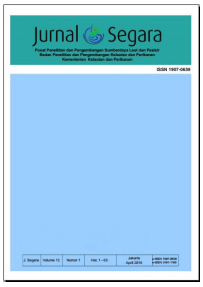

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SPATIAL PATTERN OF WATER QUALITY ON CORAL REEF AREA AROUND KALEDUPA ISLAND

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ABSTRACT

Healthy coral reefs depends on the quality of the waters , so that research and monitoring of water quality becomes important. This research attempts to asses marine waters quality at kaledupa island and it' s surrounding waters in October and November 2014. 33 In-situ samples were collected using multiparameters tool purposively which are categorized into physical parameters (temperature, turbidity and clarity), and chemical parameters (DO, salinity and pH). Waters quality defined by STORET method based on Ministry of Living Environment decree number 115 year of 2003. Analysis geographically has been conducted to describe distribution of waters quality spatially. The result shows that Kaledupa waters has sustain slightly pollution, especially on DO, turbidity, temperature and salinity parameters which have deviated from standard values. The light pollution in Kaledupa waters is suspected caused by the entry of abundance organic matter and shallow bathymetry.

Keywords: Kaledupa, Spatial, Water quality

INTRODUCTION

There are 750 out of the world total 850 coral reef species in Wakatobi Regency, of which 25 groups of coral reefare surrounded by atols. Wakatobi Islands is one of the main destinations in Indonesia's marine tourism - a tourism activity - that has been long developed there. The preeminent of this tourism asset includes the wide spread of atolls along the waters with complex submarine topography like slope, fault, drop-off, atoll and underwater cave (Anonymous, 2007). The bathymetry of TNW (Wakatobi National Park) region ranges from flat to seaward sloping and in some waters steeply sloping to the depth of up to 1044 meters.

Coral reefs require clear waters and healthy in order to grow well. Reefs are formed of corals hermatifik symbiotic with zooxanthallae. Some water quality parameters that can affect the growth of these include the temperature, salinity, pH, brightness and turbidity (Nybakken, 1992; Bayraktarov *et al.,* 2014). Additionally Browne *et al.,* 2015 says that the physiological and reef condition in addition to temperature and light also influenced the spatial distribution of water quality

Preliminary research has been conducted by Yulius *et al.* (2015) in Wangi-Wangi island that has moderate and good conditions but the waters quality on its surrounding waters has not been yet identified. TNW is a very famous marine tourism region with its many diving spots. It is of concern that high occurence of marine tourists may result in declination of water quality. Therefore a study on TNW water quality is required.

METHODOLOGY

Research Location

The water quality data were obtained through in situ measurements from October 31 until November 2014 using WQC 24 TOA-DKK multi-parameter equipment. There were 33 measurement stations spread around Kaledupa Island (Figure 1) for physical parameters like temperature, turbidity and clarity, and

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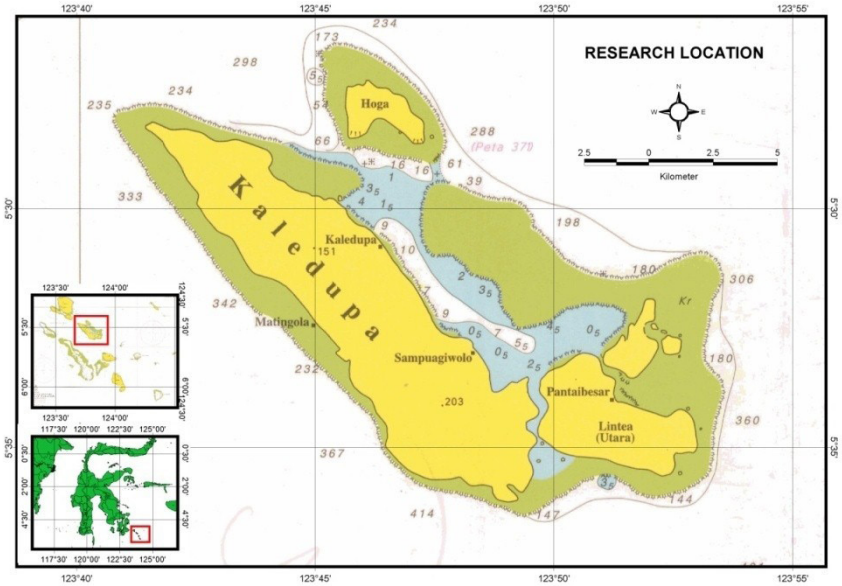

