of up to 7.4 million tons m<sup>3</sup>.year<sup>-1</sup> [1, 2]. The eastern part received freshwater input from Rivers Donan, Kembang Kuning, Dangal, and Sapuregel. The east region becomes a center of human activities and industrial activities, including petroleum processing and the cement industry, transportation, residential, fishery, tourism, and other domestic activities. The high level of human activity in the eastern part of Segara Anakan is feared to have a potential risk of the decline in environmental quality and affect aquatic biota development.

Many estuarine organisms, including shrimp, fish, crabs, and other biotas, have high economic value in the eastern part of Segara Anakan [3]. However, currently, the biological resources in Segara Anakan were declining significantly [4]. There were 29 fish species representing 18 families found in Segara Anakan waters in 1977 [5], but in 2014 there were 17 species from 12 families [6] observed that t), showing a decline in fish diversity as many as 12 species over 17 years.



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Therefore, monitoring water quality is very important to support the survival of the organisms that live there. Determination of water quality status needs to be done as a reference in monitoring water quality pollution. The saprobic coefficient is a simplified biological water quality assessment method to evaluate the level of pollution based on the proportion of species from one group of microorganisms [7]. Thus, the pollution level can be described based on the proportion of heterotrophic, myxotrophic, and autotrophic organisms. The saprobic coefficient is very simple because it is not necessary to determine the organisms present in the sample accurately. What must be done is only to determine the group of aquatic organisms determining the water saprobic.

To obtain the water quality status of Segara Anakan, determining the water pollution level was conducted in the eastern part to preserve its function. This monitoring needs to be done to control activities that can damage estuary ecosystems. Based on the Ministry of Environment decree No. 51 of 2004, one way of controlling marine environment pollution is to establish water quality standards.

Therefore, this study's purposes were to determine the water quality parameters exceeding the standard of the biota life, and to evaluate the pollution level of the Segara Anakan eastern part. This study's results can be used as a reason to reduce the concentration of water quality parameters that exceed the quality standard by limiting community activities, which causes an increase in its concentration holistically both in the catchment area and in its waters.

## 2. Methods

This research was carried out for four months in the eastern part of the Segara Anakan using a survey method in 7 sites selected purposively. Samples were taken once a month in April and May 2018, representing the rainy season, and in September and October 2018, the dry season of the highest and lowest tide. The sampling sites are representing in Figure 1.

Parameter observed were all those of water quality standard for biota life based on the Decree of the Minister of Environment No. 51, 2004, including physical, chemical, biological, and dissolved metal. Physical parameters measured were transparency, smell, Total Suspended Solid (TSS), debris, water temperature, oil layer. The chemical parameters were pH, salinity, ammonia total (NH<sub>4</sub>), Sulphide (H<sub>2</sub>S), hydrocarbon, phenol, PCB, TBT, oil, and fat. The dissolved metals were including Hg, Cd, Cu, Pb, Zn, Ni. The biological parameter was the plankton determining the water saprobic phase and level pollution [7], i.e., Ciliata, Euglenophyta, Chlorococcales, Diatomeae, Peridinae, Chrysophyceae, and Conjugateae.

The water quality data were analyzed descriptively by comparing them to Water Quality Standards for the biota life, especially for the mangrove area (KepmenLH No. 51 of 2004). Parameters measured beyond the threshold were plotted using a histogram and compared to the standard for each site observed and being evaluated descriptively.

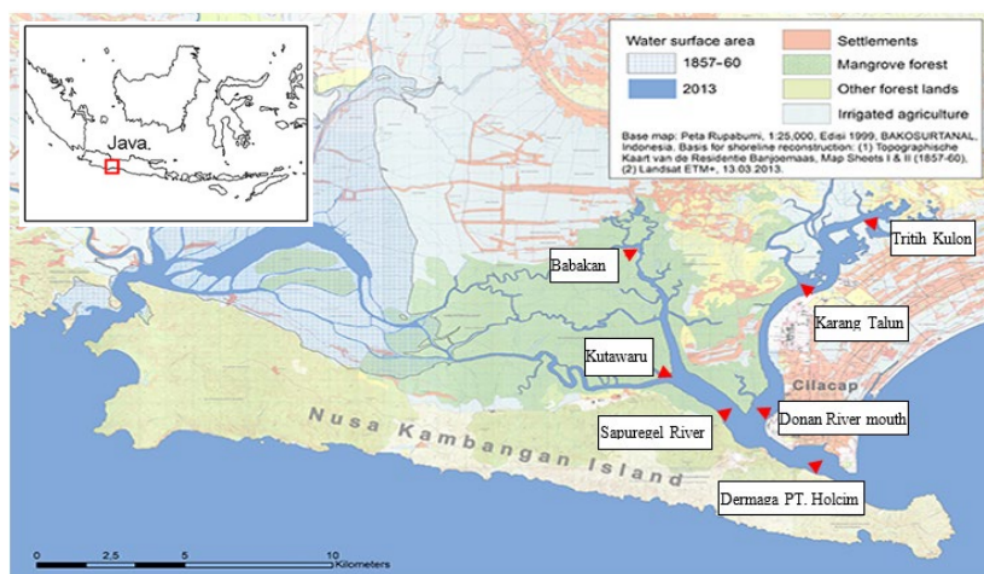
The pollution level was evaluated using the Coefficient of Saprobic based on specified plankton that represents the level of pollution and the sources of pollutant [7] using a formula as follows:

