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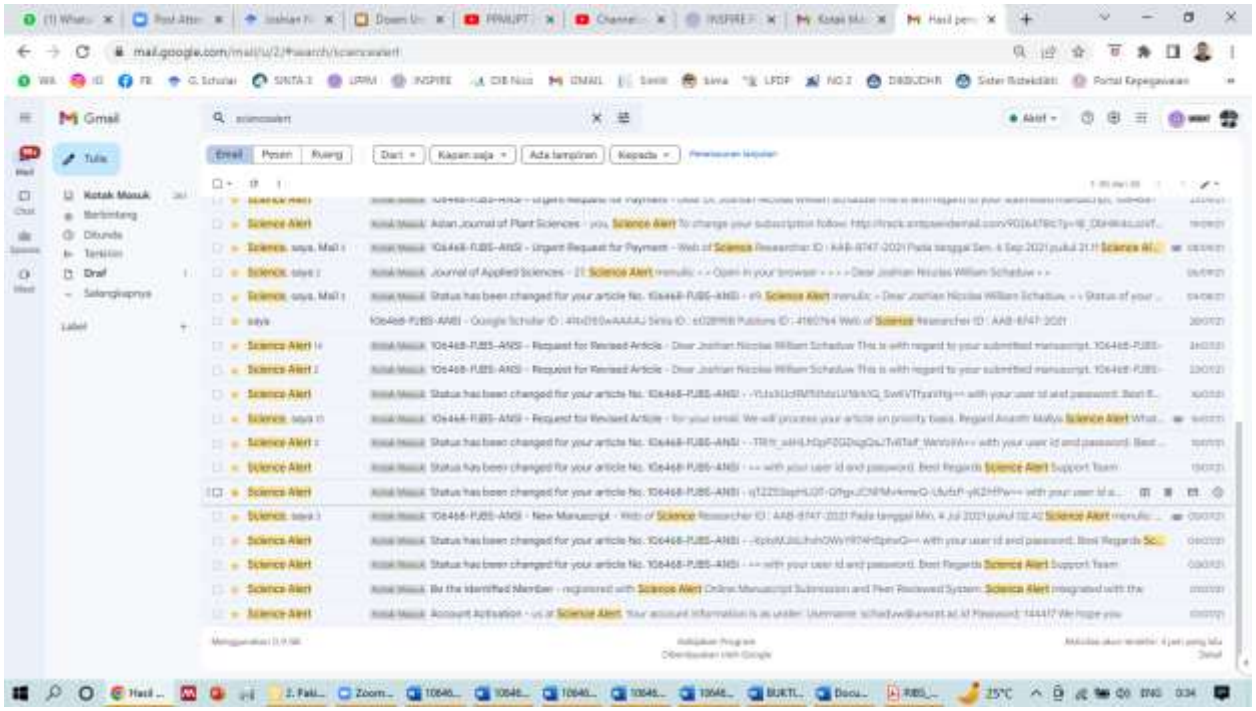

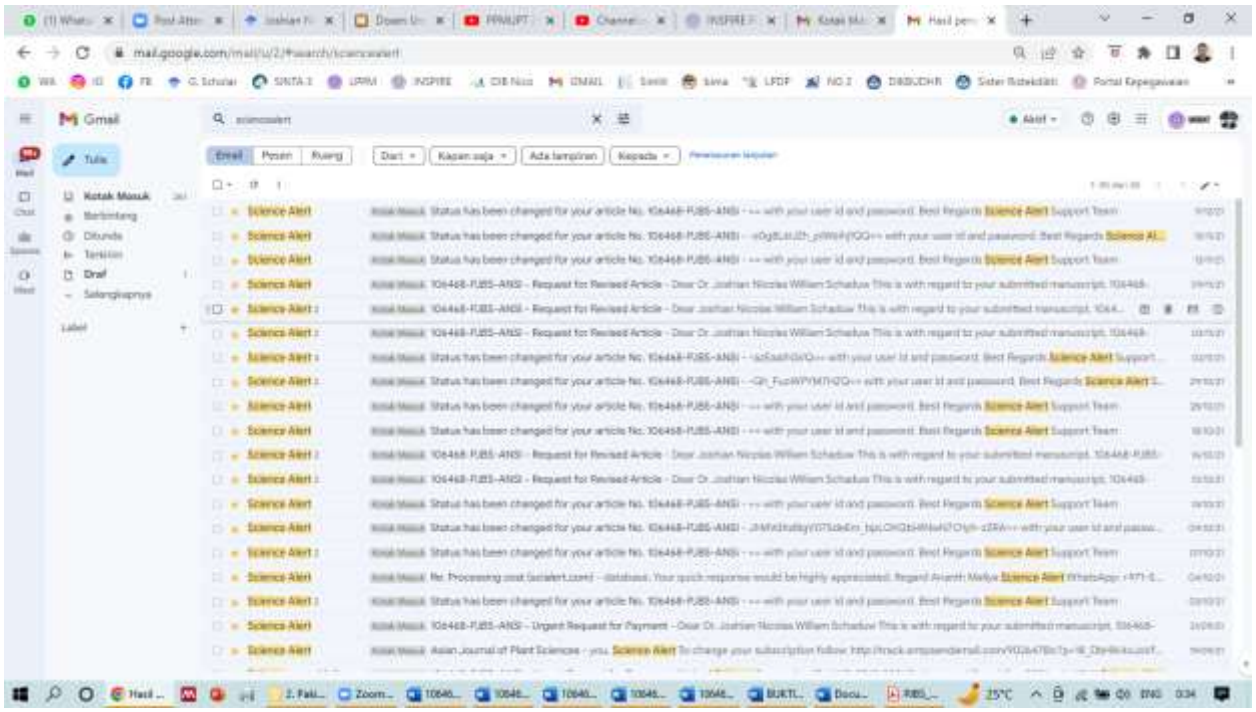

THE ANALYSIS OF SEAWATER QUALITY IN SMALL OUTERMOST ISLAND FOR INTEGRATED AND SUSTAINABLE MARINE TOURISM DEVELOPMENT (CASE STUDY ON MANTEHAGE ISLAND, NORTH SULAWESI PROVINCE)

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Abstract

There is a growing interest to significantly explore more opportunities in the coastal environment. For this reason, adequate progressive strategies appear very essential. The purpose of this study was to analyze seawater quality as a database for developing integrated and sustainable marine tourism in Mantehage Island, Indonesia. This particular habitat is among the 5 outer minor landmass regions in Bunaken National Park, with high biodiversity and the greatest mangrove population in North Sulawesi province. Also, the underwater scenery serves as an alternative tourist attraction, similar to world renowned Bunaken Island. Furthermore, the present paper applied descriptive and quantitative methods to sample 20 observation points around the selected location. In addition, the seawater content was directly measured and stored in the laboratory for further analysis. Consequently, certain parameters were evaluated, including salinity, temperature, turbidity, pH, total suspended solids, dissolved oxygen, NO_3-N and PO_4-P. The subsequent data were also compared to the related quality standards of the Minister of Environment, Decree No. 51 of 2004. Based on the results, Mantehage water quality demonstrated an excellent condition and is also believed to support the proposed marine tourism development.

Keywords: *Seawater Quality; Mantehage: Outer Island; Marine Tourism*

INTRODUCTION

Bunaken National Park exhibits high biodiversity, particularly in the Coral Triangle along the Asia Pacific region. The underwater view is famous to foreign tourists around the world and encompasses five minor islands, including, Bunaken, Siladen, Manado Tua, Mantehage, and Nain. These 5 landmasses are divided into 2 administrative regions, including Manado city and North Minahasa regency. Mantehage is a major outermost island in Indonesia with the greatest mangrove area in North Sulawesi[1]. Moreover, the nature of the coral reef ecosystem serves as a potential underwater tourist attraction[2,3]. The condition of the coral reefs in Mantehage Island seen from the percentage of coral cover ranging from 20-40%, the condition of hard coral substrates accompanied by good water quality will support this island as a new marine tourism area[3]. This island also has a good seagrass ecosystem with an average cover percentage of 33%, there are four species of seagrass including *Enhalus acoroides, Thalassia hemprichii, Cymodocea rotundata, Halophila pinifolia*[4]. The purpose of this study was to analyze the seawater quality as a database for the prospective development of marine tourism. In addition, the Minister of Environment Decree No. 51 of 2004 poses as a reference for the seawater quality standards. This research is probably a consideration for policymakers in determining the direction and strategies related to the management of coastal and marine resources, particularly for marine tourism development in Mantegehe.

RESEARCH METHOD

This research was conducted in Mantehage Island, Wori District, North Minahasa regency, North Sulawesi province, within Bunaken National Park (Fig. 1) in May 2021. Descriptive and quantitative methods with purposive sampling were employed in determining the observational base. Each station possesses coordinate points for easy monitoring and is evenly distributed. Also, the measured seawater parameters were salinity, temperature, turbidity, pH, total suspended solids, dissolved oxygen, NO_3-N and PO_4-P. However, the sampling technique and data analysis adopted the methods by[5] and [6]. The instruments used in this study is horiba U-50 series multi-parameter water quality checker enables to measure and indicate the monitoring result simultaneously up to 11 parameters with one unit. Considering user friendly field monitoring on site, such as rive, ground water, drainage water, etc. bring together feature of function and performance, which makes simple operation for everybody. Multiple sensors allow for the measurement of 11 parameters simultaneously (pH, pH(mv), ORP, DO, COND, Salinity, TDS, Seawater Specific Gravity, Temperature, Turbidity, Water Depth). For NO3-N and PO4-P analysis, seawater samples were put into glass bottles, then brought to the laboratory for further analysis. Subsequently, the results were compared to the Minister of Environment Decree No. 51 of 2004 as a reference for seawater quality standards.

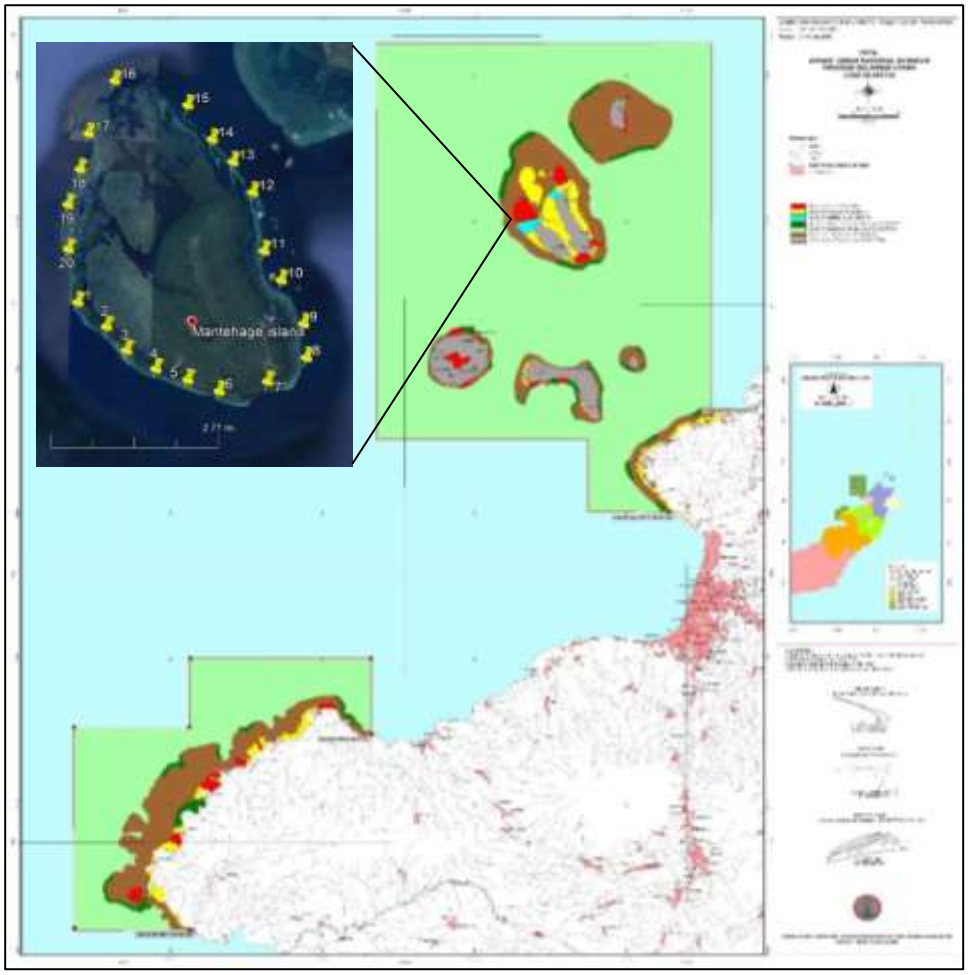

Figure 1. Research Locations Map in Mantehage Island.

RESULT AND DISCUSSION

Salinity

Salinity is described as the total amount of dissolved salt in seawater. The unit is generally accepted in mg/L, but also occurs in ppt (parts per thousand) or o/oo and practical salinity unit (PSU). Freshwater salinity values are typically <0.5 o/oo, brackish waters 0.5 - 30 o/oo, and seawaters 30-40 o/oo. Meanwhile, the estimate for coastal waters is strongly influenced by freshwater input from rivers. However, salinity potentially instigates osmotic pressure in seawater biota. The salt content in the aquatic cells occur in close proximity to the surrounding seawater salinity. As the salinity changes, osmoregulation mechanism is then required in balancing the salt levels between the cells and the environment[7]. Mantehage Island shows a salinity range of 28 - 31 PSU, with an average of 29.15 PSU. This value varies based on the climate/weather during measurement. In the dry season, seawater salinity rises above 30 PSU. Rainy weather condition was observed on the day prior to sampling, resulting in a lesser salinity value but showed good category, according to seawater quality standards. This salinity condition is not only good for tourism activities but also for the sustainability of the surrounding aquatic biota.

Temperature

Temperature influences the metabolic activity and reproduction of marine organisms. This factor is used in certain tourist destination to determine the potential and existence of coral reef growth[8]. In marine life development, the optimal average temperature is expected in the range of 230-350 °C with tolerance limits between 360-400 °C[9]. The seawater temperature of Mantehage Island occurs from 28-31°C with an average value of 29.15 °C. These conditions are convenient as quality standards for tourism development activities and underwater biota sustainability. In addition, the temperatures are identical to the average value at Carocok Painan Beach between 29-31 ºC, and also show related suitability[10]. Furthermore, similar condition was observed in the coastal waters of Labuhan Haji, East Lombok regency, with a range of 30-32 ºC[8]. The results of temperature measurements in Moyo Hilir and Lape Districts occurred between 29.20-31.57 ºC[11], in contrast to the temperature of Prialaot waters at 29-31.4 °C, with an average of 29.22° C[12]. However, temperature variations tend to influence the life of coral reefs[13]. Based on the Minister of Environment Decree No. 51 of 2004, the water temperature for marine tourism is expected at natural temperature. An appropriate range for coral reef areas exist in the range of 28-30 ºC and 28-32 ºC for mangrove regions. Discontinue in situ temperature measurement is a natural temperature with a change tolerance <2° C (Minister of Environment Decree No. 51 of 2004). However, the biota in tropical waters naturally reside in the upper limit of the highest temperature. This variations possibly interfere with the physiological processes known to endanger the biota. In the value range> 28 °C, sea surface temperature in the western equator appears very warm[14]. Moreover, the condition is considered natural as Indonesia is a tropical region. Based on the water depth, extensive seawater surface temperatures are observed, in comparison to a certain depth, probably due to the high intensity of sunlight[12].

Turbidity

Lower turbidity increases the light intensity capable of penetrating the water depth[15]. Therefore, the resulting value is expected to exist under normal condition, where water transparency is inversely proportional to the turbidity, believed to significantly influence oxygen content. Turbid water possibly interfere with the respiration process and decreases the oxygen levels[16]. The seawater turbidity condition of Mantehage Island ranges between 2.2-4.7 NTU, with an average value of 3.58 NTU, indicating an appropriate category and in line with the quality standards. Therefore, the site is suitable as a potential tourist attraction. This condition is supported by data on Mantehage Island coral reef cover in the range of 19-30%, with an average live coral cover of 29.10%[3]. Furthermore, turbidity describes an inadequate water transparency, due to colloidal and

suspended materials, including mud, organic and inorganic materials as well as aquatic microorganisms[17]. This circumstance varies from the observations in Prialaot waters with an average value of 0.08 NTU [12], in addition to Moyo Hilir and Lape Districts ranging from 0-23.3 NTU[11].

pH level

Inconsistencies in the water pH level probably influences biota existence to a certain extent of varying pH[18]. The water pH value depends on carbon dioxide and ion concentrations. Moreover, the parameter plays a significant role in the solubility of particular compounds, although appears minimal in the morning, compared to afternoon period[19,20]. Subsequently, the pH of Mantehage Island seawater ranges from 7.1-7.9, with an average value of 7.51, indicating an appropriate category for tourism development and aquatic life support. This value is also corresponds to a pH in Labuhan Haji beach between 7.6 - 7.9[8]. Meanwhile, for Carocok Painan beach, the estimate occurred between 7-8[10]. These values varied slightly from Moyo and Lape districts from 7.96 - 8.12[11], as well as in Prialaot waters by 7.64 - 8.36[12]. These variations depend on geographic position and water injection from the environment. In addition, it is also affected by the season as related to local rainfall and climate.