Figure 1. Research Location.

chemical parameters such as DO, salinity and pH. The obtained data were analysed using STORET water quality determination method as decreed by the Environment State Minister Kep.MenNeg LH No. 115 year 2003 on the Guide for Water Quality Status. This method can identify which parameter fulfills or exceeds the water quality standard. Its principle is to compare the water quality data with the water quality standard relevant to its use. The water quality status is determined using the grade system of US-EPA (Environmental Protection Agency) thatclassified it into 4 classes as follows:

1. Class A : very good, score = 0 means it fulfills the quality standard
2. Class B : good, score = -1 to -10 means it is slightly polluted
3. Class C : moderate, score = -11 to -30 means it is moderately polluted
4. Class D : bad, score ≥ -31 means it is heavily polluted

The score determination is based on the comparison between the water quality data and the water quality standard. If it fulfills the quality standard, the score is “0”, while if there is some deviation or it exceeds the quality standard its parameter will be graded as Table 1.

The total score obtained can then be used to determine the waters quality status. To identify the spatial distribution of water quality, the spatial and tabular analyses are used. The spatial analysis scheme is as in Figure 2.

Coral reef distribution was obtained from the result of Landsat 8 of 2014 image interpretation. The method used in determining the coral reef region is referred to Lyzenga (1978) which can give depth-invariant index of the cover material of the waterbottom. Parameters which being entered in this algorithm is the comparison between water attenuation coefficients of several spectrals. The referenced formula is Exponential Attenuation Model

Li (H) = Li & infin; + (Ai-Li & infin;) – 2KiH ..... 1)

where :
- Li (H) is the reflectance in band i for H (m) depth
- Li&infinis the reflectance for deep water in band i
- Ai is base albedo in band i
- H is water depth (m)
- Ki is water attenuation coefficient in band i(m-1)

UNESCO (2009) states that the calculation of ratio of attenuation coefficients is as the following formula:

$$\frac{ki}{kj} - a + \sqrt{a^2 - 1} \quad \text{..... 2)}$$

Where the a value can be calculated as this formula:

$$a_{12} = \frac{variant\ 1 - variant\ 2}{2\ xcovariant\ 12} \quad \text{..... 3)}$$

Siregar (1996) extended from Lyzenga’s algorithm to map cover material of shallow sea water bottom. The research method is by pairing two bands of TM1

and TM2 which can penetrate the water body to a certain depth,that can be used to identify object in the shallow sea water bottom. The resulted paired image provides visually clearer appeareance of shallow sea water bottom compared to the object appearance from two separate bands. Coral Reef Rehabilitation and Management Program (COREMAP) use this method in providing information on the size and distribution of coral reef in almost all Indonesian waters (Anonymous, 2007).

This research was conducted through several steps. Firstly, displaying the image in RGB (Red Green Blue) false colour format of band 532 of Landsat 8– band 4 or 5 is used to determine biomass and delineate coral reef, band 2 or 3 is used to measure vegetation fertility and band 1 or 2 to measure water clarity. Secondly, performing a radiometric correction to improve image due to radiometric error– usually it resulted from an error in the system caused by disturbance in the electromagnetic radiation from the atmosphere and the influencce of the sun's elevation angle. Thirdly, performing geometric correction for the image to be compatible with the earth coordinates. Forthly, cropping is conducted to select the area for analysis. This is to limit the data to be processed – else it will take a long time forimage processing. For this research, the Area OfInterest (AOI) is Kaledupa Island. Fifthly, Lyzenga's algorithm was being entered to obtain marine information. At this step the data coefficient of band 1 and 2 of Landsat image were combined algorithmecally which created a new band. Sixthly, masking area is conducted to separate between land and sea, and digitazing is performed to determine the coral reef area, either the healthy or the dead one, seagrass and sand.