$$X = \frac{C+3D-B-3A}{A+B+C+D}$$

Where, X = coefficient of Saprobic (range from -3 to +3)

- A = organism group of Ciliata,
- B = organism group of Euglenophyta,
- C = organism group of Chlorococcales dan Diatomeae,
- D = organism group of Chrysophyceae, Peridinae dan Conjugaceae.

The calculation result of coefficient saprobic were applied to determine saprobic phase and pollutant level based on the requirement based on coefficient of Saprobic [7].



Sites Coordinates:

1. Trith Kulon (S 07°39'41" E 108°59'07"),
2. Karang Talun (S 07°39'44" E 109°00'44")
3. Donan River mouth (S 07°43'52" E 108°59'07")
4. Dermaga Batubara (S 07°44'57" E 108°59'59")
5. Sapuregel River mouth (S 07°43'12" E 108°58'14")
6. Kutawaru (S 07°42'28" E 108°57'73")
7. Babakan (S 07°40'5.5" E 108°57'8.3")

**Figure 1.** Sampling points in Segara Anakan

### 3. Results

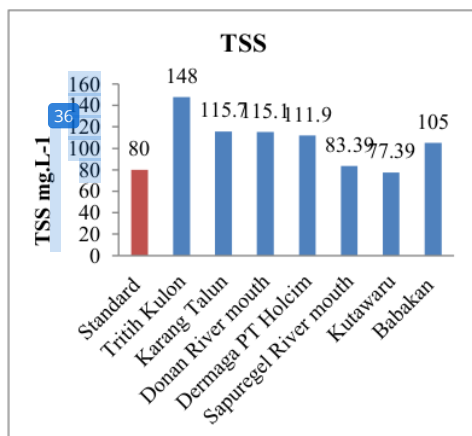
The results of the measurement of the water quality parameters in eastern part of Segara Anakan compared to the standards for the biota life are listed in Table 1. There were ten parameters exceeded the required threshold (in bold) consisting of TSS, O<sub>2</sub>, Phosphate, Nitrate, Total PCB, TBT, and heavy metals (Cr, As, Cd, Pb) (Table 3). Suspended solid material or Total Suspended Solid (TSS) was a precipitating material that inhibit a photosynthetic process by phytoplankton and plant [8]. The results of TSS measurements in Segara Anakan ranged from 83.39 - 148 mg.L<sup>-1</sup> and had exceeded the quality standards required for the life of the biota (Figure 2).

The dissolved oxygen content in Segara Anakan ranged from 3.16 -to3.36 mg.L<sup>-1</sup> and was below the quality standard for marine biota at 5 mg.L<sup>-1</sup> (Figure 3). The measurements of nitrate and orthophosphate ranged from 0.017 to 0.052 mg.L<sup>-1</sup> and exceeded the threshold (0.008 mg.L<sup>-1</sup> and 0.005 mg.L<sup>-1</sup>) as shown in Figures 4 and 5. The TBT content in Segara Anakan ranges from 0.012 to 0.016 µg.L<sup>-1</sup> and has exceeded the standard quality threshold for the life of marine organisms (0.010 µg.L<sup>-1</sup>) (Figure 6). The PCBs in all sites were almost evenly concentrated in the range of 0.068 - 0.083 µg.L<sup>-1</sup> and have exceeded the quality standard for biota life (0.010 µg.L<sup>-1</sup>) (Figure 7).