Total Suspended Solid (TSS)

The TSS of Mantehage Island waters ranged from 28.24-36.25 mg/L with an average value of 32.39 mg/L, corresponding to the quality standard for biota survival. However, in-depth study and sampling of other seasons are required for tourism development, particularly underwater ecotourism, considering the present research was only conducted in one season without repetition. This high TSS value is due to the greatest mangrove forest in Bunaken National Park, and therefore sedimentation in certain segments is inevitable. This varies from the TSS of Prialaot waters at the range of 14 - 31 mg/L, with an average of 21.83 mg/L. Also, the value is generally above the standards allowed for marine tourism (20 mg/L) and marine life (coral and seagrass by 20 mg/L, mangroves by 80 mg/L)[12]. Similarly, the TSS of Labuhan Haji beach also demonstrated a fairly higher content, ranging from 14 - 31 mg/L, with an average of 21.83 mg/L. This value is also above the quality standard allowed for marine tourism (20 mg/L) and marine life (coral and seagrass at 20 mg/L, and mangroves at 80 mg/L)[8].

Dissolved Oxygen (DO)

The dissolved oxygen source in water originates from the diffusion of oxygen from air, water currents or flow through rainwater, as well as photosynthetic activity by aquatic plants and phytoplankton[21]. Generally, aquatic creatures, e.g fish, shrimp, shellfish, and other animals, including microorganisms, e.g bacteria, require oxygen. Dissolved oxygen (DO) regulates the metabolism of organisms to grow and reproduce. Fish need water with an oxygen content of at least 5 mg/L[7]. The DO values in Mantehage waters ranged from 3.24-6.35 mg/L, with an average of 5.43 mg/L. This indicates a suitable oxygen content capable of supporting marine biota. Moreover, seawater quality standards for tourism and healthy ecological activities require DO values above 5mg/L. The condition supports the seagrass survival, covering 33% of the island[4], and also matches the results of dissolved oxygen (DO) measurements performed at Labuhan Haji beach, where the total stations obtained a yield range of 6 mg/L. Also, the value shows an excellent water condition, and relatively suffices the seawater quality standards[8]. Furthermore, dissolved oxygen describes the relative concentration of the element in water within the range of 4.28-10 mg/L[20]. In addition, the average dissolved oxygen in Pantai

Carocok Painan occurs between 5.75-9.1 mg/L, and is suitable for marine tourism activities[10]. Conversely, the DO for the entire stations in the Saleh Bay waters ranges from 4.78-6.01 mg/L[11]. The measured DO value of Prialaot Sabang ranged from 4.4-4.69 mg/L, with an average of 4.53 mg/L. However, at sea level, DO values are influenced by the diffusion of oxygen from air and the photosynthetic rate by marine plants[23].

Salinity

A particular salinity level is required for coral reefs and seagrass survival towards attracting marine tourism objects, including snorkeling and diving. The salinity range of Mantehage Island waters occurs between 29.45-32.65 ‰, with an average value of 31.05 ‰. This estimation indicates a suitable category within the applicable quality standards. Salinity plays an essential role in supporting marine biota and the water level varies based on geography and time, where the increase in the parameter is caused by evaporation and the result of freezing sea ice, while the decrease is instigated by precipitation and freshwater input from rivers[24]. This outcome slightly varies from the measurement results at Labuhan Haji beach, showing a salinity range of 32-35 ‰[8]. Subsequently, the value for Patai Carocok Painan waters also obtained an average range of 30-31 ‰[10]. Meanwhile, Saleh Bay water occurs between 27.17-30.67 ‰ [11], and 21.6-32.3 ‰ for Prialaot, with a general average of 31.27 ‰[12]. However, the salinity value to promote coral reef life is expected to range from 30-36 ‰[9]. This difference is influenced by geographical position and water type. Furthermore, stable salinity in the archipelago tends to be achieved, due to inadequate water inflow from the mainland. In addition, the value is also greatly impacted by evaporation and precipitation rates.

Nitrate

The nitrate content in the Mantehage waters ranges from 0.004-0.068 mg/L at an average of 0.034 mg/L. This value exceeded the quality standard of the Minister of Environment and Forestry Decree No. 51 of 2004, estimated at 0.008 mg/L. In addition, the extreme result is influenced by the mangrove ecosystem located on the coastal part of the island, where sedimentation is very extensive during the rainy season. Additional indicator is also due to poor mangrove management, leading to free waste from anthropogenic activities entering the aquatic environment[25]. The high concentration of nitrate is probably due to input from land and surrounding factors in the form of liquid waste, both due to agricultural operations. Moreover, the primary ingredient of fertilizers is nitrogen, known to utilize a bio-physicochemical process to become a compound. In marine waters, six types of nitrogen are formed, termed N_2, NO_3, NO_2, NH_3, NH_4, organic N and particulate N. Meanwhile, in aerobic atmosphere, the nitrogen species generated is the NO_3, as one of the constituents consumed by marine biota, including phytoplankton for growth of 3.9- 15.5 mg/L[11]. This outcome corresponds to the analysis results of the NO_3 at Labuhan Haji beach, with similar content of 0.036 mg/L. Also, the nitrate (NO3) at Labuhan Haji appears relatively high due to community activities on the coast/land, where unwanted materials are directly and inappropriately disposed into the sea. In addition, the existence of river water flowing into the beach also serves as a transportation medium for agricultural waste and other human activities related to the sea [8].

Phosphate

The phosphate content in Mantehage waters ranges from 0.008-0.019 mg/L at an average of 0.015 mg/L. This value is under the specified quality standard for marine tourism at 0.015 mg/L, based on the Minister of Environment Decree No. 51 of 2004. However, the estimate varied from the measurement results in Moyo Hilir and Lape sub-districts, between 0.03-0.3 mg/L. Extensive land activities is believed to trigger

the phosphate content beyond the quality standard, including livestock, agricultural operations, and the landfill existence in the coastal areas. Moreover, organic waste disposal, e.g detergents, fertilizers, and degradable materials tend to generate phosphate. In marine waters, the greatest phosphate compound is ortho-phosphate as the substance undergoes hydrolysis with a percentage fraction depending on the water pH and temperature[11].

Table 1. Seawater Quality Parameters in Mantehage Island.

Station	Coordinate		Temperature	Turbidity	TSS	pH	Salinity	DO	NO3-N	PO4-P	Parameter
			28-32	< 5	80	7-8.5[d]	<34	>5	0.008	0.015	Biota quality standards
	Latitude	Longitude	alami	< 5	20	7-8.5[d]	alami[3](e)	>5	0.008	0.015	Tourism quality standards
			C	NTU	mg/L	pH	PSU	mg/L	mg/L	mg/L	Unit quality standards
1	1°42'49.04"N	124°43'44.57"E	29	3.21	31.20	7.2	30.21	5.23	0.005	0.010	Decree of the Minister of Environment of the Republic of Indonesia No 51 of 2004
2	1°42'27.10"N	124°44'10.46"E	30	4.25	29.25	7.6	31.26	5.47	0.025	0.011	
3	1°42'5.66"N	124°44'28.58"E	28	3.2	33.65	7.4	31.25	5.65	0.045	0.016	
4	1°41'49.04"N	124°44'54.55"E	29	2.2	35.25	7.8	30.45	5.14	0.006	0.018	
5	1°41'39.27"N	124°45'22.47"E	30	3.2	30.56	7.5	29.45	5.98	0.068	0.014	
6	1°41'29.02"N	124°45'49.90"E	28	4.7	32.00	7.4	30.87	6.12	0.065	0.013	
7	1°41'37.80"N	124°46'31.55"E	28	3.6	33.63	7.6	32.14	3.24	0.058	0.015	
8	1°41'59.04"N	124°47'4.83"E	28	2.8	32.63	7.9	30.45	6.35	0.009	0.019	
9	1°42'29.46"N	124°47'1.90"E	30	4	34.24	7.1	31.56	5.21	0.004	0.018	
10	1°43'9.12"N	124°46'41.67"E	30	4.1	32.13	7.4	30.25	5.98	0.008	0.017	
11	1°43'35.87"N	124°46'26.20"E	30	3.2	33.26	7.5	31.25	5.87	0.025	0.009	
12	1°44'29.95"N	124°46'15.18"E	29	4.5	31.00	7.6	30.87	5.46	0.054	0.008	
13	1°44'58.36"N	124°45'57.12"E	30	2.5	31.27	7.1	31.63	5.21	0.066	0.016	
14	1°45'19.63"N	124°45'38.18"E	31	3.8	33.36	7.5	32.65	5.69	0.042	0.014	
15	1°45'51.74"N	124°45'15.50"E	29	4.7	36.25	7.8	32.4	5.19	0.061	0.018	
16	1°46'14.93"N	124°44'9.69"E	28	3.5	35.21	7.5	31.25	5.38	0.019	0.016	
17	1°45'24.98"N	124°43'48.02"E	30	3.4	28.24	7.6	30.65	5.67	0.048	0.014	
18	1°44'51.67"N	124°43'41.78"E	28	2.8	29.25	7.6	31.45	5.43	0.065	0.013	
19	1°44'18.76"N	124°43'32.41"E	29	3.6	32.25	7.6	30.14	5.28	0.008	0.017	
20	1°43'37.56"N	124°43'34.43"E	29	4.5	33.25	7.5	30.86	5.17	0.007	0.014	
Average			29.15	3.58	32.39	7.51	31.052	5.43	0.034	0.015	
Minimum			28	2.2	28.24	7.1	29.45	3.24	0.004	0.008	
Maximum			31	4.7	36.25	7.9	32.65	6.35	0.068	0.019	

CONCLUSION

Based on the values of salinity, temperature, turbidity, pH, total suspended solids, dissolved oxygen, NO_3-N, and PO_4-P, the condition of Mantehage water quality obtained a suitable category within the specified standards of the Minister of Environment Decree No. 51 of 2004. Several parameters known to exceed these provisions, including nitrate and phosphate content, indicate the instantaneous value during measurement. Therefore, an in-depth study, sufficient interval and sampling location to represent the spatial and temporal conditions of the entire island are greatly required. This outermost island generally appears suitable as a marine tourism attraction, particularly snorkeling and diving. Furthermore, the beauty of coral reefs is believed to be a major tourist object with the need for further encouragement.

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REFERENCES

1. Schaduw J. N. W. 2020. Land suitability of the Marine Ecotourism in Mantehage Village, Wori District, North Minahasa Regency, North Sulawesi Province. Journal of SPATIAL Wahana Komunikasi Dan Informasi Geografi, 20 (1) [in Indonesian]
2. Kase A., Manembu I., Schaduw J.N.W. 2019. [Condition of Mantehage Island Coral Reef, North Minahasa Regency, North Sulawesi]. Journal of coastal and tropical seas. 7 (3) : 208-212 [in Indonesian]
3. Schaduw J.N.W., Kondoy K.I.F., Manoppo V.E.N., Luasunaung A., Mudeng J., Pelle W.E., Ngangi E.L.A., Manembu I.S., Wantasen N.S., Sumilat D.A., Rumampuk N.D.C., Tilaar S.O., Manengkey H.W.A., Lintang R., Walalangi J.Y., Tampanguma B., Pungus F., Lahabu Y., Sagai B., Wantah E., Wantania L.L., Djabar B., Oli A.P., Caroles E.A., Bachmid F., Sasauw J., Kase A., Anthoni A., Uada A.D., Ladjandu R., Coloay C., Kojongian S., Mamangkey N.N.T. 2020. Data On Percentage Coral Reef Cover In Small Islands Bunaken National Park. Data in Brief, 31, 105713.
4. Schaduw J. N.W. and Kondoy K. F. I. 2020. Seagrass percent cover in small islands of Bunaken National Park, North Sulawesi Province, Indonesia. AACL Bioflux 13(2):951-957.
5. Schaduw J. N.W. 2018. [Distribution and Water Quality Characteristics of the Small Island Mangrove Ecosystem of Bunaken National Park]. Indonesian Geography Magazine. 32 (1) 40-49 [in Indonesian]
6. Kurniadi B., Sigid H., Enan M., Adiwilaga. 2015. [The waters Quality of the Buaya River in Bunyu Island, North Kalimantan in Tidal Conditions]. Indonesian Journal of Agricultural Sciences. 20 (1): 53-58. [in Indonesian]
7. Schaduw J.N.W., Ngangi E.D., Mudeng J. 2013. Land suitability of seaweed farming in Minahasa Regency, North Sulawesi Province. Aquatic Science & Management. 1 (1) : 72-81[in Indonesian]
8. Haerudin and Putra A.M. 2019. Analysis of Seawater Quality Standards for the Development of Marine Tourism in Labuhan Haji Beach, East Lombok Regency. *Journal of Geodics 3(1) : 13 – 18* [in Indonesian]
9. Bengen, D.G. 2003.Sampling Techniques and Analysis of Coastal Biophysical Data - Synopsis, IPB Coastal and Ocean Resources Research Center, Bogor.
10. Indra N., Sari S., Rahayu G, Oktaviandra R., Handoko A., Putri V.S., Hanapi N.I. 2019. Environmental Quality and Suitability of Coastal Tourism in Carocok Painan Area, Pesisir Selatan Regency. Journal of Capita Selecta Geography 2 (5): 43- 51[in Indonesian]
11. Saraswati N.G.R.A., Yulius., Rustam A., Hadiwijaya L., Salim., Heriati A., Mustikasari E. 2017. [Study of Water Quality for Coastal Marine Tourism, Moyo Hilir Subdistrict and Lape Subdistrict, Sumbawa Regency]. Journal of Segara 13 (1) : 37-47. [in Indonesian]
12. Tanto T.A., Naelul N.H.R., Ilham. 2018. [Quality of Seawater to Support Marine Tourism and Marine Life. Case Study: Around the Sinking Ship of Sophie Rickmers, Prialaot Sabang Waters]. Marine Journal, 11 (2) : 173-183. [in Indonesian]
13. Tambunan J.M., Anggoro S., Purnaweni H. 2013. [Study on Environmental Quality and Suitability of Tanjung Pesona Beach Tourism, Bangka Regency]. Proceedings of the National Seminar on Natural Resources and Environmental Management. pg 356-362. [in Indonesian]
14. Tomczak M. and Godfrey J. 2001. Regional Oceanography: An Introduction. Published Online.
15. Tanto T. A. and Kusumah G. 2016. [Seawater Quality Standards in Different Seasons]. Maspari Journal, 8 (2) : 135–146. [in Indonesian]
16. Mutmainah H. 2016.[Environmental Suitability Study for Tourism Development at Ganting Beach, Simeulue Island, Aceh Province]. Journal of Depik Unsyiah, 5 (1) : 19–30. [in Indonesian]
17. Wilson P.C. 2010. Water Quality Notes: Water Clarity (Turbidity, Suspended Solids, and Color). Department of Soil and Water Science. University of Florida.
18. Simanjuntak M. 2012. Seawater Quality Judging from Nutrient Aspects, Dissolved Oxygen and Ph in Banggai Waters, Central Sulawesi. Journal of Tropical Marine Science and Technology. 4(2):290-303.
19. Arifin T., Bengen D.G., Pariwono J.I. 2002. Evaluation on the Suitability of the Palu Bay Coastal Zone for Marine Tourism Development. Coastal and Ocean Journal. 4 (2) : 25-35 [in Indonesian]
20. Putra A. 2017. [Evaluation on Suitability of Spatial Use in the Coastal Area of Bungus Bay, Padang City] (Thesis). Andalas University Postgraduate. [in Indonesian]