Table 1. Score and and quality standard for its parameter

Number of samples[1)]	Value	Parameters			
		Physical	Chemical		Biological
< 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

[1)] Number of parameters that be used to determine waters quality status

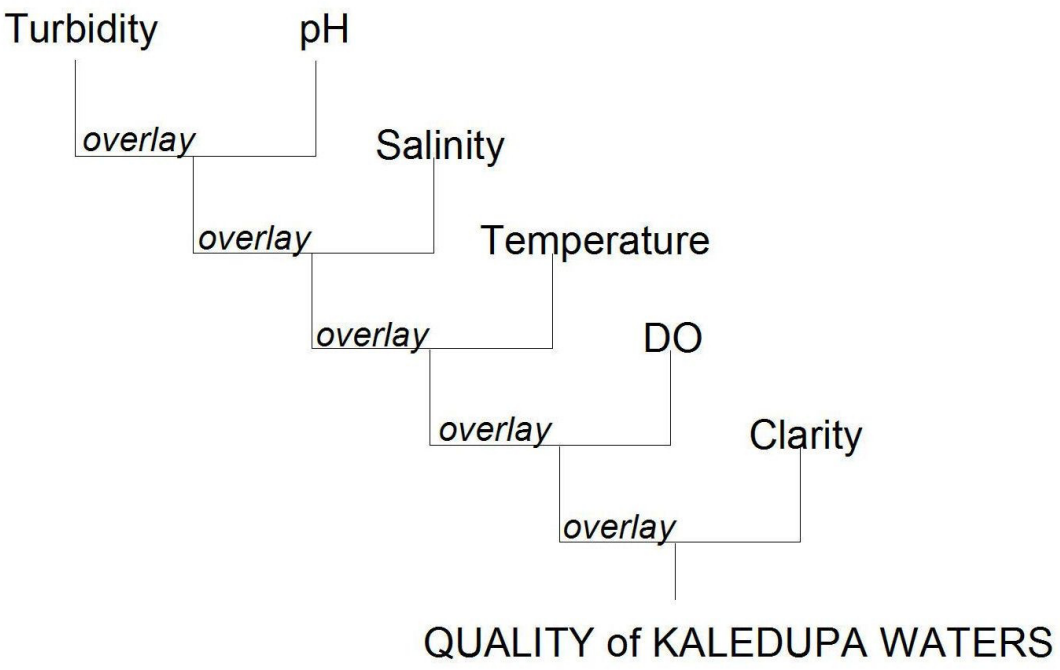

Figure 2. The spatial analysis scheme.

RESULTS AND DISCUSSION

Distribution of Coral Reef around Kaledupa Island

The analysis result indicated that the live coral reef in Kaledupa Island in 2014 is 5,706.19 Ha, while the dead coral reef is 1,241.23 Ha (Table 2). As Reef in Rehabilitation Zone (Anonymous, 2007) the reef in Kaledupa is dominated by the fringing reef and barrier reef which surrounded this Island (Figure 4.a).

Kaledupa Waters Quality

Spatial analysis result shows that most of Kaledupa Island waters and its surrounding has been slightly polluted, i.e. 85.54 km^2 or equals to 54.1% and not polluted is of 72.7 km^2 or equals to 45.9%. The slightly polluted waters spread in the north and south of Kaledupa Island (Figure 4.b).

The result of descriptive statistic conducted around Kaledupa Island is shown in Table 3.

The result of in situ analysis of the physical and chemical water quality of Kaledupa Island seawaters from October to November 2014 observation can be seen in Table 3 and 4. Generally the total score value of "-7" indicated that the waters of Kaledupa Island is in slightly polluted condition. Such analysis result, when compared with the quality standard by KepMenNeg LH No 115 of 2003, it is apparentthat out of 6 examined paramaters, 4 of them have exceeded the quality standard, i.e. DO, Turbidity, Temperature and Salinity (Figure 3).

The coral reef distribution based on the quality of Kaledupa Island waters is as shown in Figure.4.a. This is obtained as a result of overlay between maps of coral reef and water quality. There are 8 (eight) definitions as the result of this overlay. They are: Not polluted live coral (KHTT) which is approximately of 18.77% wide, Slightly polluted live coral (KHTR) of 17.85%, Not polluted dead coral (KMTT) of 6.81%, Slightly polluted dead coral (KMTR) of 0,94%, Not polluted seagrass(LTT) of 3,66%, Slightly polluted seagrass(LTR) of 11,41%, Sand of 0,08% danUndefined of 40,49% wide.