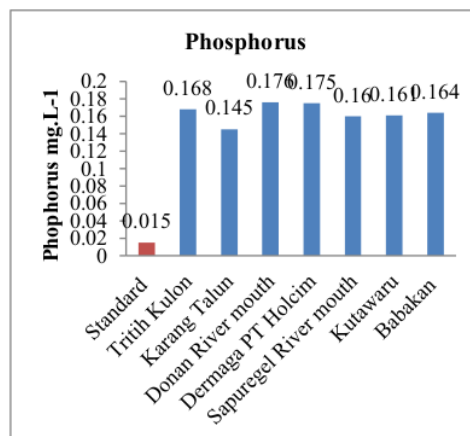
**Table 1.** Water quality measurement based on the standard for biota life ( Ministry of Environment Decree No. 51/2004)

No	Parameter	unit	Tritih Kulon	Karang Talun	Donan River Mouth	PT Holcim	Sapuregel River Mouth	Kutawaru	Babakan	Standard
			1	2	3	4	5	6	7	
1	Light Penetration	m	0,47	0,67	0,75	0,55	0,52	0,47	0,51	>3
27	smell		natural	natural	natural	natural	natural	natural	natural	no smell
3	TSS	mg.L <sup>-1</sup>	<b>148</b>	<b>115</b>	<b>115</b>	<b>111</b>	<b>83</b>	<b>77</b>	<b>77</b>	<b>80</b>
4	Debris	-	moderate	moderate	moderate	moderate	moderate	moderate	moderate	-
5	Temperature	°C	26-29	26-29	27-31	26-30	26-29	26-29	26-29	normal
6	Oil Layer	-	no	no	no	no	no	no	no	-
7	pH	-	6,8	6,7	6,7	6,6	6,8	6,7	6,7	6,5 – 8,5
8	Salinity	‰	27,8	29,0	30,5	32,3	29,3	29,8	28,5	normal
9	O <sub>2</sub>	mg.L <sup>-1</sup>	<b>3,29</b>	<b>3,35</b>	<b>3,17</b>	<b>3,16</b>	<b>3,36</b>	<b>3,26</b>	<b>3,26</b>	<b>&gt;5</b>
10	BOD	mg.L <sup>-1</sup>	<b>4,7</b>	<b>4,7</b>	<b>4,4</b>	<b>4,4</b>	4,3	4,5	4,5	20
11	AMMONIA	mg.L <sup>-1</sup>	<b>0,03</b>	<b>0,02</b>	<b>0,02</b>	<b>0,02</b>	0,03	0,03	0,03	0,03
12	PO <sub>4</sub> -P	mg.L <sup>-1</sup>	<b>0,168</b>	<b>0,145</b>	<b>0,176</b>	<b>0,175</b>	<b>0,160</b>	<b>0,161</b>	<b>0,161</b>	<b>0,005</b>
13	NITRATE	mg.L <sup>-1</sup>	<b>5,16</b>	<b>4,733</b>	<b>4,075</b>	<b>4,223</b>	<b>3,420</b>	<b>3,295</b>	<b>5,33</b>	<b>0,008</b>
14	CYANID	mg.L <sup>-1</sup>	<b>0,01</b>	<b>0,01</b>	<b>0,01</b>	<b>0,01</b>	0,01	0,01	0,01	0,05
15	SULPHIDE	mg.L <sup>-1</sup>	<b>0,007</b>	<b>0,007</b>	<b>0,009</b>	<b>0,007</b>	0,006	0,005	0,005	0,03
16	PAH (Hydrocarbon)	mg.L <sup>-1</sup>	<b>0,003</b>	<b>0,003</b>	<b>0,002</b>	<b>0,003</b>	0,003	0,002	0,003	1
17	PHENOL	mg.L <sup>-1</sup>	<0,002	<0,002	<0,002	0,005	0,002	0,002	0,003	0,002
18	PCB TOTAL	µg.L <sup>-1</sup>	<b>0,081</b>	<b>0,079</b>	<b>0,083</b>	<b>0,069</b>	<b>0,068</b>	<b>0,073</b>	<b>0,075</b>	<b>0,01</b>
19	SURFACTAN (Detergent)	MBAS	0,10	0,82	0,77	0,58	0,86	0,82	0,82	1
20	OIL/FAT	L <sup>-1</sup>	<b>35</b>	0,28	0,26	0,18	0,23	0,2	0,20	5
21	TBT (Tributil Tin)	µg.L <sup>-1</sup>	<b>0,01</b>	<b>0,01</b>	<b>0,02</b>	<b>0,01</b>	<b>0,01</b>	<b>0,02</b>	<b>0,01</b>	<b>0,01</b>
22	Hg	mg.L <sup>-1</sup>	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	0,001
23	Cr	mg.L <sup>-1</sup>	<b>0,0165</b>	<b>0,02825</b>	<b>0,0265</b>	<b>0,02833</b>	<b>0,006</b>	<b>0,01</b>	<b>0,01</b>	<b>0,005</b>
24	As	mg.L <sup>-1</sup>	<b>0,13465</b>	<b>0,13437</b>	<b>0,13675</b>	<b>0,13066</b>	0,1175	0,12475	0,12475	0,012
25	Cd	mg.L <sup>-1</sup>	<b>0,022</b>	<b>0,017</b>	<b>0,017</b>	<b>0,013</b>	<b>0,007</b>	<b>0,011</b>	<b>0,011</b>	<b>0,001</b>
26	Cu	mg.L <sup>-1</sup>	<b>0,01</b>	<b>0,01</b>	<b>0,01</b>	<b>0,01</b>	<b>0,01</b>	<b>0,01</b>	<b>0,01</b>	<b>0,008</b>
27	Pb	mg.L <sup>-1</sup>	<b>0,03</b>	<b>0,02</b>	<b>0,03</b>	<b>0,03</b>	<b>0,03</b>	<b>0,03</b>	<b>0,03</b>	<b>0,008</b>
28	Zn	mg.L <sup>-1</sup>	<b>0,02</b>	<b>0,02</b>	<b>0,02</b>	<b>0,02</b>	0,02	0,03	0,03	0,05
29	Ni	mg.L <sup>-1</sup>	<b>0,007</b>	<b>0,005</b>	<b>0,003</b>	<b>0,003</b>	0,004	0,007	0,006	0,05
30	Plankton	Ind.L <sup>-1</sup>	no bloom	no bloom	no bloom	no bloom	no bloom	no bloom	no bloom	no bloom