21. Novonty V. and Olem H. 1994. Water quality, prevention, identification and management of diffuse pollution. New York: Van Nostrans Reinhold.
22. Putra A., Tanto T.A., Pranowo W.S., Ilham., Damanhuri H., Suasti Y., Triyatno T. 2018. Suitability Of Coastal Ecotourism In Padang City-West Sumatera: Case Study Of Beach Recreation And Mangrove. Journal of Segara, 14 (2) : 87-94.
23. Wisha U.J., Tanto T.A., Ilham. 2016. Physical and Chemical Conditions of Bayur Bay Waters on the East and West Season.Journal of Marine Science UNDIP. 22(1) : 15–24.
24. Talley L. D. 2002. Salinity Patterns in The Ocean. Encyclopedia of Global Environmental Change, Vol 1 : 629-640.
25. Schaduw J.N.W. 2015. [Sustainable Management of the Mantehage Island Mangrove Ecosystem, Wori Subdistrict, North Minahasa District, North Sulawesi Province]. Journal of the LPPM (Institute for Research and Community Service) UNSRAT in the field of Science and Technology, 2 (2) : 60-70. [in Indonesian]

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The Analysis of Seawater Quality in Small Outermost Mantehage Island for Integrated and Sustainable Marine Tourism Development in North Sulawesi Province

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Conflict of interest: The authors declare no conflict of interest

Abstract

Background and Objective: There is a growing interest to significantly explore more opportunities in the coastal environment. For this reason, adequate progressive strategies appear very essential. The purpose of this study was to analyze seawater quality as a database for developing integrated and sustainable marine tourism in Mantehage Island, Indonesia. **Materials and Methods:** the present paper applied descriptive and quantitative methods to sample 20 observation points around the selected location. In addition, the seawater content was directly measured and stored in the laboratory for further analysis. Consequently, certain parameters were evaluated, including salinity, temperature, turbidity, pH, total suspended solids, dissolved oxygen, NO_3-N and PO_4-P. The subsequent data were also compared to the related quality standards of the Minister of Environment, Decree No. 51 of 2004. **Results**: Based on the results, Mantehage water quality demonstrated an excellent condition and is also believed to support the proposed marine tourism development. **Conclusion**: the values of salinity, temperature, turbidity, pH, total suspended solids, dissolved oxygen, NO_3-N, and PO_4-P, the condition of Mantehage water quality obtained a suitable category within the specified standards of the Minister of Environment Decree No. 51 of 2004. Several parameters known to exceed these provisions, including nitrate and phosphate content, indicate the instantaneous value during measurement

Keywords: *Seawater Quality; Mantehage: Outer Island; Marine Tourism*

INTRODUCTION

The quality of sea water greatly determines the feasibility of an underwater tourism area, diving and snorkeling activities require good sea water conditions, this greatly affects the comfort and safety of tourists. Bunaken National Park exhibits high biodiversity, particularly in the Coral Triangle along the Asia Pacific region. The underwater view is famous to foreign tourists around the world and encompasses five minor islands, including, Bunaken, Siladen, Manado Tua, Mantehage, and Nain. These 5 landmasses are divided into 2 administrative regions, including Manado city and North Minahasa regency. Mantehage is a major outermost island in Indonesia with the greatest mangrove area in North Sulawesi[1]. Moreover, the nature of the coral reef ecosystem serves as a potential underwater tourist attraction[2,3]. The condition of the coral reefs in Mantehage Island seen from the percentage of coral cover ranging from 20-40%, the condition of hard coral substrates accompanied by good water quality will support this island as a new marine tourism area[3]. This island also has a good seagrass ecosystem with an average cover percentage of 33%, there are four species of seagrass including *Enhalusacoroides*, *Thalassiahemprichii*, *Cymodocearotundata*, *Halophilapinifolia*[4]. Some important water quality parameters include salinity, temperature, turbidity, pH, total suspended solids, dissolved oxygen, NO3-N and PO4-P. Information about these parameters will be very helpful in the development of tourist areas. This research is probably a consideration for policymakers in determining the direction and strategies related to the management of coastal and marine resources, particularly for marine tourism development in Mantegehe. The purpose of this study was to analyze the seawater quality as a database for the prospective development of marine tourism. In addition, the Minister of Environment Decree No. 51 of 2004 poses as a reference for the seawater quality standards.

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MATERIALS AND METHODS

Study area: This research was conducted in Mantehage Island, Wori District, North Minahasa regency, North Sulawesi province, within Bunaken National Park from March to May 2021.

Research protocol: Descriptive and quantitative methods with purposive sampling were employed in determining the observational base. Each station possesses coordinate points for easy monitoring and is evenly distributed.

Parameters measurement: the measured seawater parameters were salinity, temperature, turbidity, pH, total suspended solids, dissolved oxygen, NO_3-N and PO_4-P. However, the sampling technique and data analysis adopted the methods by[5] and[6].

Instruments used: The instruments used in this study is horibaU-50 series multi-parameter water quality checker enables to measure and indicate the monitoring result simultaneously up to 11 parameters with one unit. Considering user friendly field monitoring on site, such as rive, ground water, drainage water, etc. bring together feature of function and performance, which makes simple operation for everybody. Multiple sensors allow for the measurement of 11 parameters simultaneously (pH, pH(mv), ORP, DO, COND, Salinity, TDS, Seawater Specific Gravity, Temperature, Turbidity, Water Depth).For NO3-N and PO4-P analysis, seawater samples were put into glass bottles, then brought to the laboratory for further analysis. Subsequently, the results were compared to the Minister of Environment Decree No. 51 of 2004 as a reference for seawater quality standards.

RESULTS AND DISCUSSION

Salinity: Salinity is described as the total amount of dissolved salt in seawater. The unit is generally accepted in mg/L, but also occurs in ppt (parts per thousand) or o/oo and practical salinity unit (PSU). Freshwater salinity values are typically <0.5 o/oo, brackish waters 0.5 - 30 o/oo, and seawaters 30-40 o/oo. Meanwhile, the estimate for coastal waters is strongly influenced by freshwater input from rivers. However, salinity potentially instigates osmotic pressure in seawater biota. The salt content in the aquatic cells occur in close proximity to the surrounding seawater salinity. As the salinity changes, osmoregulation mechanism is then required in balancing the salt levels between the cells and the environment[7]. Mantehage Island shows a salinity range of 28 - 31 PSU, with an average of 29.15 PSU. This value varies based on the

climate/weather during measurement. In the dry season, seawater salinity rises above 30 PSU. Rainy weather condition was observed on the day prior to sampling, resulting in a lesser salinity value but showed good category, according to seawater quality standards. This salinity condition is not only good for tourism activities but also for the sustainability of the surrounding aquatic biota.

Temperature

Temperature influences the metabolic activity and reproduction of marine organisms. This factor is used in certain tourist destination to determine the potential and existence of coral reef growth[8]. In marine life development, the optimal average temperature is expected in the range of 23^0-35^0C with tolerance limits between 36-40°C. The seawater temperature of Mantehage Island occurs from 28-31°C with an average value of 29.15 °C. These conditions are convenient as quality standards for tourism development activities and underwater biota sustainability. In addition, the temperatures are identical to the average value at CarocokPainan Beach between 29-31 ºC, and also show related suitability[9]. Furthermore, similar condition was observed in the coastal waters of Labuhan Haji, East Lombok regency, with a range of 30-32 ºC[8]. The results of temperature measurements in MoyoHilir and Lape Districts occurred between 29.20-31.57 ºC[10], in contrast to the temperature of Prialaot waters at 29-31.4 °C, with an average of 29.22° C[11]. However, temperature variations tend to influence the life of coral reefs[12]. Based on the Minister of Environment Decree No. 51 of 2004, the water temperature for marine tourism is expected at natural temperature. An appropriate range for coral reef areas exist in the range of 28-30 ºC and 28-32 ºC for mangrove regions. Discontinue in situ temperature measurement is a natural temperature with a change tolerance <2° C (Minister of Environment Decree No. 51 of 2004). However, the biota in tropical waters naturally reside in the upper limit of the highest temperature. This variations possibly interfere with the physiological processes known to endanger the biota. In the value range> 28 °C, sea surface temperature in the western equator appears very warm[13]. Moreover, the condition is considered natural as Indonesia is a tropical region. Based on the water depth, extensive seawater surface temperatures are observed, in comparison to a certain depth, probably due to the high intensity of sunlight[12].

Turbidity

Lower turbidity increases the light intensity capable of penetrating the water depth[14]. Therefore, the resulting value is expected to exist under normal condition, where water transparency is inversely proportional to the turbidity, believed to significantly influence oxygen content. Turbid water possibly interfere with the respiration process and decreases the oxygen levels[15]. The seawater turbidity condition of Mantehage Island ranges between 2.2-4.7 NTU, with an average value of 3.58 NTU, indicating an appropriate category and in line with the quality standards. Therefore, the site is suitable as a potential tourist attraction. This condition is supported by data on Mantehage Island coral reef cover in the range of 19-30%, with an average live coral cover of 29.10%[3]. Furthermore, turbidity describes an inadequate water transparency, due to colloidal and suspended materials, including mud, organic and inorganic materials as well as aquatic microorganisms[16]. This circumstance varies from the observations in Prialaot waters with an average value of 0.08 NTU[11], in addition to MoyoHilir and Lape Districts ranging from 0-23.3 NTU[10].

pH level

Inconsistencies in the water pH level probably influences biota existence to a certain extent of varying pH[17]. The water pH value depends on carbon dioxide and ion concentrations. Moreover, the parameter plays a significant role in the solubility of particular compounds, although appears minimal in the morning, compared to afternoon period[18]. Subsequently, the pH of Mantehage Island seawater ranges from 7.1-7.9, with an average value of 7.51, indicating an appropriate category for tourism development and aquatic life support. This value is also corresponds to a pH in Labuhan Haji beach between 7.6 - 7.9[8]. Meanwhile, for CarocokPainan beach, the estimate occurred between 7-8[9]. These values varied slightly from Moyo and Lape districts from 7.96 - 8.12[10], as well as in Prialaot waters by 7.64 - 8.36[11]. These variations depend on geographic position and water injection from the environment. In addition, it is also affected by the season as related to local rainfall and climate.

Total Suspended Solid (TSS)

The TSS of Mantehage Island waters ranged from 28.24-36.25 mg/L with an average value of 32.39 mg/L, corresponding to the quality standard for biota survival. However, in-depth study and sampling of other seasons are required for tourism development, particularly underwater ecotourism, considering the present research was only conducted in one season without repetition. This high TSS value is due to the greatest mangrove forest in Bunaken National Park, and therefore sedimentation in certain segments is inevitable. This varies from the TSS of Prialaot waters at the range of 14 - 31 mg/L, with an average of 21.83 mg/L. Also, the value is generally above the standards allowed for marine tourism (20 mg/L) and marine life (coral and seagrass by 20 mg/L, mangroves by 80 mg/L)[11]. Similarly, the TSS of Labuhan Haji beach also demonstrated a fairly higher content, ranging from 14 - 31 mg/L, with an average of 21.83 mg/L. This value is also above the quality standard allowed for marine tourism (20 mg/L) and marine life (coral and seagrass at 20 mg/L, and mangroves at 80 mg/L)[8].

Dissolved Oxygen (DO)

The dissolved oxygen source in water originates from the diffusion of oxygen from air, water currents or flow through rainwater, as well as photosynthetic activity by aquatic plants and phytoplankton. Generally, aquatic creatures, e.g fish, shrimp, shellfish, and other animals, including microorganisms, e.g bacteria, require oxygen. Dissolved oxygen (DO) regulates the metabolism of organisms to grow and reproduce. Fish need water with an oxygen content of at least 5 mg/L[7]. The DO values in Mantehage waters ranged from 3.24-6.35 mg/L, with an average of 5.43 mg/L. This indicates a suitable oxygen content capable of supporting marine biota. Moreover, seawater quality standards for tourism and healthy ecological activities require DO values above 5mg/L. The condition supports the seagrass survival, covering 33% of the island[4], and also matches the results of dissolved oxygen (DO) measurements performed at Labuhan Haji beach, where the total stations obtained a yield range of 6 mg/L. Also, the value shows an excellent water condition, and relatively suffices the seawater quality standards[8]. Furthermore, dissolved oxygen describes the relative concentration of the element in water within the range of 4.28-10 mg/L[19]. In addition, the average dissolved oxygen in PantaiCarocokPainan occurs

between 5.75-9.1 mg/L, and is suitable for marine tourism activities[9]. Conversely, the DO for the entire stations in the Saleh Bay waters ranges from 4.78-6.01 mg/L[11]. The measured DO value of PrialaotSabang ranged from 4.4-4.69 mg/L, with an average of 4.53 mg/L. However, at sea level, DO values are influenced by the diffusion of oxygen from air and the photosynthetic rate by marine plants[20].

Salinity

A particular salinity level is required for coral reefs and seagrass survival towards attracting marine tourism objects, including snorkeling and diving. The salinity range of Mantehage Island waters occurs between 29.45-32.65 ‰, with an average value of 31.05 ‰. This estimation indicates a suitable category within the applicable quality standards. Salinity plays an essential role in supporting marine biota and the water level varies based on geography and time, where the increase in the parameter is caused by evaporation and the result of freezing sea ice, while the decrease is instigated by precipitation and freshwater input from rivers. This outcome slightly varies from the measurement results at Labuhan Haji beach, showing a salinity range of 32-35 ‰[8]. Subsequently, the value for PataiCarocokPainan waters also obtained an average range of 30-31 ‰[9]. Meanwhile, Saleh Bay water occurs between 27.17-30.67 ‰ [10], and 21.6-32.3 ‰ for Prialaot, with a general average of 31.27 ‰[11]. However, the salinity value to promote coral reef life is expected to range from 30-36 ‰[8]. This difference is influenced by geographical position and water type. Furthermore, stable salinity in the archipelago tends to be achieved, due to inadequate water inflow from the mainland. In addition, the value is also greatly impacted by evaporation and precipitation rates.

Nitrate

The nitrate content in the Mantehage waters ranges from 0.004-0.068 mg/L at an average of 0.034 mg/L. This value exceeded the quality standard of the Minister of Environment and Forestry Decree No. 51 of 2004, estimated at 0.008 mg/L. In addition, the extreme result is influenced by the mangrove ecosystem located on the coastal part of the island, where sedimentation is very extensive during the rainy season. Additional indicator is also due to poor mangrove management, leading to free waste from anthropogenic activities entering the aquatic environment[21]. The high concentration of nitrate is probably due to input from land and

surrounding factors in the form of liquid waste, both due to agricultural operations. Moreover, the primary ingredient of fertilizers is nitrogen, known to utilize a bio-physicochemical process to become a compound. In marine waters, six types of nitrogen are formed, termed N_2, NO_3, NO_2, NH_3, NH_4, organic N and particulate N. Meanwhile, in aerobic atmosphere, the nitrogen species generated is the NO_3, as one of the constituents consumed by marine biota, including phytoplankton for growth of 3.9- 15.5 mg/L[10]. This outcome corresponds to the analysis results of the NO_3 at Labuhan Haji beach, with similar content of 0.036 mg/L. Also, the nitrate (NO3) at Labuhan Haji appears relatively high due to community activities on the coast/land, where unwanted materials are directly and inappropriately disposed into the sea. In addition, the existence of river water flowing into the beach also serves as a transportation medium for agricultural waste and other human activities related to the sea [8].

Phosphate

The phosphate content in Mantehage waters ranges from 0.008-0.019 mg/L at an average of 0.015 mg/L. This value is under the specified quality standard for marine tourism at 0.015 mg/L, based on the Minister of Environment Decree No. 51 of 2004. However, the estimate varied from the measurement results in MoyoHilir and Lape sub-districts, between 0.03-0.3 mg/L. Extensive land activities is believed to trigger the phosphate content beyond the quality standard, including livestock, agricultural operations, and the landfill existence in the coastal areas. Moreover, organic waste disposal, e.g detergents, fertilizers, and degradable materials tend to generate phosphate. In marine waters, the greatest phosphate compound is ortho-phosphate as the substance undergoes hydrolysis with a percentage fraction depending on the water pH and temperature[10].

Table 1. Seawater Quality Parameters in Mantehage Island.