DO

The range of obtained DO is 4.28-11.09 with an average of 7.06±1.51. Rangka & Paena (2012) found the DO value in Wakatobi Regency is between 6.06-6.25. The analysed DO contents in almost all locations are in normal categories, despite there were 2 locations (station 19 and 20 as in Table.4) that fell under the quality standard value of higher than 5 mg/l. The low DO contents in those locations are due to the organic material that goes into the water (Suhartono, 2009). Microoorganisms need a lot of oxygen to disperse those organic matters which resulted in lower oxygen content. Salmin (2005) stated that several factors affecting the speed of oxygen diffusion including turbidity, temperature, salinity, current, wave and tide.

Table 2. Area of Coral Reef in Kaledupa

Item	Area (Ha)
Live Coral Reef	5706.19
Dead Coral Reef	1241.23
Sand	12.44
Seagrass	2451.00
TOTAL	9410.86

Source : Result of Landsat Imagery Analysis in 2014

Table 3. Waters quality and its score

Parameters	Min	Max	Average	Standard of Quality	Minimum Score	Maximum Score	Average Score	Total
DO (mg/l)	4.28	11.09	7.06	> 5	-2	0	0	-2
Turbidity (NTU)	0.00	13.40	0.75	< 5	0	-1	0	-1
Temperature(oC)	27.70	30.70	29.00	28 - 30	-1	-1	0	-2
Salinity (0/00)	31.30	33.00	32.12	33 - 34	-2	0	0	-2
pH	7.71	8.13	7.95	7 - 8.5	0	0	0	0
Clarity (m)	9	> 10	> 10	> 5	0	0	0	0
TOTAL								-7

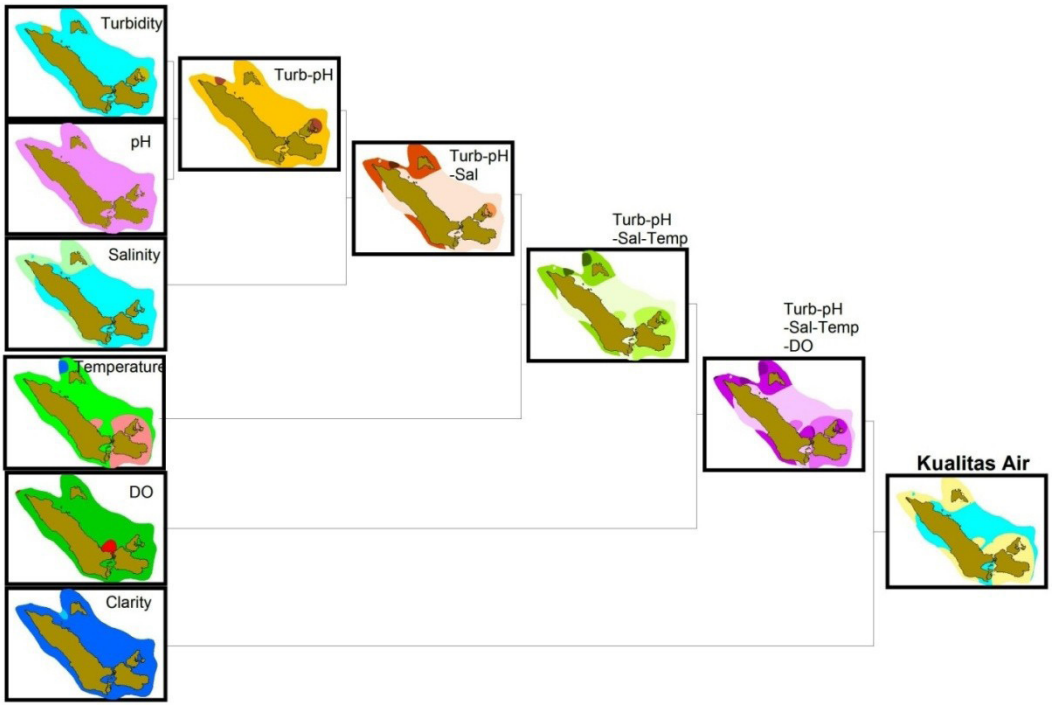

Figure 3. Overlay scheme on determining waters quality.