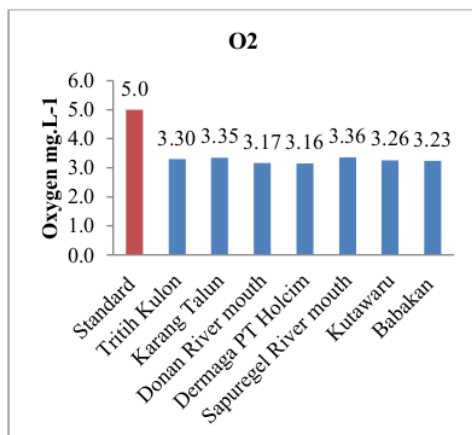
Note: A number in bold is the parameter measured beyond the threshold.



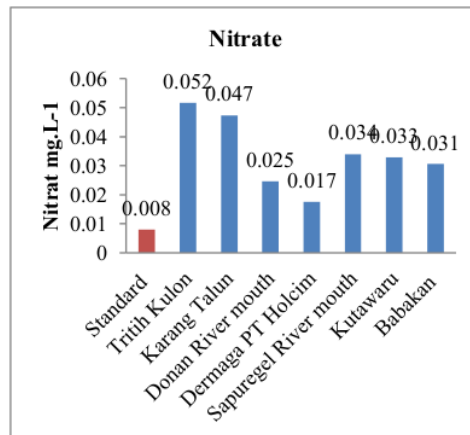
**Figure 2.** Concentration of TSS in Segara Anakan compared to threshold for biota life (Ministry of Environment Decree No. 51/2004).



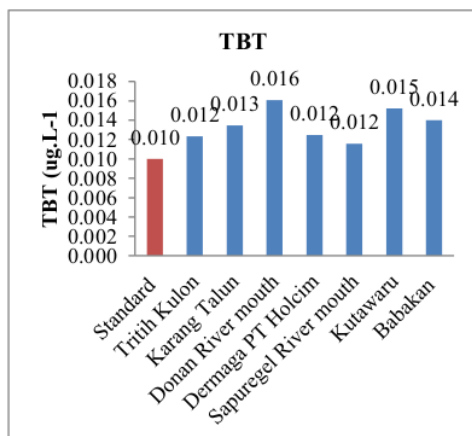
**Figure 4.** Concentration of PO<sub>4</sub> in Segara Anakan compared to threshold for biota life (Ministry of Environment Decree No. 51/2004)