Station	Coordinate		Temperature	Turbidity	TSS	pH	Salinity	DO	NO3-N	PO4-P	Parameter
	Latitude	Longitude	28-32	< 5	80	7-8.5[d]	<34	>5	0.008	0.015	Biota quality standards
			alami	< 5	20	7-8.5[d]	alami[3](e)	>5	0.008	0.015	Tourism quality standards
			C	NTU	mg/L	pH	PSU	mg/L	mg/L	mg/L	Unit quality standards
1	1°42'49.04"N	124°43'44.57"E	29	3.21	31.20	7.2	30.21	5.23	0.005	0.010	Decree of the Minister of Environment of the Republic of Indonesia No 51 of 2004
2	1°42'27.10"N	124°44'10.46"E	30	4.25	29.25	7.6	31.26	5.47	0.025	0.011	
3	1°42'5.66"N	124°44'28.58"E	28	3.2	33.65	7.4	31.25	5.65	0.045	0.016	
4	1°41'49.04"N	124°44'54.55"E	29	2.2	35.25	7.8	30.45	5.14	0.006	0.018	
5	1°41'39.27"N	124°45'22.47"E	30	3.2	30.56	7.5	29.45	5.98	0.068	0.014	
6	1°41'29.02"N	124°45'49.90"E	28	4.7	32.00	7.4	30.87	6.12	0.065	0.013	
7	1°41'37.80"N	124°46'31.55"E	28	3.6	33.63	7.6	32.14	3.24	0.058	0.015	
8	1°41'59.04"N	124°47'4.83"E	28	2.8	32.63	7.9	30.45	6.35	0.009	0.019	
9	1°42'29.46"N	124°47'1.90"E	30	4	34.24	7.1	31.56	5.21	0.004	0.018	
10	1°43'9.12"N	124°46'41.67"E	30	4.1	32.13	7.4	30.25	5.98	0.008	0.017	
11	1°43'35.87"N	124°46'26.20"E	30	3.2	33.26	7.5	31.25	5.87	0.025	0.009	
12	1°44'29.95"N	124°46'15.18"E	29	4.5	31.00	7.6	30.87	5.46	0.054	0.008	
13	1°44'58.36"N	124°45'57.12"E	30	2.5	31.27	7.1	31.63	5.21	0.066	0.016	
14	1°45'19.63"N	124°45'38.18"E	31	3.8	33.36	7.5	32.65	5.69	0.042	0.014	
15	1°45'51.74"N	124°45'15.50"E	29	4.7	36.25	7.8	32.4	5.19	0.061	0.018	
16	1°46'14.93"N	124°44'9.69"E	28	3.5	35.21	7.5	31.25	5.38	0.019	0.016	
17	1°45'24.98"N	124°43'48.02"E	30	3.4	28.24	7.6	30.65	5.67	0.048	0.014	
18	1°44'51.67"N	124°43'41.78"E	28	2.8	29.25	7.6	31.45	5.43	0.065	0.013	
19	1°44'18.76"N	124°43'32.41"E	29	3.6	32.25	7.6	30.14	5.28	0.008	0.017	
20	1°43'37.56"N	124°43'34.43"E	29	4.5	33.25	7.5	30.86	5.17	0.007	0.014	
Average			29.15	3.58	32.39	7.51	31.052	5.43	0.034	0.015	
Minimum			28	2.2	28.24	7.1	29.45	3.24	0.004	0.008	
Maximum			31	4.7	36.25	7.9	32.65	6.35	0.068	0.019	

CONCLUSION

Based on the values of salinity, temperature, turbidity, pH, total suspended solids, dissolved oxygen, NO_3-N, and PO_4-P, the condition of Mantehage water quality obtained a suitable category within the specified standards of the Minister of Environment Decree No. 51 of 2004[22]. Several parameters known to exceed these provisions, including nitrate and phosphate content, indicate the instantaneous value during measurement. Therefore, an in-depth study, sufficient interval and sampling location to represent the spatial and temporal conditions of the entire island are greatly required. This outermost island generally appears suitable as a marine tourism attraction, particularly snorkeling and diving. Furthermore, the beauty of coral reefs is believed to be a major tourist object with the need for further encouragement.

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Significance statement

"This study discovered the condition of the sea water quality of Mantehage Island which can be developed as an underwater tourism location, the good status of coral reefs supported by underwater beauty makes Mantehage Island worthy of development, that can be beneficial for for the government, researchers, and the people of Mantehage Island in developing tourism.This study will help the researchers to uncover the critical areas of of the outermost small island of Indonesia that many researchers were not able to explore. Thus a new theory on the condition of sea water quality for the development of marine tourism may be arrived at"

REFERENCES

1. Schaduw J. N. W. 2020. Land suitability of the Marine Ecotourism in Mantehage Village, Wori District, North Minahasa Regency, North Sulawesi Province. Journal of SPATIAL WahanaKomunikasi Dan InformasiGeografi, 20 (1) [in Indonesian]
   http://journal.unj.ac.id/unj/index.php/spatial/article/view/14347
   135540op
2. Kase A., Manembu I., Schaduw J.N.W. 2019. [Condition of Mantehage Island Coral Reef, North Minahasa Regency, North Sulawesi]. Journal of coastal and tropical seas. 7 (3) : 208-212[in Indonesian]
   Https://Doi.Org/10.35800/Jplt.7.3.2019.24466
   https://ejournal.unsrat.ac.id/index.php/jplt/article/view/24466/24143
3. Schaduw J.N.W., Kondoy K.I.F., Manoppo V.E.N., Luasunaung A., Mudeng J., Pelle W.E., Ngangi E.L.A., Manembu I.S., Wantasen N.S., Sumilat D.A., Rumampuk N.D.C., Tilaar S.O., Manengkey H.W.A., Lintang R., Walalangi J.Y., Tampanguma B., Pungus F., Lahabu Y., Sagai B., Wantah E., Wantania L.L., Djabar B., Oli A.P., Caroles E.A., Bachmid F., Sasauw J., Kase A., Anthoni A., Uada A.D., Ladjandu R., Coloay C., Kojongian S., Mamangkey N.N.T. 2020. Data On Percentage Coral Reef Cover In Small Islands Bunaken National Park. Data in Brief, 31, 105713.
   https://doi.org/10.1016/j.dib.2020.105713
   135541op
4. Schaduw J. N.W. and Kondoy K. F. I. 2020. Seagrass percent cover in small islands of Bunaken National Park, North Sulawesi Province, Indonesia. AACL Bioflux 13(2):951-957.
   http://www.bioflux.com.ro/docs/2020.951-957.pdf
   2233174ja
5. Schaduw J. N.W. 2018. [Distribution and Water Quality Characteristics of the Small Island Mangrove Ecosystem of Bunaken National Park]. Indonesian Geography Magazine. 32 (1) 40-49 [in Indonesian]
   https://jurnal.ugm.ac.id/mgi/article/view/32204
   https://doi.org/10.22146/mgi.32204
6. Kurniadi B., Sigid H., Enan M., Adiwilaga. 2015. [The waters Quality of the Buaya River in Bunyu Island, North Kalimantan in Tidal Conditions]. Indonesian Journal of Agricultural Sciences. 20 (1): 53-58. [in Indonesian]
   https://journal.ipb.ac.id/index.php/JIPI/article/view/9289/7287
   2233175ja
7. Schaduw J.N.W., Ngangi E.D., Mudeng J. 2013. Land suitability of seaweed farming in Minahasa Regency, North Sulawesi Province. Aquatic Science & Management. 1 (1) : 72-81[in Indonesian]
   https://ejournal.unsrat.ac.id/index.php/jasm/article/view/1972
   https://doi.org/10.35800/jasm.1.1.2013.1972
8. Haerudin and Putra A.M. 2019. Analysis of Seawater Quality Standards for the Development of Marine Tourism in Labuhan Haji Beach, East Lombok Regency. *Journal of Geodics 3(1) : 13 – 18*[in Indonesian]
   https://e-journal.hamzanwadi.ac.id/index.php/gdk/article/view/1473
9. Indra N., Sari S., Rahayu G, Oktaviandra R., Handoko A., Putri V.S., Hanapi N.I. 2019. Environmental Quality and Suitability of Coastal Tourism in CarocokPainan Area,

Commented [S2]: •All references must be in English language. References other than English language are not allowed to include in reference list.
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•Therefore, author is requested to reduce the number of self-cited references.

Pesisir Selatan Regency. Journal of Capita Selecta Geography 2 (5): 43- 51[in Indonesian]
http://ksgeo.ppj.unp.ac.id/index.php/ksgeo/article/view/251
https://doi.org/10.24036/ksgeo.v2i5.251

10. Saraswati N.G.R.A., Yulius., Rustam A., Hadiwijaya L., Salim., Heriati A., Mustikasari E. 2017. [Study of Water Quality for Coastal Marine Tourism, MoyoHilirSubdistrict and LapeSubdistrict, Sumbawa Regency]. Journal of Segara 13 (1) : 37-47. [in Indonesian]
http://ejournal-balitbang.kkp.go.id/index.php/segara/article/view/6421
http://dx.doi.org/10.15578/segara.v13i1.6421
11. Tanto T.A., Naelul N.H.R., Ilham. 2018. [Quality of Seawater to Support Marine Tourism and Marine Life. Case Study: Around the Sinking Ship of Sophie Rickmers, PrialaotSabang Waters]. Marine Journal, 11 (2) : 173-183. [in Indonesian]
https://journal.trunojoyo.ac.id/jurnalkelautan/article/view/4276
https://doi.org/10.21107/jk.v11i2.4276
12. Tambunan J.M., Anggoro S., Purnaweni H. 2013. [Study on Environmental Quality and Suitability of TanjungPesona Beach Tourism, Bangka Regency]. Proceedings of the National Seminar on Natural Resources and Environmental Management. pg 356-362. [in Indonesian]
13. Tomczak M. and Godfrey J. 2001. Regional Oceanography: An Introduction. Published Online.
14. Tanto T. A. and Kusumah G. 2016. [Seawater Quality Standards in Different Seasons]. Maspari Journal, 8 (2) : 135–146. [in Indonesian]
https://ejournal.unsri.ac.id/index.php/maspari/article/view/3490
https://doi.org/10.36706/maspari.v8i2.3490
15. Mutmainah H. 2016.[Environmental Suitability Study for Tourism Development at Ganting Beach, Simeulue Island, Aceh Province]. Journal of DepikUnsyiah, 5 (1) : 19–30. [in Indonesian]
http://jurnal.unsyiah.ac.id/depik/article/view/3844
https://doi.org/10.13170/depik.5.1.3844
16. Wilson P.C. 2010. Water Quality Notes: Water Clarity (Turbidity, Suspended Solids, and Color). Department of Soil and Water Science. University of Florida.
17. Simanjuntak M. 2012. Seawater Quality Judging from Nutrient Aspects, Dissolved Oxygen and Ph in Banggai Waters, Central Sulawesi. Journal of Tropical Marine Science and Technology. 4(2):290-303.
https://journal.ipb.ac.id/index.php/jurnalikt/article/view/7791
https://doi.org/10.29244/jitkt.v4i2.7791
2233177ja
18. Arifin T., Bengen D.G., Pariwono J.I. 2002. Evaluation on the Suitability of the Palu Bay Coastal Zone for Marine Tourism Development. Coastal and Ocean Journal. 4 (2) : 25-35 [in Indonesian]
https://repository.ipb.ac.id/jspui/bitstream/123456789/26592/1/Taslim%20Arifin_Herni%20%2811%20hal%29.pdf
19. Putra A., Tanto T.A., Pranowo W.S., Ilham., Damanhuri H., Suasti Y., Triyatno T. 2018. Suitability Of Coastal Ecotourism In Padang City-West Sumatera: Case Study Of Beach Recreation And Mangrove. Journal of Segara, 14 (2) : 87-94.
http://ejournal-balitbang.kkp.go.id/index.php/segara/article/view/6642

http://dx.doi.org/10.15578/segara.v14i2.6642
2233178ja
20. Wisha U.J., Tanto T.A., Ilham. 2016. Physical and Chemical Conditions of Bayur Bay Waters on the East and West Season.Journal of Marine Science UNDIP. 22(1) : 15–24. https://ejournal.undip.ac.id/index.php/ijms/article/view/10505 doi:10.14710/ik.ijms.22.1.15-24
2233179ja
21. Schaduw J.N.W. 2015. [Sustainable Management of the Mantehage Island Mangrove Ecosystem, WoriSubdistrict, North Minahasa District, North Sulawesi Province]. Journal of the LPPM (Institute for Research and Community Service) UNSRAT in the field of Science and Technology, 2 (2) : 60-70. [in Indonesian] https://ejournal.unsrat.ac.id/index.php/lppmsains/article/view/10692
22. Minister of Environment Decree No. 51 of 2004 poses as a reference for the seawater quality standards. https://environmentalchemistry.files.wordpress.com/2013/08/kepmenlh-no-51-tahun-2004.pdf

The Analysis of Seawater Quality in Small Outermost Mantehage Island for Integrated and Sustainable Marine Tourism Development in North Sulawesi Province

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Abstract

Background and Objective: There is a growing interest to significantly explore more opportunities in the coastal environment. For this reason, adequate progressive strategies appear very essential. The purpose of this study was to analyze seawater quality as a database for developing integrated and sustainable marine tourism in Mantehage Island, Indonesia. **Materials and Methods:** the present paper applied descriptive and quantitative methods to sample 20 observation points around the selected location. In addition, the seawater content was directly measured and stored in the laboratory for further analysis. Consequently, certain parameters were evaluated, including salinity, temperature, turbidity, pH, total suspended solids, dissolved oxygen, NO_3-N and PO_4-P. The subsequent data were also compared to the related quality standards of the Minister of Environment, Decree No. 51 of 2004. **Results**: Based on the results, Mantehage water quality demonstrated an excellent condition and is also believed to support the proposed marine tourism development. **Conclusion**: the values of salinity, temperature, turbidity, pH, total suspended solids, dissolved oxygen, NO_3-N, and PO_4-P, the condition of Mantehage water quality obtained a suitable category within the specified standards of the Minister of Environment Decree No. 51 of 2004. Several parameters known to exceed these provisions, including nitrate and phosphate content, indicate the instantaneous value during measurement

Keywords: *Seawater Quality; Mantehage: Outer Island; Marine Tourism*

INTRODUCTION

The quality of sea water greatly determines the feasibility of an underwater tourism area, diving and snorkeling activities require good sea water conditions, this greatly affects the comfort and safety of tourists. Bunaken National Park exhibits high biodiversity, particularly in the Coral Triangle along the Asia Pacific region. The number of tourists visiting has a real connection with extensive coral cover. Increase on the number of tourist arrivals will affect the broad decline in coral cover, and vice versa. Otherwise, decline in coral cover will cause the number of tourists to decrease[1]. The underwater view is famous to foreign tourists around the world and encompasses five minor islands, including, Bunaken, Siladen, Manado Tua, Mantehage, and Nain. These 5 landmasses are divided into 2 administrative regions, including Manado city and North Minahasa regency. Mantehage is a major outermost island in Indonesia with the greatest mangrove area in North Sulawesi, the mangrove flora in Bunaken National Park was floristically rich with at least 27 species, and the broader northern distribution limit of *L. littorea and L. racemosa, C. philippinense, S. ovata* was confirmed [2], The mangroves community structure shows that it is unstable with low values of diversity, and evenness, while the value of domination and species richness is high. The highest density of the mangroves found in station 9 is C. tagal. In general, mangroves species richness is found in the moderate category [3]. Moreover, the nature of the coral reef ecosystem serves as a potential underwater tourist attraction[4,5]. The condition of the coral reefs in Mantehage Island seen from the percentage of coral cover ranging from 20-40%, the condition of hard coral substrates accompanied by good water quality will support this island as a new marine tourism area[5]. This island also has a good seagrass ecosystem with an average cover percentage of 33%, there are four species of seagrass including *Enhalusacoroides, Thalassiahemprichii, Cymodocearotundata, Halophilapinifolia*[8]. As far as can be ascertained, the marine biodiversity of Bunaken National Park is notably high. However, there seems to be a lack of a more comprehensive assessment, especially in Mantehage Island. To date, no comprehensive studies have been done on other marine fauna such as seasnakes, turtles, shorebirds, and marine mammals [6]. Another factor might be the establishment and management histories of BNP since management was principally initiated by the Indonesian national government (topbottom approach) unlike in other well-known cases (e.g. Apo Island Reserve in central Philippines) where protection was initiated and even to this day actively participated by the local communities [7]. Some important water quality parameters include salinity, temperature, turbidity, pH, total suspended solids, dissolved oxygen, NO3-N and PO4-P. Information about these parameters will be very helpful in the development of tourist areas. This research is probably a consideration for policymakers in determining the direction and strategies related to the management of coastal and marine resources, particularly for marine tourism development in Mantegehe. The purpose of this study was to analyze the seawater quality as a database for the prospective development of marine tourism. In addition, the Minister of Environment Decree No. 51 of 2004 poses as a reference for the seawater quality standards.

MATERIALS AND METHODS

Study area: This research was conducted in Mantehage Island, Wori District, North Minahasa regency, North Sulawesi province, within Bunaken National Park from March to May 2021.

Research protocol: Descriptive and quantitative methods with purposive sampling were employed in determining the observational base. Each station possesses coordinate points for easy monitoring and is evenly distributed.