Stations 19 and 20 were located in shallow water of less than 2 m depth. Those locations are of seaweed cultures with a lot of dissolved organic material, or compound and mineral output. This is in accordance with Suandra (2011) which states that the organic material that gets into the water may lower the DO content. The depth affect the DO value in that the more shallow the water, the temperature will increase which resulted in the discharge of oxygen to the air. Nevertheless there are factors other than depth that may affect DO value like current movement, which, according to Welch (1980) water physical factors like current and sea wave are also affecting the speed of oxygen entering and being distributed in the water.

Based on such condition it can be said that the DO of TNW's waters is still within the range of quality standard and is still good for marine tourism and marine organisms especially coral and the ecosystem within.

Turbidity

The range of turbidity in the research location is 0 – 13.4 NTU with an average of 0.75±2.63 NTU. Meanwhile, the turbidity according to KepMenNegLH no 51 of 2004 for marine tourism is < 5 NTU, which confirmed that in general the turbidity in the research location is very good. The distribution of turbidity measured in situ shows that generally the turbidity of 0 NTU indicated a very clear waters visibility, except in stations 5 and 22 with turbidity higher than 5 NTU. The high turbidity in station 22 is mostly caused by the upraising of bottom (sand) substrate due to the physical process in such shallow water and as it is the location of seaweed culture which generated seaweed litter. The high occurrence of local populations boat traffic in this location is one of the anthropogenic activities which, according to Amri (2013) may influence the waters turbidity. Generally in areas with more than 10 m depth, the turbidity is low and even none or zero. In station 5, the high turbidity may be caused by an error in data reading, as it is located far from the coast –approximately 1.5 km northeast toward Banda Sea –in more than 10 m depth.

Temperature

The range of temperature in the research location is 27.7 – 30.7 ˚C with an average of 29.00±0.87˚C. The waters temperature is the natural temperature measured in situ during the research. Based on KepMenNeg LH no 51 of 2004, the good temperature for marine tourism is the natural temperature with the range of 28 - 30 ˚C for coral reef area. The range of temperature in 2013 in TNW waters is 29.42 – 30.2 ˚C (Rangka & Paena, 2012). The result of in situ natural temperature measurement shows that there are 3 stations (stations 21, 22 and 23) with higher temperature for coral reef area compared to the temperature stated in KepMenNegLH No. 51 of 2004 and Rangka & Paena, (2012). This might be caused by the time range of measurement which was on a sunny noon on the water surface. The research location is in the tropics which, according to Riyadi *et al.* (2005) has warm waters as a result of continuous warming over the year. Nevertheless, there are 2 stations (31