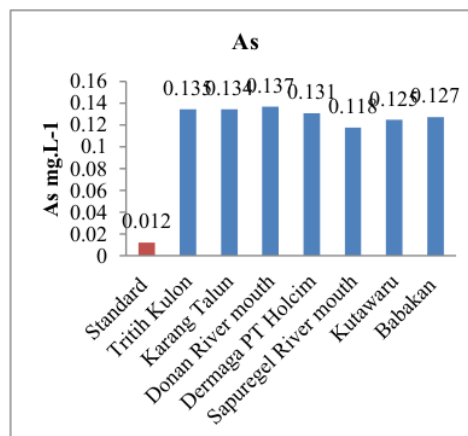
**Figure 3.** Concentration of dissolved Oxygen in Segara Anakan compared to threshold for biota life (Ministry of Environment Decree No. 51/2004)



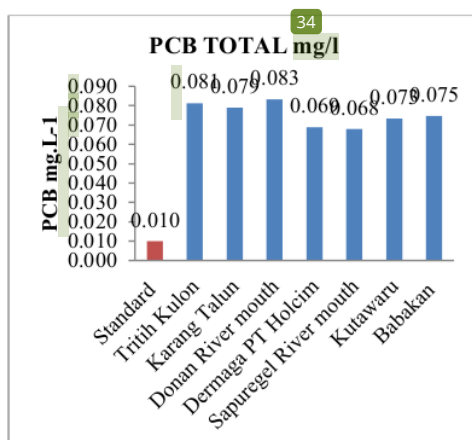
**Figure 5.** Concentration of NO<sub>3</sub> in Segara Anakan compared to threshold for biota life (Ministry of Environment Decree No. 51/2004)



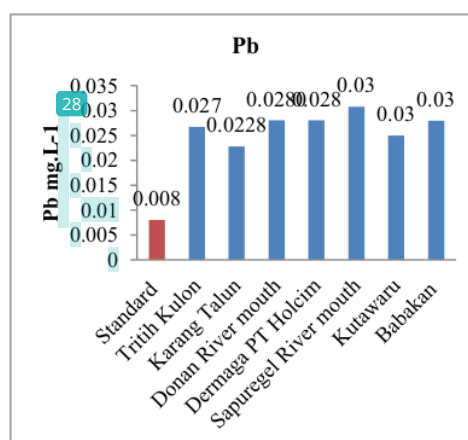
**Figure 6.** Concentration of TBT in Segara Anakan compared to threshold for biota life (Ministry of Environment Decree No. 51/2004)



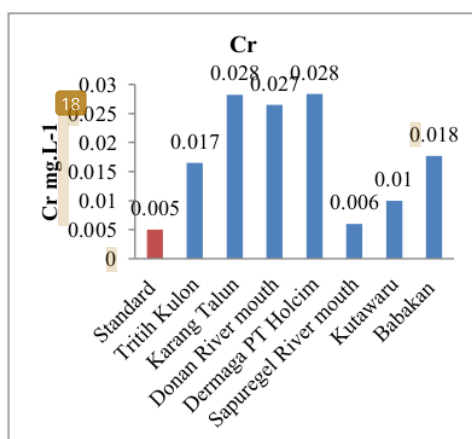
**Figure 8.** Concentration of Arsen (As) in Segara Anakan compared to threshold for biota life (Ministry of Environment Decree No. 51/2004)



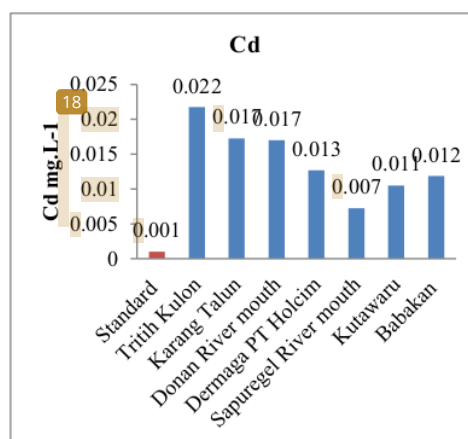
**Figure 7.** Concentration of PCB in Segara Anakan compared to threshold for biota life (Ministry of Environment Decree No. 51/2004)



**Figure 9.** Concentration of Plumbum (Pb) in Segara Anakan compared to threshold for biota life (Ministry of Environment Decree No. 51/2004)



**Figure 10.** Concentration of Cromium (Cr) in Segara Anakan compared to threshold for biota life (Ministry of Environment Decree No. 51/2004)



**Figure 11.** Concentration of Cadmium (Cd) in Segara Anakan compared to threshold for biota life (Ministry of Environment Decree No. 51/2004)