Parameters measurement: the measured seawater parameters were salinity, temperature, turbidity, pH, total suspended solids, dissolved oxygen, NO_3-N and PO_4-P. However, the sampling technique and data analysis adopted the methods by[9] and[10].

Instruments used: The instruments used in this study is horibaU-50 series multi-parameter water quality checker enables to measure and indicate the monitoring result simultaneously up to 11 parameters with one unit. Considering user friendly field monitoring on site, such as rive, ground water, drainage water, etc. bring together feature of function and performance, which makes simple operation for everybody. Multiple sensors allow for the measurement of 11 parameters simultaneously (pH, pH(mv), ORP, DO, COND, Salinity, TDS, Seawater Specific Gravity, Temperature, Turbidity, Water Depth).For NO3-N and PO4-P analysis, seawater samples were put into glass bottles, then brought to the laboratory for further analysis. Subsequently, the results were compared to the Minister of Environment Decree No. 51 of 2004 as a reference for seawater quality standards.

RESULTS AND DISCUSSION

Salinity: Salinity is described as the total amount of dissolved salt in seawater. The unit is generally accepted in mg/L, but also occurs in ppt (parts per thousand) or o/oo and practical salinity unit (PSU). Freshwater salinity values are typically <0.5 o/oo, brackish waters 0.5 - 30 o/oo, and seawaters 30-40 o/oo. Meanwhile, the estimate for coastal waters is strongly influenced by freshwater input from rivers. However, salinity potentially instigates osmotic pressure in seawater biota. The salt content in the aquatic cells occur in close proximity to the surrounding seawater salinity. As the salinity changes, osmoregulation mechanism is then required in balancing the salt levels between the cells and the environment. Mantehage Island shows a salinity range of 28 - 31 PSU, with an average of 29.15 PSU. This value varies based on the climate/weather during

measurement. In the dry season, seawater salinity rises above 30 PSU. Rainy weather condition was observed on the day prior to sampling, resulting in a lesser salinity value but showed good category, according to seawater quality standards. This salinity condition is not only good for tourism activities but also for the sustainability of the surrounding aquatic biota.

Temperature

Temperature influences the metabolic activity and reproduction of marine organisms. This factor is used in certain tourist destination to determine the potential and existence of coral reef growth[11]. In marine life development, the optimal average temperature is expected in the range of 23^0-35^0C with tolerance limits between 36-40°C. The seawater temperature of Mantehage Island occurs from 28-31°C with an average value of 29.15 °C. These conditions are convenient as quality standards for tourism development activities and underwater biota sustainability. In addition, the temperatures are identical to the average value at CarocokPainan Beach between 29-31 ºC, and also show related suitability[12]. Furthermore, similar condition was observed in the coastal waters of Labuhan Haji, East Lombok regency, with a range of 30-32 ºC[11]. The results of temperature measurements in MoyoHilir and Lape Districts occurred between 29.20-31.57 ºC[13], in contrast to the temperature of Prialaot waters at 29-31.4 °C, with an average of 29.22° C[14]. However, temperature variations tend to influence the life of coral reefs[15]. Based on the Minister of Environment Decree No. 51 of 2004, the water temperature for marine tourism is expected at natural temperature. An appropriate range for coral reef areas exist in the range of 28-30 ºC and 28-32 ºC for mangrove regions. Discontinue in situ temperature measurement is a natural temperature with a change tolerance <2° C (Minister of Environment Decree No. 51 of 2004). However, the biota in tropical waters naturally reside in the upper limit of the highest temperature. This variations possibly interfere with the physiological processes known to endanger the biota. In the value range> 28 °C, sea surface temperature in the western equator appears very warm[16]. Moreover, the condition is considered natural as Indonesia is a tropical region. Based on the water depth, extensive seawater surface temperatures are observed, in comparison to a certain depth, probably due to the high intensity of sunlight[15].

Turbidity

Lower turbidity increases the light intensity capable of penetrating the water depth[17]. Therefore, the resulting value is expected to exist under normal condition, where water transparency is inversely proportional to the turbidity, believed to significantly influence oxygen content. Turbid water possibly interfere with the respiration process and decreases the oxygen levels[18]. The seawater turbidity condition of Mantehage Island ranges between 2.2-4.7 NTU, with an average value of 3.58 NTU, indicating an appropriate category and in line with the quality standards. Therefore, the site is suitable as a potential tourist attraction. This condition is supported by data on Mantehage Island coral reef cover in the range of 19-30%, with an average live coral cover of 29.10%[5]. Furthermore, turbidity describes an inadequate water transparency, due to colloidal and suspended materials, including mud, organic and inorganic materials as well as aquatic microorganisms[19]. This circumstance varies from the observations in Prialaot waters with an average value of 0.08 NTU[14], in addition to MoyoHilir and Lape Districts ranging from 0-23.3 NTU[13].

pH level

Inconsistencies in the water pH level probably influences biota existence to a certain extent of varying pH[20]. The water pH value depends on carbon dioxide and ion concentrations. Moreover, the parameter plays a significant role in the solubility of particular compounds, although appears minimal in the morning, compared to afternoon period[21]. Subsequently, the pH of Mantehage Island seawater ranges from 7.1-7.9, with an average value of 7.51, indicating an appropriate category for tourism development and aquatic life support. This value is also corresponds to a pH in Labuhan Haji beach between 7.6 - 7.9[11]. Meanwhile, for CarocokPainan beach, the estimate occurred between 7-8[12]. These values varied slightly from Moyo and Lape districts from 7.96 - 8.12[13], as well as in Prialaot waters by 7.64 - 8.36[14]. These variations depend on geographic position and water injection from the environment. In addition, it is also affected by the season as related to local rainfall and climate.

Total Suspended Solid (TSS)

The TSS of Mantehage Island waters ranged from 28.24-36.25 mg/L with an average value of 32.39 mg/L, corresponding to the quality standard for biota survival. However, in-depth study and sampling of other seasons are required for tourism development, particularly underwater ecotourism, considering the present research was only conducted in one season without repetition. This high TSS value is due to the greatest mangrove forest in Bunaken National Park, and therefore sedimentation in certain segments is inevitable. This varies from the TSS of Prialaot waters at the range of 14 - 31 mg/L, with an average of 21.83 mg/L. Also, the value is generally above the standards allowed for marine tourism (20 mg/L) and marine life (coral and seagrass by 20 mg/L, mangroves by 80 mg/L)[14]. Similarly, the TSS of Labuhan Haji beach also demonstrated a fairly higher content, ranging from 14 - 31 mg/L, with an average of 21.83 mg/L. This value is also above the quality standard allowed for marine tourism (20 mg/L) and marine life (coral and seagrass at 20 mg/L, and mangroves at 80 mg/L)[11].

Dissolved Oxygen (DO)

The dissolved oxygen source in water originates from the diffusion of oxygen from air, water currents or flow through rainwater, as well as photosynthetic activity by aquatic plants and phytoplankton. Generally, aquatic creatures, e.g fish, shrimp, shellfish, and other animals, including microorganisms, e.g bacteria, require oxygen. Dissolved oxygen (DO) regulates the metabolism of organisms to grow and reproduce. Fish need water with an oxygen content of at least 5 mg/L. The DO values in Mantehage waters ranged from 3.24-6.35 mg/L, with an average of 5.43 mg/L. This indicates a suitable oxygen content capable of supporting marine biota. Moreover, seawater quality standards for tourism and healthy ecological activities require DO values above 5mg/L. The condition supports the seagrass survival, covering 33% of the island[8], and also matches the results of dissolved oxygen (DO) measurements performed at Labuhan Haji beach, where the total stations obtained a yield range of 6 mg/L. Also, the value shows an excellent water condition, and relatively suffices the seawater quality standards[11]. Furthermore, dissolved oxygen describes the relative concentration of the element in water within the range of 4.28-10 mg/L[22]. In addition, the average dissolved oxygen in PantaiCarocokPainan occurs between 5.75-

9.1 mg/L, and is suitable for marine tourism activities[12]. Conversely, the DO for the entire stations in the Saleh Bay waters ranges from 4.78-6.01 mg/L[14]. The measured DO value of PrialaotSabang ranged from 4.4-4.69 mg/L, with an average of 4.53 mg/L. However, at sea level, DO values are influenced by the diffusion of oxygen from air and the photosynthetic rate by marine plants[23].

Salinity

A particular salinity level is required for coral reefs and seagrass survival towards attracting marine tourism objects, including snorkeling and diving. The salinity range of Mantehage Island waters occurs between 29.45-32.65 ‰, with an average value of 31.05 ‰. This estimation indicates a suitable category within the applicable quality standards. Salinity plays an essential role in supporting marine biota and the water level varies based on geography and time, where the increase in the parameter is caused by evaporation and the result of freezing sea ice, while the decrease is instigated by precipitation and freshwater input from rivers. This outcome slightly varies from the measurement results at Labuhan Haji beach, showing a salinity range of 32-35 ‰[11]. Subsequently, the value for PataiCarocokPainan waters also obtained an average range of 30-31 ‰[12] Meanwhile, Saleh Bay water occurs between 27.17-30.67 ‰ [13], and 21.6-32.3 ‰ for Prialaot, with a general average of 31.27 ‰[14]. However, the salinity value to promote coral reef life is expected to range from 30-36 ‰[11]. This difference is influenced by geographical position and water type. Furthermore, stable salinity in the archipelago tends to be achieved, due to inadequate water inflow from the mainland. In addition, the value is also greatly impacted by evaporation and precipitation rates.

Nitrate

The nitrate content in the Mantehage waters ranges from 0.004-0.068 mg/L at an average of 0.034 mg/L. This value exceeded the quality standard of the Minister of Environment and Forestry Decree No. 51 of 2004, estimated at 0.008 mg/L. In addition, the extreme result is influenced by the mangrove ecosystem located on the coastal part of the island, where sedimentation is very extensive during the rainy season. Additional indicator is also due to poor mangrove management, leading to free waste from anthropogenic activities entering the aquatic environment. The high concentration of nitrate is probably due to input from land and surrounding factors in the form of liquid waste, both due to agricultural operations. Moreover, the primary

ingredient of fertilizers is nitrogen, known to utilize a bio-physicochemical process to become a compound. In marine waters, six types of nitrogen are formed, termed N_2, NO_3, NO_2, NH_3, NH_4, organic N and particulate N. Meanwhile, in aerobic atmosphere, the nitrogen species generated is the NO_3, as one of the constituents consumed by marine biota, including phytoplankton for growth of 3.9- 15.5 mg/L[13]. This outcome corresponds to the analysis results of the NO_3 at Labuhan Haji beach, with similar content of 0.036 mg/L. Also, the nitrate (NO3) at Labuhan Haji appears relatively high due to community activities on the coast/land, where unwanted materials are directly and inappropriately disposed into the sea. In addition, the existence of river water flowing into the beach also serves as a transportation medium for agricultural waste and other human activities related to the sea [11].

Phosphate

The phosphate content in Mantehage waters ranges from 0.008-0.019 mg/L at an average of 0.015 mg/L. This value is under the specified quality standard for marine tourism at 0.015 mg/L, based on the Minister of Environment Decree No. 51 of 2004. However, the estimate varied from the measurement results in MoyoHilir and Lape sub-districts, between 0.03-0.3 mg/L. Extensive land activities is believed to trigger the phosphate content beyond the quality standard, including livestock, agricultural operations, and the landfill existence in the coastal areas. Moreover, organic waste disposal, e.g detergents, fertilizers, and degradable materials tend to generate phosphate. In marine waters, the greatest phosphate compound is ortho-phosphate as the substance undergoes hydrolysis with a percentage fraction depending on the water pH and temperature[13].

Table 1. Seawater Quality Parameters in Mantehage Island.

Station	Coordinate		Temperature	Turbidity	TSS	pH	Salinity	DO	NO3-N	PO4-P	Parameter
	Latitude	Longitude	28-32	< 5	80	7-8.5[(d)]	<34	>5	0.008	0.015	Biota quality standards
			alami	< 5	20	7-8.5[(d)]	alami[3](e)	>5	0.008	0.015	Tourism quality standards
			C	NTU	mg/L	pH	PSU	mg/L	mg/L	mg/L	Unit quality standards
1	1°42'49.04"N	124°43'44.57"E	29	3.21	31.20	7.2	30.21	5.23	0.005	0.010	Decree of the Minister of Environment of the Republic of Indonesia No 51 of 2004
2	1°42'27.10"N	124°44'10.46"E	30	4.25	29.25	7.6	31.26	5.47	0.025	0.011	
3	1°42'5.66"N	124°44'28.58"E	28	3.2	33.65	7.4	31.25	5.65	0.045	0.016	
4	1°41'49.04"N	124°44'54.55"E	29	2.2	35.25	7.8	30.45	5.14	0.006	0.018	
5	1°41'39.27"N	124°45'22.47"E	30	3.2	30.56	7.5	29.45	5.98	0.068	0.014	
6	1°41'29.02"N	124°45'49.90"E	28	4.7	32.00	7.4	30.87	6.12	0.065	0.013	
7	1°41'37.80"N	124°46'31.55"E	28	3.6	33.63	7.6	32.14	3.24	0.058	0.015	
8	1°41'59.04"N	124°47'4.83"E	28	2.8	32.63	7.9	30.45	6.35	0.009	0.019	
9	1°42'29.46"N	124°47'1.90"E	30	4	34.24	7.1	31.56	5.21	0.004	0.018	
10	1°43'9.12"N	124°46'41.67"E	30	4.1	32.13	7.4	30.25	5.98	0.008	0.017	
11	1°43'35.87"N	124°46'26.20"E	30	3.2	33.26	7.5	31.25	5.87	0.025	0.009	
12	1°44'29.95"N	124°46'15.18"E	29	4.5	31.00	7.6	30.87	5.46	0.054	0.008	
13	1°44'58.36"N	124°45'57.12"E	30	2.5	31.27	7.1	31.63	5.21	0.066	0.016	
14	1°45'19.63"N	124°45'38.18"E	31	3.8	33.36	7.5	32.65	5.69	0.042	0.014	
15	1°45'51.74"N	124°45'15.50"E	29	4.7	36.25	7.8	32.4	5.19	0.061	0.018	
16	1°46'14.93"N	124°44'9.69"E	28	3.5	35.21	7.5	31.25	5.38	0.019	0.016	
17	1°45'24.98"N	124°43'48.02"E	30	3.4	28.24	7.6	30.65	5.67	0.048	0.014	
18	1°44'51.67"N	124°43'41.78"E	28	2.8	29.25	7.6	31.45	5.43	0.065	0.013	
19	1°44'18.76"N	124°43'32.41"E	29	3.6	32.25	7.6	30.14	5.28	0.008	0.017	
20	1°43'37.56"N	124°43'34.43"E	29	4.5	33.25	7.5	30.86	5.17	0.007	0.014	
Average			29.15	3.58	32.39	7.51	31.052	5.43	0.034	0.015	
Minimum			28	2.2	28.24	7.1	29.45	3.24	0.004	0.008	
Maximum			31	4.7	36.25	7.9	32.65	6.35	0.068	0.019	

CONCLUSION

Based on the values of salinity, temperature, turbidity, pH, total suspended solids, dissolved oxygen, NO_3-N, and PO_4-P, the condition of Mantehage water quality obtained a suitable category within the specified standards of the Minister of Environment Decree No. 51 of 2004[24]. Several parameters known to exceed these provisions, including nitrate and phosphate content, indicate the instantaneous value during measurement. Therefore, an in-depth study, sufficient interval and sampling location to represent the spatial and temporal conditions of the entire island are greatly required. This outermost island generally appears suitable as a marine tourism attraction, particularly snorkeling and diving. Furthermore, the beauty of coral reefs is believed to be a major tourist object with the need for further encouragement.