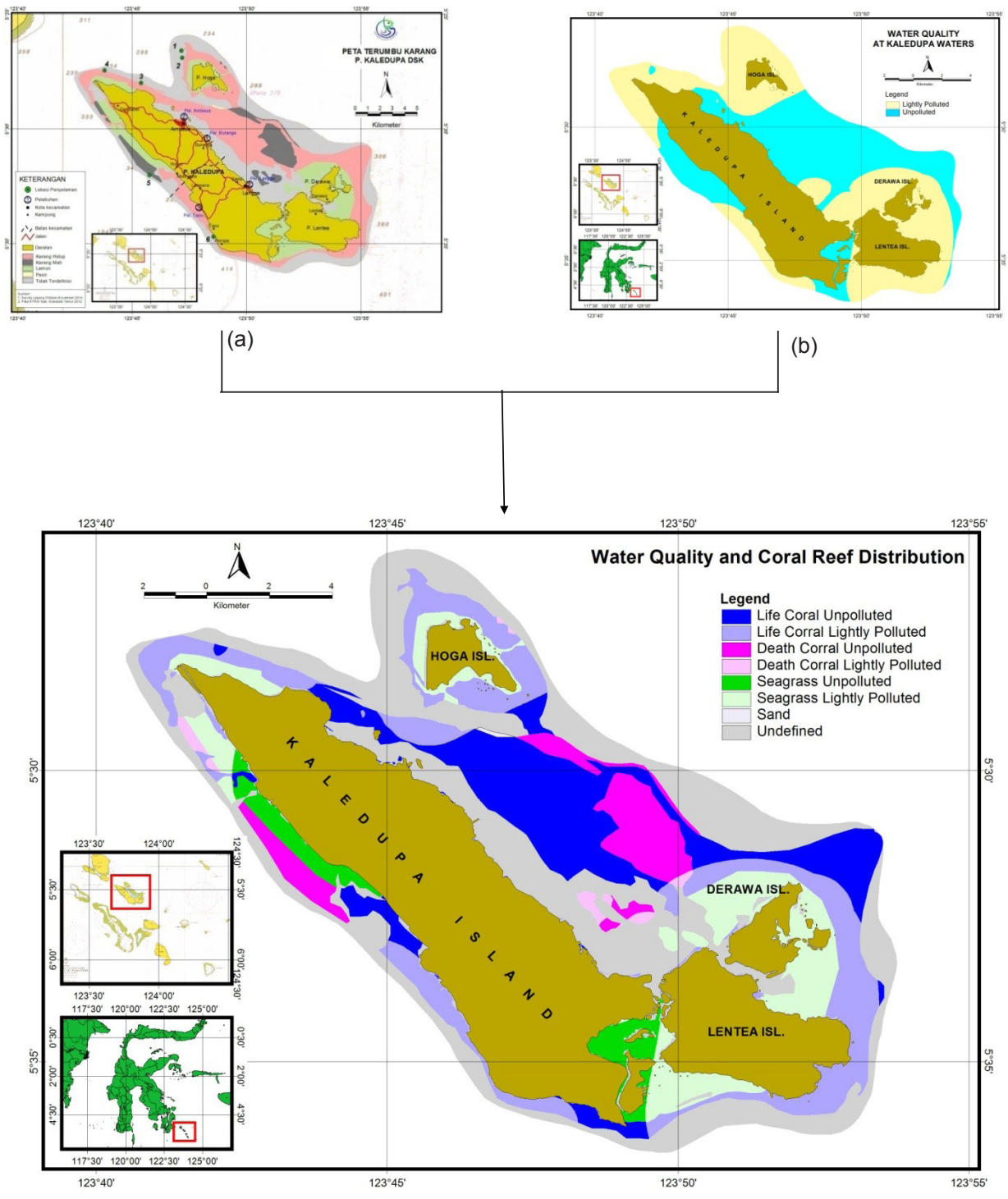

Figure 4. Coral reef distribution in Kaledupa island waters (a), and Condition of waters quality (b) which determine the distribution of coral reef based on waters quality (c).

and 32) with temperature lower than as inKepMen LH which might be caused by the morning measurement. The temperature observation is important in that it is one of the limiting factorsfor marine ecosystem and organism, as the temperature change may affect the physical, chemical and biological process in the water body. A rise in the water temperature above the natural temperature range may cause a decrease in gas dissolution in the water like O2 andan increase in dissolution of gasses as CO2, N2and CH4 (Sanusi, 2006). Other than that, the research location is a coral ecosystem area, where a rise in the temperature may

Table 4. Distribution of waters quality based on station

Station	Parameters					
	Clarity	DO	Turbidity	Temperature	Salinity	pH
1	> 10	6.89	0.0	29.7	32.1	8.07
2	9	5.79	0.0	28.4	31.3	7.98
3	> 10	8.80	0.0	30.1	32.5	8.13
4	> 10	6.39	0.0	28.3	31.9	7.97
5	> 10	6.70	13.4	28.4	31.9	7.99
6	> 10	6.48	0.0	28.4	31.8	7.98
7	> 10	11.09	0.0	29.4	32.1	8.11
8	> 10	7.09	0.0	28.5	32.0	8.00
9	> 10	9.63	0.0	29.7	32.2	8.07
10	> 10	10.31	0.0	29.9	32.1	8.11
11	> 10	8.19	1.0	29.3	32.0	7.98
12	> 10	6.76	0.0	28.3	31.8	7.94
13	> 10	6.93	0.0	28.3	31.8	7.95
14	> 10	6.95	0.0	28.4	31.8	7.94
15	> 10	6.82	0.0	28.5	31.8	7.94
16	> 10	5.29	0.0	29.3	32.8	7.87
17	> 10	6.32	0.0	30.1	33.0	7.90
18	> 10	5.98	0.0	30.1	32.9	7.85
19	> 10	4.28	0.3	29.6	33.0	7.71
20	> 10	4.50	2.9	29.9	32.9	7.76
21	> 10	7.51	0.0	30.7	32.5	8.10
22	> 10	6.65	7.1	30.4	32.6	7.96
23	> 10	9.90	0.0	30.6	32.6	8.02
24	> 10	6.68	0.0	28.3	31.9	7.93
25	> 10	6.63	0.0	28.4	32.0	7.93
26	> 10	6.51	0.0	28.1	31.9	7.93
27	> 10	6.70	0.0	28.4	31.8	7.94
28	> 10	8.73	0.0	29.0	31.9	7.99
29	> 10	6.68	0.0	28.6	31.8	7.91
30	> 10	6.62	0.0	28.3	31.9	7.72
31	> 10	6.35	0.0	27.8	31.8	7.94
32	> 10	6.27	0.0	27.7	31.7	7.94
33	> 10	6.65	0.0	28.1	31.8	7.92
Standard Value	> 5	> 5	< 5	28 - 30	33 - 34	7 - 8.5