It was shown that the Segara anakan had been contaminated with heavy metals As, Cd, Cr and Pb and had exceeded the quality standard for the life of the biota based on the Ministry of Environment No. 51 of 2004 (Figure 8-11). The concentration of Pb in Segara Anakan were ranging from 0.02 to 0.03 mg. L<sup>-1</sup> and have exceeded the required water quality standard of 0.01 mg. L<sup>-1</sup> in all locations (Figure 9). Cr metal content in Segara anakan ranges from 0.006 to 0.028 mg.L<sup>-1</sup> and has exceeded the required quality standard (0.005 mg.L<sup>-1</sup>) (Figure 10). The results of Cd measurements in the Titih Kulon area were 0.02 mg.L<sup>-1</sup> which exceeded the quality standard for biota life of 0.001 mg.L<sup>-1</sup> (Figure 11).

#### 4. Discussion

The water is polluted when it is disturbed by anthropogenic contaminants that could not support the life of biotic constituents, such as fish and other aquatic organisms [9]. High TSS concentrations can reduce marine plants photosynthesis so that the oxygen released by plants is reduced and causes the fish to die. The presence of high concentrations of TSS can also cause high mortality rates for fish eggs caused by a decrease in the flow of water and dissolved oxygen into the eggs [10]. The presence of TSS in waters that exceed the threshold can disturb aquatic organisms [11]. The dissolved oxygen content in Segara Anakan ranged from 3.16 to 3.36 mg. L<sup>-1</sup> and was below the quality standard for marine biota at 5 mg. L<sup>-1</sup> (Figure 3). This showed that photosynthetic activity to support sea life was still inadequate.

Nitrate and orthophosphate are nutrients derived from the dissolved form of nitrogen and phosphorus that are needed to grow water plants. The nitrate and orthophosphate measurements ranged from 0.017 to 0.052 mg.L<sup>-1</sup> and exceeded the threshold (0.008 mg.L<sup>-1</sup> and 0.005 mg.L<sup>-1</sup>), as shown in Figures 4 and 5. Nutrients came from human activities in the catchment and the waters. In natural waters, nutrients are in small amounts, but it causes a massive water pollution problem called eutrophication when an increase in concentration. So, the condition in Segara Anakan has the potential for eutrophication.

Nitrate (NO<sub>3</sub>-N) and orthophosphate (PO<sub>4</sub>-P) has already beyond threshold (Figure 4 and Figure 5). This condition stimulates plants and algae rapid growth, clogs the waterways, and sometimes creates blooms of poisonous blue-green algae. When plants and algae die and decompose, they use large amounts of oxygen (O<sub>2</sub>). Consequently, the amount of oxygen available for fish and other aquatic species decreases. In extreme cases, it creates an environment that cannot support anything except a few

anaerobic bacteria species. It can also kill fish and other aquatic life and reduce lake aesthetic value and recreation. Nutrients included nitrates that found in waste and fertilizers and phosphates in detergents and fertilizers

Tributyltin (TBT) is antifouling paint for ships, wood preservatives, and textiles with intense biocidal activity against aquatic organisms, including bacteria, fungi, algae, mollusks, and crustaceans. These compounds are widely used for various purposes, such as antifouling paint for ships, wood preservatives and textiles, lubrication in industrial processes, rocks, and molluscicides. The content of TBT in Segara Anakan ranges from 0.012 - 0.016  $\mu\text{g. L}^{-1}$  and has exceeded the standard quality threshold for marine organisms (0.010  $\mu\text{g. L}^{-1}$ ) (Figure 6).

Polychlorinated Biphenyls (PCBs) are synthetic organic chemicals used in industrial and commercial applications - including the oil in electrical and hydraulic equipment. The results of PCBs measurements in all sites were almost evenly concentrated in the range of 0.068 - 0.083  $\mu\text{g.L}^{-1}$  and have exceeded the quality standard for biota life (0.010  $\mu\text{g.L}^{-1}$ ) (Picture 7). These areas are near PT. Pertamina and PT. Holcim that are also close to residential areas (Cilacap City). This area is also used for passenger and large ship transportation lines operating for these two major industries. PCBs are released into the environment through evaporation during combustion, leakage, industrial fluids disposal, and waste in landfills and dumps. PCB contamination in the environment comes from human activity. High concentration areas of PCBs tend to be around industrial areas. PCBs enter the environment mainly by system leaks from disposal sites, waste combustion, agricultural land, and industrial waste.