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Significance statement

"This study discovered the condition of the sea water quality of Mantehage Island which can be developed as an underwater tourism location, the good status of coral reefs supported by underwater beauty makes Mantehage Island worthy of development, that can be beneficial for for the government, researchers, and the people of Mantehage Island in developing tourism.This study will help the researchers to uncover the critical areas of of the outermost small island of Indonesia that many researchers were not able to explore. Thus a new theory on the condition of sea water quality for the development of marine tourism may be arrived at"

REFERENCES

1. Tangian, D., Djokosetiyanto, D., Kholil, K., & Munandar, A. (2015). Model of Ecotourism Management in Small Islands of Bunaken National Park, North Sulawesi. *Journal of Indonesian Tourism and Development Studies*, *3*(2), 75-84. https://jitode.ub.ac.id/index.php/jitode/article/view/156
2. Djamaluddin, R. (2018). The mangrove flora and their physical habitat characteristics in Bunaken National Park, North Sulawesi, Indonesia. *Biodiversitas Journal of Biological Diversity*, *19*(4), 1303-1312. https://www.smujo.id/biodiv/article/view/2787
3. Opa E. T., Kusen J. D., Kepel R. C., Jusuf A., Lumingas L. J. L., 2019 Community structure of mangrove in Mantehage Island and Paniki Island, North Sulawesi, Indonesia. AACL Bioflux 12(4):1388-1403. http://www.bioflux.com.ro/docs/2019.1388-1403.pdf
4. Kase A., Manembu I., Schaduw J.N.W. 2019. [Condition of Mantehage Island Coral Reef, North Minahasa Regency, North Sulawesi]. Journal of coastal and tropical seas. 7 (3) : 208-212. Https://Doi.Org/10.35800/Jplt.7.3.2019.24466 https://ejournal.unsrat.ac.id/index.php/jplt/article/view/24466/24143
5. Schaduw J.N.W., Kondoy K.I.F., Manoppo V.E.N., Luasunaung A., Mudeng J., Pelle W.E., Ngangi E.L.A., Manembu I.S., Wantasen N.S., Sumilat D.A., Rumampuk N.D.C., Tilaar S.O., Manengkey H.W.A., Lintang R., Walalangi J.Y., Tampanguma B., Pungus F., Lahabu Y., Sagai B., Wantah E., Wantania L.L., Djabar B., Oli A.P., Caroles E.A., Bachmid F., Sasauw J., Kase A., Anthoni A., Uada A.D., Ladjandu R., Coloay C., Kojongian S., Mamangkey N.N.T. 2020. Data On Percentage Coral Reef Cover In Small Islands Bunaken National Park. Data in Brief, 31, 105713. https://doi.org/10.1016/j.dib.2020.105713
6. Wagey B. T., Boneka F. B., Mantiri R., 2020 Status of marine biodiversity and community perception on marine conservation in Mantehage Island, Bunaken National Park, North Sulawesi, Indonesia. AACL Bioflux 13(6):3830- 3839. http://www.bioflux.com.ro/docs/2020.3830-3839.pdf
7. Kalalo F. P., 2017 Law enforcement and conservation at Bunaken National Park, North Sulawesi, Indonesia as perceived by the local coastal communities. AACL Bioflux 10(6):1413-1420. http://www.bioflux.com.ro/docs/2017.1413-1420.pdf
8. Schaduw J. N.W. and Kondoy K. F. I. 2020. Seagrass percent cover in small islands of Bunaken National Park, North Sulawesi Province, Indonesia. AACL Bioflux 13(2):951-957. http://www.bioflux.com.ro/docs/2020.951-957.pdf
9. Schaduw J. N.W. 2018. [Distribution and Water Quality Characteristics of the Small Island Mangrove Ecosystem of Bunaken National Park]. Indonesian Geography Magazine. 32 (1) 40-49. https://jurnal.ugm.ac.id/mgi/article/view/32204 https://doi.org/10.22146/mgi.32204

10. Kurniadi B., Sigid H., Enan M., Adiwilaga. 2015. [The waters Quality of the Buaya River in Bunyu Island, North Kalimantan in Tidal Conditions]. Indonesian Journal of Agricultural Sciences. 20 (1): 53-58. https://journal.ipb.ac.id/index.php/JIPI/article/view/9289/7287 https://doi.org/10.35800/jasm.1.1.2013.1972
11. Haerudin and Putra A.M. 2019. Analysis of Seawater Quality Standards for the Development of Marine Tourism in Labuhan Haji Beach, East Lombok Regency. *Journal of Geodics 3(1) : 13 – 18* https://e-journal.hamzanwadi.ac.id/index.php/gdk/article/view/1473
12. Indra N., Sari S., Rahayu G, Oktaviandra R., Handoko A., Putri V.S., Hanapi N.I. 2019. Environmental Quality and Suitability of Coastal Tourism in CarocokPainan Area, Pesisir Selatan Regency. Journal of Capita Selecta Geography 2 (5): 43- 51 http://ksgeo.ppj.unp.ac.id/index.php/ksgeo/article/view/251 https://doi.org/10.24036/ksgeo.v2i5.251
13. Saraswati N.G.R.A., Yulius., Rustam A., Hadiwijaya L., Salim., Heriati A., Mustikasari E. 2017. [Study of Water Quality for Coastal Marine Tourism, MoyoHilirSubdistrict and LapeSubdistrict, Sumbawa Regency]. Journal of Segara 13 (1) : 37-47. http://ejournal-balitbang.kkp.go.id/index.php/segara/article/view/6421 http://dx.doi.org/10.15578/segara.v13i1.6421
14. Tanto T.A., Naelul N.H.R., Ilham. 2018. [Quality of Seawater to Support Marine Tourism and Marine Life. Case Study: Around the Sinking Ship of Sophie Rickmers, PrialaotSabang Waters]. Marine Journal, 11 (2) : 173-183. https://journal.trunojoyo.ac.id/jurnalkelautan/article/view/4276 https://doi.org/10.21107/jk.v11i2.4276
15. Tambunan J.M., Anggoro S., Purnaweni H. 2013. [Study on Environmental Quality and Suitability of TanjungPesona Beach Tourism, Bangka Regency]. Proceedings of the National Seminar on Natural Resources and Environmental Management. pg 356-362.
16. Tomczak M. and Godfrey J. 2001. Regional Oceanography: An Introduction. Published Online.
17. Tanto T. A. and Kusumah G. 2016. [Seawater Quality Standards in Different Seasons]. Maspari Journal, 8 (2) : 135–146. [in Indonesian] https://ejournal.unsri.ac.id/index.php/maspari/article/view/3490 https://doi.org/10.36706/maspari.v8i2.3490
18. Mutmainah H. 2016.[Environmental Suitability Study for Tourism Development at Ganting Beach, Simeulue Island, Aceh Province]. Journal of DepikUnsyiah, 5 (1) : 19–30. http://jurnal.unsyiah.ac.id/depik/article/view/3844 https://doi.org/10.13170/depik.5.1.3844
19. Wilson P.C. 2010. Water Quality Notes: Water Clarity (Turbidity, Suspended Solids, and Color). Department of Soil and Water Science. University of Florida.
20. Simanjuntak M. 2012. Seawater Quality Judging from Nutrient Aspects, Dissolved Oxygen and Ph in Banggai Waters, Central Sulawesi. Journal of Tropical Marine Science and Technology. 4(2):290-303. https://journal.ipb.ac.id/index.php/jurnalikt/article/view/7791

https://doi.org/10.29244/jitkt.v4i2.7791
21. Arifin T., Bengen D.G., Pariwono J.I. 2002. Evaluation on the Suitability of the Palu Bay Coastal Zone for Marine Tourism Development. Coastal and Ocean Journal. 4 (2) : 25-35 https://repository.ipb.ac.id/jspui/bitstream/123456789/26592/1/Taslim%20Arifin_Herni%20%2811%20hal%29.pdf
22. Putra A., Tanto T.A., Pranowo W.S., Ilham., Damanhuri H., Suasti Y., Triyatno T. 2018. Suitability Of Coastal Ecotourism In Padang City-West Sumatera: Case Study Of Beach Recreation And Mangrove. Journal of Segara, 14 (2) : 87-94. http://ejournal-balitbang.kkp.go.id/index.php/segara/article/view/6642 http://dx.doi.org/10.15578/segara.v14i2.6642
23. Wisha U.J., Tanto T.A., Ilham. 2016. Physical and Chemical Conditions of Bayur Bay Waters on the East and West Season.Journal of Marine Science UNDIP. 22 (1) : 15–24. https://ejournal.undip.ac.id/index.php/ijms/article/view/10505 doi:10.14710/ik.ijms.22.1.15-24 https://ejournal.unsrat.ac.id/index.php/lppmsains/article/view/10692
24. Minister of Environment Decree No. 51 of 2004 poses as a reference for the seawater quality standards. https://environmentalchemistry.files.wordpress.com/2013/08/kepmenlh-no-51-tahun-2004.pdf

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The Analysis of Seawater Quality in Small Outermost Mantehage Island for Integrated and Sustainable Marine Tourism Development in North Sulawesi Province

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Abstract

Background and Objective: There is a growing interest to significantly explore more opportunities in the coastal environment. For this reason, adequate progressive strategies appear very essential. The purpose of this study was to analyze seawater quality as a database for developing integrated and sustainable marine tourism in Mantehage Island, Indonesia. **Materials and Methods:** the present paper applied descriptive and quantitative methods to sample 20 observation points around the selected location. In addition, the seawater content was directly measured and stored in the laboratory for further analysis. Consequently, certain parameters were evaluated, including salinity, temperature, turbidity, pH, total suspended solids, dissolved oxygen, NO_3-N and PO_4-P. The subsequent data were also compared to the related quality standards of the Minister of Environment, Decree No. 51 of 2004. **Results**: Based on the results, Mantehage water quality demonstrated an excellent condition and is also believed to support the proposed marine tourism development. **Conclusion**: the values of salinity, temperature, turbidity, pH, total suspended solids, dissolved oxygen, NO_3-N, and PO_4-P, the condition of Mantehage water quality obtained a suitable category within the specified standards of the Minister of Environment Decree No. 51 of 2004. Several parameters known to exceed these provisions, including nitrate and phosphate content, indicate the instantaneous value during measurement

Keywords: *Seawater Quality; Mantehage: Outer Island; Marine Tourism*

INTRODUCTION

The quality of sea water greatly determines the feasibility of an underwater tourism area, diving and snorkeling activities require good sea water conditions, this greatly affects the comfort and safety of tourists. Bunaken National Park exhibits high biodiversity, particularly in the Coral Triangle along the Asia Pacific region. The number of tourists visiting has a real connection with extensive coral cover. Increase on the number of tourist arrivals will affect the broad decline in coral cover, and vice versa. Otherwise, decline in coral cover will cause the number of tourists to decrease[1]. The underwater view is famous to foreign tourists around the world and encompasses five minor islands, including, Bunaken, Siladen, Manado Tua, Mantehage, and Nain. These 5 landmasses are divided into 2 administrative regions, including Manado city and North Minahasa regency. Mantehage is a major outermost island in Indonesia with the greatest mangrove area in North Sulawesi, the mangrove flora in Bunaken National Park was floristically rich with at least 27 species, and the broader northern distribution limit of *L. littorea and L. racemosa, C. philippinense, S. ovata* was confirmed [2], The mangroves community structure shows that it is unstable with low values of diversity, and evenness, while the value of domination and species richness is high. The highest density of the mangroves found in station 9 is C. tagal. In general, mangroves species richness is found in the moderate category [3]. Moreover, the nature of the coral reef ecosystem serves as a potential underwater tourist attraction[4,5]. The condition of the coral reefs in Mantehage Island seen from the percentage of coral cover ranging from 20-40%, the condition of hard coral substrates accompanied by good water quality will support this island as a new marine tourism area[5]. This island also has a good seagrass ecosystem with an average cover percentage of 33%, there are four species of seagrass including *Enhalusacoroides, Thalassiahemprichii, Cymodocearotundata, Halophilapinifolia*[8]. As far as can be ascertained, the marine biodiversity of Bunaken National Park is notably high. However, there seems to be a lack of a more comprehensive assessment, especially in Mantehage Island. To date, no comprehensive studies have been done on other marine fauna such as seasnakes, turtles, shorebirds, and marine mammals [6]. Another factor might be the establishment and management histories of BNP since management was principally initiated by the Indonesian national government (topbottom approach) unlike in other well-known cases (e.g. Apo Island Reserve in central Philippines) where protection was initiated and even to this day actively participated by the local communities [7]. Some important water quality parameters include salinity, temperature, turbidity, pH, total suspended solids, dissolved oxygen, NO3-N and PO4-P. Information about these parameters will be very helpful in the development of tourist areas. This research is probably a consideration for policymakers in determining the direction and strategies related to the management of coastal and marine resources, particularly for marine tourism development in Mantegehe. The purpose of this study was to analyze the seawater quality as a database for the prospective development of marine tourism. In addition, the Minister of Environment Decree No. 51 of 2004 poses as a reference for the seawater quality standards.

MATERIALS AND METHODS

Study area: This research was conducted in Mantehage Island, Wori District, North Minahasa regency, North Sulawesi province, within Bunaken National Park from March to May 2021.

Research protocol: Descriptive and quantitative methods with purposive sampling were employed in determining the observational base. Each station possesses coordinate points for easy monitoring and is evenly distributed.

Parameters measurement: the measured seawater parameters were salinity, temperature, turbidity, pH, total suspended solids, dissolved oxygen, NO_3-N and PO_4-P. However, the sampling technique and data analysis adopted the methods by[9] and[10].

Instruments used: The instruments used in this study is horibaU-50 series multi-parameter water quality checker enables to measure and indicate the monitoring result simultaneously up to 11 parameters with one unit. Considering user friendly field monitoring on site, such as rive, ground water, drainage water, etc. bring together feature of function and performance, which makes simple operation for everybody. Multiple sensors allow for the measurement of 11 parameters simultaneously (pH, pH(mv), ORP, DO, COND, Salinity, TDS, Seawater Specific Gravity, Temperature, Turbidity, Water Depth).For NO3-N and PO4-P analysis, seawater samples were put into glass bottles, then brought to the laboratory for further analysis. Subsequently, the results were compared to the Minister of Environment Decree No. 51 of 2004 as a reference for seawater quality standards.

RESULTS AND DISCUSSION

Salinity: Salinity is described as the total amount of dissolved salt in seawater. The unit is generally accepted in mg/L, but also occurs in ppt (parts per thousand) or o/oo and practical salinity unit (PSU). Freshwater salinity values are typically <0.5 o/oo, brackish waters 0.5 - 30 o/oo, and seawaters 30-40 o/oo. Meanwhile, the estimate for coastal waters is strongly influenced by freshwater input from rivers. However, salinity potentially instigates osmotic pressure in seawater biota. The salt content in the aquatic cells occur in close proximity to the surrounding seawater salinity. As the salinity changes, osmoregulation mechanism is then required in balancing the salt levels between the cells and the environment. Mantehage Island shows a salinity range of 28 - 31 PSU, with an average of 29.15 PSU. This value varies based on the

climate/weather during measurement. In the dry season, seawater salinity rises above 30 PSU. Rainy weather condition was observed on the day prior to sampling, resulting in a lesser salinity value but showed good category, according to seawater quality standards. This salinity condition is not only good for tourism activities but also for the sustainability of the surrounding aquatic biota.

Temperature

Temperature influences the metabolic activity and reproduction of marine organisms. This factor is used in certain tourist destination to determine the potential and existence of coral reef growth[11]. In marine life development, the optimal average temperature is expected in the range of 23^0-35^0C with tolerance limits between 36-40°C. The seawater temperature of Mantehage Island occurs from 28-31°C with an average value of 29.15 °C. These conditions are convenient as quality standards for tourism development activities and underwater biota sustainability. In addition, the temperatures are identical to the average value at CarocokPainan Beach between 29-31 ºC, and also show related suitability[12]. Furthermore, similar condition was observed in the coastal waters of Labuhan Haji, East Lombok regency, with a range of 30-32 ºC[11]. The results of temperature measurements in MoyoHilir and Lape Districts occurred between 29.20-31.57 ºC[13], in contrast to the temperature of Prialaot waters at 29-31.4 °C, with an average of 29.22° C[14]. However, temperature variations tend to influence the life of coral reefs[15]. Based on the Minister of Environment Decree No. 51 of 2004, the water temperature for marine tourism is expected at natural temperature. An appropriate range for coral reef areas exist in the range of 28-30 ºC and 28-32 ºC for mangrove regions. Discontinue in situ temperature measurement is a natural temperature with a change tolerance <2° C (Minister of Environment Decree No. 51 of 2004). However, the biota in tropical waters naturally reside in the upper limit of the highest temperature. This variations possibly interfere with the physiological processes known to endanger the biota. In the value range> 28 °C, sea surface temperature in the western equator appears very warm[16]. Moreover, the condition is considered natural as Indonesia is a tropical region. Based on the water depth, extensive seawater surface temperatures are observed, in comparison to a certain depth, probably due to the high intensity of sunlight[15].