cause coral bleaching for those coral located close to the surface. Therefore, the temperature monitoring is really needed to be done especially in that area with the highest value measured, which is in station 21 on the east of Lentea Island.

The temperature value that are above and below the decree of KepMenNeg LH for coral reef ecosystem marine tourism i.e. higher than 30°C are in 6 stations out of 33 research station orabout 18.2 %. Nevertheless, there are 3 stations (21,22 and 23) with much higher temperature values. The lowest temperature of about 27.7°C is measured at station 32 which is on the northwest of Hoga Island that directly faces the Banda Sea.

Salinity

The distribution of salinity in the research location ranges from 31.3 - 33 PSU, with an average of 32.12±0.44 PSU. The salinity value is in accordance with Nurgayah (2011) research result around Kaledupa Island, whichis in the range of 29.83 – 31. Evenso, this value is lower than those found by both Rangka and Paena (2012) whichis in the range of 34.95 – 36.88 PSU and the report of CRITC – COREMAP LIPI of 2001 whichis in the range of 34.15 – 34.34 PSU. Based on the quality standard by KepmennegLH no 51 of 2004, the research result of salinity in October and November is below the naturalsalinity for coralreef which of 33 - 34. Nevertheless, this salinity range is still with in the threshold of quality standard for marine organism, which is26 – 35 (Affan, 2010).

Acidity (pH)

The range of pH is 7.71 – 8.13 with an average of 7.95±0.1. Rangka & Paena (2012) found the pH value

in Wakatobiranges from 7.58 to 8.23. The pH value is still very good, where pH value is very close related with the climate change that is being researched all over the world relevant to the climate change and the fear of the occurrence of ocean acidification. When ocean acidification occurs, it will affect the occurrence of coral reef and other shellfish organism, where it is feared there will be decaying of CaCO3 as the forming material of shell or even coral reef due to the pHdeclination.

A good pH range according to the quality standard as inKepMenNeg LH No. 51 of 2004 for marine tourism and marine organisms is 7 – 8.5 with < 0.2 change. Based on the result data of measurement, it can be said that the pH of TNW waters is still within the quality standard range and is still good for marine tourism especially for coral and the ecosystem within.

Clarity

The color of waters is one as based on visual observation. The waters color is obtained based on the light absorption by waters, i.e. bright greenish blue where the weather at the research time was cloud-free bright. The waters clarity rangesbetween 90 -100 % in all observation stations that the water bottom can be clearly seen, either as white sand or coral reef shelf. The waters in observation stations have natural smell, instead of that smelly rubbish/trash. This is as the TNW research locations are not connected with big river that bring waste or sediment from land. The low number of population is one factors related to its low household waste that gets into the coast and sea. Based on the physical parameter criteria above, the TNW waters at the research location is still in good condition.

CONCLUSION

Geographically analysis especially spatial analysis can be applied on assessing waters quality at coral reef area. This research assessed not only descriptively but also simple statistically on waters quality parameters distribution at live coral reef, dead coral reed and sand area. Kaledupa waters and its surrounding area showed slightly pollution especially on DO, turbidity, temperature and salinity parameter which have deviated from Ministry of Living Environment standard value. The slightly pollution in Kaledupa waters is suspected caused by the entry of abundance organic matter and shallow bathymetry.

Related to the allocation Kaledupa island and its surrounding area as a marine tourism location, it is necessary to conduct further research to examine the nutrient and heavy metals and also social factors. There should also be conducting ecosystem-based and community-based carrying capacity analysis so that environment continuity can be maintained and sustained.

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