The eastern area of Segara Anakan is rapidly developed for various industries, some of which have locations directly adjacent to the River Donan. This includes PT Pertamina RU IV Cilacap (oil refinery), Holcim Tbk (cement production and distribution), and PT Pusri (fertilizer production) [12]. Also, industrial shipping activities, public transportation, and fishing vessels produce heavy metal waste [13]. This industrial activity is likely to release heavy metal waste. Heavy metals have recalcitrant properties, easily dissolved in water settle in sediments, and accumulate in aquatic biota. Heavy metals can be absorbed in the fish body in two ways (diet exposure) and the surface of the gills (water exposure) [14]. The most common heavy metal pollutants are arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), nickel (Ni), lead (Pb), and mercury (Hg). The presence of heavy metals in the waters can harm aquatic organisms from the individual to the community level. Fish is one of the aquatic biotas often used as a bioindicator of heavy metals in the waters because fish are included in the highest trophic and a source of human protein. If humans consume fish that accumulates heavy metals, then heavy metals can accumulate in the human body. And heavy metals that have exceeded the specified threshold can endanger human life.

The restricted heavy metals in the ecosystem based on the Ministry of Environment Decree No 51/2004 for mangrove organisms life are Hg, Cr, As, Cd, Cu, Pb, Zn, Ni. During this observation, four of them exceeded the quality standard, including As, Pb, Cr, and Cd. There was a high level of contamination in water and sediments around oil refineries and a broad spectrum of contaminants in aquatic organism tissues [9]. The efficiency of oil spill distillation is the primary source of pollution. However, municipal waste inputs were detected, even though at relatively low levels due to insufficient input. Mangrove shells (*Polymesoda erosa*) and mangrove snails (*Telescopium telescopium*) store the highest number of contaminants, which are most likely related to their microhabitat and their feeding mode. They may be bioindicators useful for coastal organic pollution [15, 16].

Based on April - September 2016 observation, Segara Anakan was contaminated with As, Cd, Cr, and Pb and had exceeded the quality standard for biota life (Ministry of Environment No. 51 of 2004) (Figure 8-11). The concentration of As was distributed to all locations (0.118 - 0.138  $\text{mg. L}^{-1}$ ) and has far exceeded the quality standard of 0.012  $\text{mg. L}^{-1}$  (Figure 8). Arsenic is in soil, water, and air. The element is a by-product of melting copper, tin, zinc, and other metals that release it into the environment. Burning fossils, especially coal, releases  $\text{As}_2\text{O}_3$  into the environment, where most will enter natural waters. Arsenic is found in nature together with phosphate minerals and released into the environment together with phosphate compounds. Arsenic is in  $\text{As}^{3+}$  (arsenite) and  $\text{As}^{5+}$  (Arsenal) [17].

Human activities such as mining and industrial waste/vehicle fuel emissions or boat engines (workshop waste) that enter through the river flow can increase the Pb content in the waters. In comparison, contamination of pesticides is likely from agricultural activities in the upstream areas of the rivers that enter the lake. The highest Pb metal content was in the Sapuregel river estuary. The river meets River Kembangkuning and other small rivers that experience sedimentation dominated by sand-type sediments. In the River Sapuregel estuary, fishing activities were carried out using apung by fishers. This high Pb in the waters may be absorbed by fish that live in these waters to become potentially contaminated by these metals. If humans consume it, it will potentially cause various diseases, both short and long term, depending on the concentration and patient condition. The rejang fish caught in Segara Anakan, especially from River Donan, was no longer safe to consume because of Pb content beyond the threshold [18].

Chromium (Cr) is widely used in gilding, leather tanning, chromate coatings, and metal coatings. Fish that have been contaminated with heavy metals when consumed will potentially cause various diseases both in the short and long term [17] and are accumulative [19]. Cr metal content in Segara Anakan ranged from 0.006 to 0.028 mg. L<sup>-1</sup> and exceeded the required quality standard (0.005 mg. L<sup>-1</sup>). In Karang Talun, River Donan, and PT Holcim Pier, the content was higher than in other locations (Figure 10). This is because the sites are the industrial centers, as previously discussed.

Cd presence in the waters originates from natural processes such as abrasion from the river and community activities, such as disposal of market waste and household waste [20]. In Segara Anakan, Cd may come from ship painting and reparation, agriculture, and industrial areas (PT Holcim). Cd measurements in the Titih Kulon area were 0.02 mg. L<sup>-1</sup>, which exceeded the quality standard for biota life of 0.001 mg. L<sup>-1</sup> (Figure 11).