Turbidity

Lower turbidity increases the light intensity capable of penetrating the water depth[17]. Therefore, the resulting value is expected to exist under normal condition, where water transparency is inversely proportional to the turbidity, believed to significantly influence oxygen content. Turbid water possibly interfere with the respiration process and decreases the oxygen levels[18]. The seawater turbidity condition of Mantehage Island ranges between 2.2-4.7 NTU, with an average value of 3.58 NTU, indicating an appropriate category and in line with the quality standards. Therefore, the site is suitable as a potential tourist attraction. This condition is supported by data on Mantehage Island coral reef cover in the range of 19-30%, with an average live coral cover of 29.10%[5]. Furthermore, turbidity describes an inadequate water transparency, due to colloidal and suspended materials, including mud, organic and inorganic materials as well as aquatic microorganisms[19]. This circumstance varies from the observations in Prialaot waters with an average value of 0.08 NTU[14], in addition to MoyoHilir and Lape Districts ranging from 0-23.3 NTU[13].

pH level

Inconsistencies in the water pH level probably influences biota existence to a certain extent of varying pH[20]. The water pH value depends on carbon dioxide and ion concentrations. Moreover, the parameter plays a significant role in the solubility of particular compounds, although appears minimal in the morning, compared to afternoon period[21]. Subsequently, the pH of Mantehage Island seawater ranges from 7.1-7.9, with an average value of 7.51, indicating an appropriate category for tourism development and aquatic life support. This value is also corresponds to a pH in Labuhan Haji beach between 7.6 - 7.9[11]. Meanwhile, for CarocokPainan beach, the estimate occurred between 7-8[12]. These values varied slightly from Moyo and Lape districts from 7.96 - 8.12[13], as well as in Prialaot waters by 7.64 - 8.36[14]. These variations depend on geographic position and water injection from the environment. In addition, it is also affected by the season as related to local rainfall and climate.

Total Suspended Solid (TSS)

The TSS of Mantehage Island waters ranged from 28.24-36.25 mg/L with an average value of 32.39 mg/L, corresponding to the quality standard for biota survival. However, in-depth study and sampling of other seasons are required for tourism development, particularly underwater ecotourism, considering the present research was only conducted in one season without repetition. This high TSS value is due to the greatest mangrove forest in Bunaken National Park, and therefore sedimentation in certain segments is inevitable. This varies from the TSS of Prialaot waters at the range of 14 - 31 mg/L, with an average of 21.83 mg/L. Also, the value is generally above the standards allowed for marine tourism (20 mg/L) and marine life (coral and seagrass by 20 mg/L, mangroves by 80 mg/L)[14]. Similarly, the TSS of Labuhan Haji beach also demonstrated a fairly higher content, ranging from 14 - 31 mg/L, with an average of 21.83 mg/L. This value is also above the quality standard allowed for marine tourism (20 mg/L) and marine life (coral and seagrass at 20 mg/L, and mangroves at 80 mg/L)[11].

Dissolved Oxygen (DO)

The dissolved oxygen source in water originates from the diffusion of oxygen from air, water currents or flow through rainwater, as well as photosynthetic activity by aquatic plants and phytoplankton. Generally, aquatic creatures, e.g fish, shrimp, shellfish, and other animals, including microorganisms, e.g bacteria, require oxygen. Dissolved oxygen (DO) regulates the metabolism of organisms to grow and reproduce. Fish need water with an oxygen content of at least 5 mg/L. The DO values in Mantehage waters ranged from 3.24-6.35 mg/L, with an average of 5.43 mg/L. This indicates a suitable oxygen content capable of supporting marine biota. Moreover, seawater quality standards for tourism and healthy ecological activities require DO values above 5mg/L. The condition supports the seagrass survival, covering 33% of the island[8], and also matches the results of dissolved oxygen (DO) measurements performed at Labuhan Haji beach, where the total stations obtained a yield range of 6 mg/L. Also, the value shows an excellent water condition, and relatively suffices the seawater quality standards[11]. Furthermore, dissolved oxygen describes the relative concentration of the element in water within the range of 4.28-10 mg/L[22]. In addition, the average dissolved oxygen in PantaiCarocokPainan occurs

between 5.75-9.1 mg/L, and is suitable for marine tourism activities[12]. Conversely, the DO for the entire stations in the Saleh Bay waters ranges from 4.78-6.01 mg/L[14]. The measured DO value of PrialaotSabang ranged from 4.4-4.69 mg/L, with an average of 4.53 mg/L. However, at sea level, DO values are influenced by the diffusion of oxygen from air and the photosynthetic rate by marine plants[23].

Salinity

A particular salinity level is required for coral reefs and seagrass survival towards attracting marine tourism objects, including snorkeling and diving. The salinity range of Mantehage Island waters occurs between 29.45-32.65 ‰, with an average value of 31.05 ‰. This estimation indicates a suitable category within the applicable quality standards. Salinity plays an essential role in supporting marine biota and the water level varies based on geography and time, where the increase in the parameter is caused by evaporation and the result of freezing sea ice, while the decrease is instigated by precipitation and freshwater input from rivers. This outcome slightly varies from the measurement results at Labuhan Haji beach, showing a salinity range of 32-35 ‰[11]. Subsequently, the value for PataiCarocokPainan waters also obtained an average range of 30-31 ‰[12] Meanwhile, Saleh Bay water occurs between 27.17-30.67 ‰ [13], and 21.6-32.3 ‰ for Prialaot, with a general average of 31.27 ‰[14]. However, the salinity value to promote coral reef life is expected to range from 30-36 ‰[11]. This difference is influenced by geographical position and water type. Furthermore, stable salinity in the archipelago tends to be achieved, due to inadequate water inflow from the mainland. In addition, the value is also greatly impacted by evaporation and precipitation rates.

Nitrate

The nitrate content in the Mantehage waters ranges from 0.004-0.068 mg/L at an average of 0.034 mg/L. This value exceeded the quality standard of the Minister of Environment and Forestry Decree No. 51 of 2004, estimated at 0.008 mg/L. In addition, the extreme result is influenced by the mangrove ecosystem located on the coastal part of the island, where sedimentation is very extensive during the rainy season. Additional indicator is also due to poor mangrove management, leading to free waste from anthropogenic activities entering the aquatic environment. The high concentration of nitrate is probably due to input from land and

surrounding factors in the form of liquid waste, both due to agricultural operations. Moreover, the primary ingredient of fertilizers is nitrogen, known to utilize a bio-physicochemical process to become a compound. In marine waters, six types of nitrogen are formed, termed N_2, NO_3, NO_2, NH_3, NH_4, organic N and particulate N. Meanwhile, in aerobic atmosphere, the nitrogen species generated is the NO_3, as one of the constituents consumed by marine biota, including phytoplankton for growth of 3.9- 15.5 mg/L[13]. This outcome corresponds to the analysis results of the NO_3 at Labuhan Haji beach, with similar content of 0.036 mg/L. Also, the nitrate (NO3) at Labuhan Haji appears relatively high due to community activities on the coast/land, where unwanted materials are directly and inappropriately disposed into the sea. In addition, the existence of river water flowing into the beach also serves as a transportation medium for agricultural waste and other human activities related to the sea [11].

Phosphate

The phosphate content in Mantehage waters ranges from 0.008-0.019 mg/L at an average of 0.015 mg/L. This value is under the specified quality standard for marine tourism at 0.015 mg/L, based on the Minister of Environment Decree No. 51 of 2004. However, the estimate varied from the measurement results in MoyoHilir and Lape sub-districts, between 0.03-0.3 mg/L. Extensive land activities is believed to trigger the phosphate content beyond the quality standard, including livestock, agricultural operations, and the landfill existence in the coastal areas. Moreover, organic waste disposal, e.g detergents, fertilizers, and degradable materials tend to generate phosphate. In marine waters, the greatest phosphate compound is ortho-phosphate as the substance undergoes hydrolysis with a percentage fraction depending on the water pH and temperature[13].

Table 1. Seawater Quality Parameters in Mantehage Island.

Station	Coordinate		Temperature	Turbidity	TSS	pH	Salinity	DO	NO3-N	PO4-P	Parameter
	Latitude	Longitude	28-32	< 5	80	7-8.5[(d)]	<34	>5	0.008	0.015	Biota quality standards
			alami	< 5	20	7-8.5[(d)]	alami[3](e)	>5	0.008	0.015	Tourism quality standards
			C	NTU	mg/L	pH	PSU	mg/L	mg/L	mg/L	Unit quality standards
1	1°42'49.04"N	124°43'44.57"E	29	3.21	31.20	7.2	30.21	5.23	0.005	0.010	Decree of the Minister of Environment of the Republic of Indonesia No 51 of 2004
2	1°42'27.10"N	124°44'10.46"E	30	4.25	29.25	7.6	31.26	5.47	0.025	0.011	
3	1°42'5.66"N	124°44'28.58"E	28	3.2	33.65	7.4	31.25	5.65	0.045	0.016	
4	1°41'49.04"N	124°44'54.55"E	29	2.2	35.25	7.8	30.45	5.14	0.006	0.018	
5	1°41'39.27"N	124°45'22.47"E	30	3.2	30.56	7.5	29.45	5.98	0.068	0.014	
6	1°41'29.02"N	124°45'49.90"E	28	4.7	32.00	7.4	30.87	6.12	0.065	0.013	
7	1°41'37.80"N	124°46'31.55"E	28	3.6	33.63	7.6	32.14	3.24	0.058	0.015	
8	1°41'59.04"N	124°47'4.83"E	28	2.8	32.63	7.9	30.45	6.35	0.009	0.019	
9	1°42'29.46"N	124°47'1.90"E	30	4	34.24	7.1	31.56	5.21	0.004	0.018	
10	1°43'9.12"N	124°46'41.67"E	30	4.1	32.13	7.4	30.25	5.98	0.008	0.017	
11	1°43'35.87"N	124°46'26.20"E	30	3.2	33.26	7.5	31.25	5.87	0.025	0.009	
12	1°44'29.95"N	124°46'15.18"E	29	4.5	31.00	7.6	30.87	5.46	0.054	0.008	
13	1°44'58.36"N	124°45'57.12"E	30	2.5	31.27	7.1	31.63	5.21	0.066	0.016	
14	1°45'19.63"N	124°45'38.18"E	31	3.8	33.36	7.5	32.65	5.69	0.042	0.014	
15	1°45'51.74"N	124°45'15.50"E	29	4.7	36.25	7.8	32.4	5.19	0.061	0.018	
16	1°46'14.93"N	124°44'9.69"E	28	3.5	35.21	7.5	31.25	5.38	0.019	0.016	
17	1°45'24.98"N	124°43'48.02"E	30	3.4	28.24	7.6	30.65	5.67	0.048	0.014	
18	1°44'51.67"N	124°43'41.78"E	28	2.8	29.25	7.6	31.45	5.43	0.065	0.013	
19	1°44'18.76"N	124°43'32.41"E	29	3.6	32.25	7.6	30.14	5.28	0.008	0.017	
20	1°43'37.56"N	124°43'34.43"E	29	4.5	33.25	7.5	30.86	5.17	0.007	0.014	
Average			29.15	3.58	32.39	7.51	31.052	5.43	0.034	0.015	
Minimum			28	2.2	28.24	7.1	29.45	3.24	0.004	0.008	
Maximum			31	4.7	36.25	7.9	32.65	6.35	0.068	0.019	

CONCLUSION

Based on the values of salinity, temperature, turbidity, pH, total suspended solids, dissolved oxygen, NO_3-N, and PO_4-P, the condition of Mantehage water quality obtained a suitable category within the specified standards of the Minister of Environment Decree No. 51 of 2004[24]. Several parameters known to exceed these provisions, including nitrate and phosphate content, indicate the instantaneous value during measurement. Therefore, an in-depth study, sufficient interval and sampling location to represent the spatial and temporal conditions of the entire island are greatly required. This outermost island generally appears suitable as a marine tourism attraction, particularly snorkeling and diving. Furthermore, the beauty of coral reefs is believed to be a major tourist object with the need for further encouragement.

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Significance statement

“This study discovered the condition of the sea water quality of Mantehage Island which can be developed as an underwater tourism location, the good status of coral reefs supported by underwater beauty makes Mantehage Island worthy of development, that can be beneficial for for the government, researchers, and the people of Mantehage Island in developing tourism.This study will help the researchers to uncover the critical areas of of the outermost small island of Indonesia that many researchers were not able to explore. Thus a new theory on the condition of sea water quality for the development of marine tourism may be arrived at”

REFERENCES

1. Tangian, D., Djokosetiyanto, D., Kholil, K., & Munandar, A. (2015). Model of Ecotourism Management in Small Islands of Bunaken National Park, North Sulawesi. *Journal of Indonesian Tourism and Development Studies*, *3*(2), 75-84. https://jitode.ub.ac.id/index.php/jitode/article/view/156
2. Djamaluddin, R. (2018). The mangrove flora and their physical habitat characteristics in Bunaken National Park, North Sulawesi, Indonesia. *Biodiversitas Journal of Biological Diversity*, *19*(4), 1303-1312. https://www.smujo.id/biodiv/article/view/2787
3. Opa E. T., Kusen J. D., Kepel R. C., Jusuf A., Lumingas L. J. L., 2019 Community structure of mangrove in Mantehage Island and Paniki Island, North Sulawesi, Indonesia. AACL Bioflux 12(4):1388-1403. http://www.bioflux.com.ro/docs/2019.1388-1403.pdf
4. Kase A., Manembu I., Schaduw J.N.W. 2019. [Condition of Mantehage Island Coral Reef, North Minahasa Regency, North Sulawesi]. Journal of coastal and tropical seas. 7 (3) : 208-212. Https://Doi.Org/10.35800/Jplt.7.3.2019.24466 https://ejournal.unsrat.ac.id/index.php/jplt/article/view/24466/24143
5. Schaduw J.N.W., Kondoy K.I.F., Manoppo V.E.N., Luasunaung A., Mudeng J., Pelle W.E., Ngangi E.L.A., Manembu I.S., Wantasen N.S., Sumilat D.A., Rumampuk N.D.C., Tilaar S.O., Manengkey H.W.A., Lintang R., Walalangi J.Y., Tampanguma B., Pungus F., Lahabu Y., Sagai B., Wantah E., Wantania L.L., Djabar B., Oli A.P., Caroles E.A., Bachmid F., Sasauw J., Kase A., Anthoni A., Uada A.D., Ladjandu R., Coloay C., Kojongian S., Mamangkey N.N.T. 2020. Data On Percentage Coral Reef Cover In Small Islands Bunaken National Park. Data in Brief, 31, 105713. https://doi.org/10.1016/j.dib.2020.105713
6. Wagey B. T., Boneka F. B., Mantiri R., 2020 Status of marine biodiversity and community perception on marine conservation in Mantehage Island, Bunaken National Park, North Sulawesi, Indonesia. AACL Bioflux 13(6):3830- 3839. http://www.bioflux.com.ro/docs/2020.3830-3839.pdf
7. Kalalo F. P., 2017 Law enforcement and conservation at Bunaken National Park, North Sulawesi, Indonesia as perceived by the local coastal communities. AACL Bioflux 10(6):1413-1420. http://www.bioflux.com.ro/docs/2017.1413-1420.pdf
8. Schaduw J. N.W. and Kondoy K. F. I. 2020. Seagrass percent cover in small islands of Bunaken National Park, North Sulawesi Province, Indonesia. AACL Bioflux 13(2):951-957. http://www.bioflux.com.ro/docs/2020.951-957.pdf
9. Schaduw J. N.W. 2018. [Distribution and Water Quality Characteristics of the Small Island Mangrove Ecosystem of Bunaken National Park]. Indonesian Geography Magazine. 32 (1) 40-49. https://jurnal.ugm.ac.id/mgi/article/view/32204 https://doi.org/10.22146/mgi.32204