The water quality status is an instrument for determining in a particular time whether the waters are in polluted conditions or good conditions. The use of biological data in water quality monitoring will better illustrate the actual state due to organisms being considered capable of accumulating substances from the surrounding area. The concentration of a substance in the body of organism tissues could describe the substance concentration in its environment and indicate the environment quality. Furthermore, in contaminated conditions, only adaptable organisms can survive, and these changes will be followed by changes in the constituent populations of a community. Changes in a community of aquatic organisms will indicate changes in the quality of water.

The deterioration of mangrove forest ecological function will decrease capture fisheries production in that location and other locations. This is based on the ecological nature of mangrove forests, which are part of the marine ecosystem, including functions to provide nutrients, especially in the plankton for both pelagic and demersal organisms. The upwelling process in the river estuary areas, which empties into the coast, is more enriched by organic material produced by the mangrove vegetation community. Therefore, the primary production on the edges of aquatic ecosystems such as mangroves is classified as high and often remarkably high, usually in the form of planktonic algae. The movement of fish species into spawning areas contains the purpose of adjusting and reassuring the most favorable place for egg development and larvae [21]. Likewise, fish that feed into mangroves aim to obtain a specific area that is safe and capable of providing nutrients and other ecological needs for egg and larvae development. The fertility of waters can be seen from the presence of planktons. Plankton can describe the productivity level of the waters [22]. Phytoplankton is particularly important in aquatic ecosystems, including the sea, which plays a basic food for other life in the aquatic ecosystem. In aquatic ecosystem trophic, planktons are the producers at a basic level, which determines the presence of organisms at the next level, such as various types of fish. Thus, the presence of plankton in waters is very influential for fish survival, especially for plankton-eating fish or fish at the early development level. Disruption of marine aquatic ecosystems such as the occurrence of organic and inorganic pollution into water bodies and damage to coastal vegetation that occurs in areas along the coast in the form of damage to mangrove forests is estimated to have disrupted the lives of various types of plankton.

The disruption of marine plankton life in the study area is caused by damage to coastal vegetation as already mentioned and other activities in the territorial waters, including the disposal of domestic waste

from human activities and companies around it. Disruption of plankton life, both its abundance and composition, will significantly interfere with other life such as diversity and production of surrounding fish [23]. Considering the vital role of plankton as natural bodies and producers of aquatic ecosystems, it is necessary to research the composition and abundance of plankton and the diversity index and saprobic index of plankton communities in Segara Anakan. The plankton diversity index will describe the level of stability or stability of the plankton community and general estimates of the level of pollution. The saprobic index that will be known will describe the amount of pollutant load that occurs in the ecosystem in the study area.

The Saprobic Coefficient calculation is based on the composition of plankton groups [7]. Plankton will respond to the aquatic environment conditions so that the composition of plankton can indicate the water fertility status. The saprobic level is a measure for the phase in which biological conversion processes can be decomposed by substances that have occurred in the surface water. The plankton composition was Ciliate, Euglenophyta, Chlorococcales and Diatomae, Chrysophyceae, Peridinae, and Conjugaceae. The results of coefficients of saprobic and pollution levels in Segara Anakan were listed in Table 2.

**Table 2.** Coefficients, phase of saprobic, and pollution level of Segara Anakan during observation

No	Sites	Coeff of Saprobic	Phase of Saprobic	Pollution Level
1	Tritih Kulon	1.00	$\beta$ - Mesosaprobic	Light polluted by both organic and anorganic materials
2	Karangtalun	1.00	$\beta$ - Mesosaprobic	
3	Donan River Mouth	1.00	$\beta$ - Mesosaprobic	
4	Dermaga PT. Holcim	1.00	$\beta$ - Mesosaprobic	
5	Sapuregel River Mouth	0.95	$\beta$ - Mesosaprobic	
6	Kutawaru	1.06	$\beta$ - Mesosaprobic	
7	Babakan	1.00	$\beta$ - Mesosaprobic	

## 5. Conclusion

The water quality of Segara Anakan was not completely good for biota life due to 10 parameters beyond the threshold (TSS, Dissolved Oxygen, Orthophosphate, Nitrates, PCBs, TBT, and metals Cd, Cr, As, Pb). However, water pollution levels of Segara Anakan was lightly polluted by organic and organics materials, so its fertility level was on the  $\beta$ -mesosaprobic phase. It was recommended that human activities that potentially pollute the environment, such as waste disposal, be restricted to avoid the water quality from becoming worse.

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