10. Kurniadi B., Sigid H., Enan M., Adiwilaga. 2015. [The waters Quality of the Buaya River in Bunyu Island, North Kalimantan in Tidal Conditions]. Indonesian Journal of Agricultural Sciences. 20 (1): 53-58. https://journal.ipb.ac.id/index.php/JIPI/article/view/9289/7287 https://doi.org/10.35800/jasm.1.1.2013.1972
11. Haerudin and Putra A.M. 2019. Analysis of Seawater Quality Standards for the Development of Marine Tourism in Labuhan Haji Beach, East Lombok Regency. *Journal of Geodics 3(1) : 13 – 18* https://e-journal.hamzanwadi.ac.id/index.php/gdk/article/view/1473
12. Indra N., Sari S., Rahayu G, Oktaviandra R., Handoko A., Putri V.S., Hanapi N.I. 2019. Environmental Quality and Suitability of Coastal Tourism in CarocokPainan Area, Pesisir Selatan Regency. Journal of Capita Selecta Geography 2 (5): 43- 51 http://ksgeo.ppj.unp.ac.id/index.php/ksgeo/article/view/251 https://doi.org/10.24036/ksgeo.v2i5.251
13. Saraswati N.G.R.A., Yulius., Rustam A., Hadiwijaya L., Salim., Heriati A., Mustikasari E. 2017. [Study of Water Quality for Coastal Marine Tourism, MoyoHilirSubdistrict and LapeSubdistrict, Sumbawa Regency]. Journal of Segara 13 (1) : 37-47. http://ejournal-balitbang.kkp.go.id/index.php/segara/article/view/6421 http://dx.doi.org/10.15578/segara.v13i1.6421
14. Tanto T.A., Naelul N.H.R., Ilham. 2018. [Quality of Seawater to Support Marine Tourism and Marine Life. Case Study: Around the Sinking Ship of Sophie Rickmers, PrialaotSabang Waters]. Marine Journal, 11 (2) : 173-183. https://journal.trunojoyo.ac.id/jurnalkelautan/article/view/4276 https://doi.org/10.21107/jk.v11i2.4276
15. Tambunan J.M., Anggoro S., Purnaweni H. 2013. [Study on Environmental Quality and Suitability of TanjungPesona Beach Tourism, Bangka Regency]. Proceedings of the National Seminar on Natural Resources and Environmental Management. pg 356-362.
16. Tomczak M. and Godfrey J. 2001. Regional Oceanography: An Introduction. Published Online.
17. Tanto T. A. and Kusumah G. 2016. [Seawater Quality Standards in Different Seasons]. Maspari Journal, 8 (2) : 135–146. [in Indonesian] https://ejournal.unsri.ac.id/index.php/maspari/article/view/3490 https://doi.org/10.36706/maspari.v8i2.3490
18. Mutmainah H. 2016.[Environmental Suitability Study for Tourism Development at Ganting Beach, Simeulue Island, Aceh Province]. Journal of DepikUnsyiah, 5 (1) : 19–30. http://jurnal.unsyiah.ac.id/depik/article/view/3844 https://doi.org/10.13170/depik.5.1.3844
19. Wilson P.C. 2010. Water Quality Notes: Water Clarity (Turbidity, Suspended Solids, and Color). Department of Soil and Water Science. University of Florida.
20. Simanjuntak M. 2012. Seawater Quality Judging from Nutrient Aspects, Dissolved Oxygen and Ph in Banggai Waters, Central Sulawesi. Journal of Tropical Marine Science and Technology. 4(2):290-303. https://journal.ipb.ac.id/index.php/jurnalikt/article/view/7791

https://doi.org/10.29244/jitkt.v4i2.7791
21. Arifin T., Bengen D.G., Pariwono J.I. 2002. Evaluation on the Suitability of the Palu Bay Coastal Zone for Marine Tourism Development. Coastal and Ocean Journal. 4 (2) : 25-35 https://repository.ipb.ac.id/jspui/bitstream/123456789/26592/1/Taslim%20Arifin_Herni%20%2811%20hal%29.pdf
22. Putra A., Tanto T.A., Pranowo W.S., Ilham., Damanhuri H., Suasti Y., Triyatno T. 2018. Suitability Of Coastal Ecotourism In Padang City-West Sumatera: Case Study Of Beach Recreation And Mangrove. Journal of Segara, 14 (2) : 87-94. http://ejournal-balitbang.kkp.go.id/index.php/segara/article/view/6642 http://dx.doi.org/10.15578/segara.v14i2.6642
23. Wisha U.J., Tanto T.A., Ilham. 2016. Physical and Chemical Conditions of Bayur Bay Waters on the East and West Season.Journal of Marine Science UNDIP. 22 (1) : 15–24. https://ejournal.undip.ac.id/index.php/ijms/article/view/10505 doi:10.14710/ik.ijms.22.1.15-24 https://ejournal.unsrat.ac.id/index.php/lppmsains/article/view/10692
24. Minister of Environment Decree No. 51 of 2004 poses as a reference for the seawater quality standards. https://environmentalchemistry.files.wordpress.com/2013/08/kepmenlh-no-51-tahun-2004.pdf

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Seawater Quality Analysis in Mantehage Island for Integrated and Sustainable Marine Tourism Development

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Abstract

Background and Objective: There is a growing interest to significantly explore more opportunities in the coastal environment. For this reason, adequate progressive strategies appear very essential. The purpose of this study was to analyze seawater quality as a database for developing integrated and sustainable marine tourism in Mantehage Island, Indonesia. **Materials and Methods:** the present paper applied descriptive and quantitative methods to sample 20 observation points around the selected location. In addition, the seawater content was directly measured and stored in the laboratory for further analysis. Consequently, certain parameters were evaluated, including salinity, temperature, turbidity, pH, total suspended solids, dissolved oxygen, NO_3-N and PO_4-P. The subsequent data were also compared to the related quality standards of the Minister of Environment, Decree No. 51 of 2004. **Results**: Based on the results, Mantehage water quality demonstrated an excellent condition and is also believed to support the proposed marine tourism development. **Conclusion**: the values of salinity, temperature, turbidity, pH, total suspended solids, dissolved oxygen, NO_3-N, and PO_4-P, the condition of Mantehage water quality obtained a suitable category within the specified standards of the Minister of Environment Decree No. 51 of 2004. Several parameters known to exceed these provisions, including nitrate and phosphate content, indicate the instantaneous value during measurement

Keywords: *Seawater Quality; Mantehage; Marine Tourism; Development; Small Island*

INTRODUCTION

The quality of seawater greatly determines the feasibility of an underwater tourism area, diving and snorkelling activities require good seawater conditions, this greatly affects the comfort and safety of tourists. Bunaken National Park exhibits high biodiversity, particularly in the Coral Triangle along the Asia Pacific region. The number of tourists visiting has a real connection with extensive coral cover. An increase in the number of tourist arrivals will affect the broad decline in coral cover and vice versa. Otherwise, the decline in coral cover will cause the number of tourists to decrease[1]. The underwater view is famous to foreign tourists around the world and

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encompasses five minor islands, including, Bunaken, Siladen, Manado Tua, Mantehage, and Nain. These 5 landmasses are divided into 2 administrative regions, including Manado city and North Minahasa regency. Mantehage is a major outermost island in Indonesia with the greatest mangrove area in North Sulawesi, the mangrove flora in Bunaken National Park was floristically rich with at least 27 species, and the broader northern distribution limit of *L. littorea and L. racemosa, C. philippinense, S. ovata* was confirmed [2], The mangroves community structure shows that it is unstable with low values of diversity, and evenness, while the value of domination and species richness is high. The highest density of the mangroves found in station 9 is *C. tagal*. In general, mangroves species richness is found in the moderate category [3]. Moreover, the nature of the coral reef ecosystem serves as a potential underwater tourist attraction[4,5]. The condition of the coral reefs in Mantehage Island seen from the percentage of coral cover ranging from 20-40%, the condition of hard coral substrates accompanied by good water quality will support this island as a new marine tourism area[5]. This island also has a good seagrass ecosystem with an average cover percentage of 33%, there are four species of seagrass including *Enhalus acoroides, Thalassia hemprichii, Cymodocea rotundata, Halophila pinifolia*[8]. As far as can be ascertained, the marine biodiversity of Bunaken National Park is notably high. However, there seems to be a lack of a more comprehensive assessment, especially in Mantehage Island. To date, no comprehensive studies have been done on other marine fauna such as sea snakes, turtles, shorebirds, and marine mammals [6]. Another factor might be the establishment and management histories of BNP since management was principally initiated by the Indonesian national government (top-bottom approach) unlike in other well-known cases (e.g. Apo Island Reserve in the central Philippines) where protection was initiated and even to this day actively participated by the local communities [7]. Some important water quality parameters include salinity, temperature, turbidity, pH, total suspended solids, dissolved oxygen, NO3-N and PO4-P. Information about these parameters will be very helpful in the development of tourist areas. This research is probably a consideration for policymakers in determining the direction and strategies related to the management of coastal and marine resources, particularly for marine tourism development in Mantegehe.

The purpose of this study was to analyze the seawater quality as a database for the prospective development of marine tourism. In addition, the Minister of Environment Decree No. 51 of 2004 poses as a reference for the seawater quality standards.

MATERIALS AND METHODS

Study area: This research was conducted in Mantehage Island, Wori District, North Minahasa regency, North Sulawesi province, within Bunaken National Park from March-May 2021.

Research protocol: Descriptive and quantitative methods with purposive sampling were employed in determining the observational base. Each station possesses coordinate points for easy monitoring and is evenly distributed.

Parameters measurement: the measured seawater parameters were salinity, temperature, turbidity, pH, total suspended solids, dissolved oxygen, NO_3-N and PO_4-P. However, the sampling technique and data analysis adopted the methods[9,10].

Instruments used: The instrument used in this study is horibaU-50 series multi-parameter water quality checker that enables to measure and indicate the monitoring result simultaneously up to 11 parameters with one unit. Considering user-friendly field monitoring on-site, such as rive, groundwater, drainage water, etc. bring together feature of function and performance, which makes simple operation for everybody. Multiple sensors allow for the measurement of 11 parameters simultaneously (pH, pH(mv), ORP, DO, COND, Salinity, TDS, Seawater Specific Gravity, Temperature, Turbidity, Water Depth). For NO3-N and PO4-P analysis, seawater samples were put into glass bottles, then brought to the laboratory for further analysis. Subsequently, the results were compared to the Minister of Environment Decree No. 51 of 2004 as a reference for seawater quality standards.

RESULTS AND DISCUSSION

Salinity: Salinity is described as the total amount of dissolved salt in seawater. The unit is generally accepted in mg/L but also occurs in ppt (parts per thousand) or o/oo and practical salinity unit (PSU). Freshwater salinity values are typically <0.5 o/oo, brackish waters 0.5 - 30 o/oo, and seawaters 30-40 o/oo. Meanwhile, the estimate for coastal waters is strongly influenced by freshwater input from rivers. However, salinity potentially instigates osmotic pressure in seawater biota. The salt content in the aquatic cells occurs close to the surrounding seawater salinity. As the salinity changes, an osmoregulation mechanism is then required in balancing the salt levels between the cells and the environment. Mantehage Island shows a salinity range of 28 - 31 PSU, with an average of 29.15 PSU (Table. 1). This value varies based on the climate/weather during measurement. In the dry season, seawater salinity rises above 30 PSU. Rainy weather

condition was observed on the day before sampling, resulting in a lesser salinity value but showed good category, according to seawater quality standards. This salinity condition is not only good for tourism activities but also for the sustainability of the surrounding aquatic biota.

Temperature

Temperature influences the metabolic activity and reproduction of marine organisms. This factor is used in a certain tourist destination to determine the potential and existence of coral reef growth[11]. In marine life development, the optimal average temperature is expected in the range of 23^0-35^0C with tolerance limits between 36-40°C. The seawater temperature of Mantehage Island occurs from 28-31°C with an average value of 29.15 °C (Table. 1). These conditions are convenient as quality standards for tourism development activities and underwater biota sustainability. In addition, the temperatures are identical to the average value at CarocokPainan Beach between 29-31 ºC, and also show related suitability[12]. Furthermore, a similar condition was observed in the coastal waters of Labuhan Haji, East Lombok regency, with a range of 30-32 ºC[11]. The results of temperature measurements in MoyoHilir and Lape Districts occurred between 29.20-31.57 ºC[13], in contrast to the temperature of Prialaot waters at 29-31.4 °C, with an average of 29.22° C[14]. However, temperature variations tend to influence the life of coral reefs[15]. Based on the Minister of Environment Decree No. 51 of 2004, the water temperature for marine tourism is expected at natural temperature. An appropriate range for coral reef areas exists in the range of 28-30 ºC and 28-32 ºC for mangrove regions. Discontinue in situ temperature measurement is a natural temperature with a change tolerance <2° C (Minister of Environment Decree No. 51 of 2004). However, the biota in tropical waters naturally resides in the upper limit of the highest temperature. These variations possibly interfere with the physiological processes known to endanger the biota. In the value range> 28 °C, sea surface temperature in the western equator appears very warm[16]. Moreover, the condition is considered natural as Indonesia is a tropical region. Based on the water depth, extensive seawater surface temperatures are observed, in comparison to a certain depth, probably due to the high intensity of sunlight[15].

Turbidity

Lower turbidity increases the light intensity capable of penetrating the water depth[17]. Therefore, the resulting value is expected to exist under normal conditions, where water transparency is inversely proportional to the turbidity, believed to significantly influence oxygen content. Turbid

water possibly interferes with the respiration process and decreases the oxygen levels[18]. The seawater turbidity condition of Mantehage Island ranges between 2.2-4.7 NTU, with an average value of 3.58 NTU (Table. 1), indicating an appropriate category and in line with the quality standards. Therefore, the site is suitable as a potential tourist attraction. This condition is supported by data on Mantehage Island coral reef cover in the range of 19-30%, with an average live coral cover of 29.10%[5]. Furthermore, turbidity describes inadequate water transparency, due to colloidal and suspended materials, including mud, organic and inorganic materials as well as aquatic microorganisms[19]. This circumstance varies from the observations in Prialaot waters with an average value of 0.08 NTU[14], in addition to MoyoHilir and Lape Districts ranging from 0-23.3 NTU[13].

pH level

Inconsistencies in the water pH level probably influence biota existence to a certain extent of varying pH[20]. The water pH value depends on carbon dioxide and ion concentrations. Moreover, the parameter plays a significant role in the solubility of particular compounds, although appears minimal in the morning, compared to the afternoon period[21]. Subsequently, the pH of Mantehage Island seawater ranges from 7.1-7.9, with an average value of 7.51, indicating an appropriate category for tourism development and aquatic life support (Table. 1). This value also corresponds to a pH in Labuhan Haji beach between 7.6 - 7.9[11]. Meanwhile, for CarocokPainan beach, the estimate occurred between 7-8[12]. These values varied slightly from Moyo and Lape districts from 7.96 - 8.12[13], as well as in Prialaot waters by 7.64 - 8.36[14]. These variations depend on geographic position and water injection from the environment. In addition, it is also affected by the season as related to local rainfall and climate.

Total Suspended Solid (TSS)

The TSS of Mantehage Island waters ranged from 28.24-36.25 mg/L with an average value of 32.39 mg/L, corresponding to the quality standard for biota survival (Table 1). However, in-depth study and sampling of other seasons are required for tourism development, particularly underwater ecotourism, considering the present research was only conducted in one season without repetition. This high TSS value is due to the greatest mangrove forest in Bunaken National Park, and therefore sedimentation in certain segments is inevitable. This varies from the TSS of Prialaot waters at the range of 14 - 31 mg/L, with an average of 21.83 mg/L. Also, the

value is generally above the standards allowed for marine tourism (20 mg/L) and marine life (coral and seagrass by 20 mg/L, mangroves by 80 mg/L)[14]. Similarly, the TSS of Labuhan Haji beach also demonstrated a fairly higher content, ranging from 14 - 31 mg/L, with an average of 21.83 mg/L. This value is also above the quality standard allowed for marine tourism (20 mg/L) and marine life (coral and seagrass at 20 mg/L, and mangroves at 80 mg/L)[11].

Dissolved Oxygen (DO)

The dissolved oxygen source in water originates from the diffusion of oxygen from the air, water currents or flow through rainwater, as well as photosynthetic activity by aquatic plants and phytoplankton. Generally, aquatic creatures, e.g fish, shrimp, shellfish, and other animals, including microorganisms, e.g bacteria, require oxygen. Dissolved oxygen (DO) regulates the metabolism of organisms to grow and reproduce. Fish need water with an oxygen content of at least 5 mg/L. The DO values in Mantehage waters ranged from 3.24-6.35 mg/L, with an average of 5.43 mg/L (Table 1). This indicates a suitable oxygen content capable of supporting marine biota. Moreover, seawater quality standards for tourism and healthy ecological activities require DO values above 5mg/L. The condition supports the seagrass survival, covering 33% of the island[8], and also matches the results of dissolved oxygen (DO) measurements performed at Labuhan Haji beach, where the total stations obtained a yield range of 6 mg/L. Also, the value shows an excellent water condition and relatively suffices the seawater quality standards[11]. Furthermore, dissolved oxygen describes the relative concentration of the element in water within the range of 4.28-10 mg/L[22]. In addition, the average dissolved oxygen in PantaiCarocokPainan occurs between 5.75-9.1 mg/L, and is suitable for marine tourism activities[12]. Conversely, the DO for the entire stations in the Saleh Bay waters ranges from 4.78-6.01 mg/L[14]. The measured DO value of PrialaotSabang ranged from 4.4-4.69 mg/L, with an average of 4.53 mg/L. However, at sea level, DO values are influenced by the diffusion of oxygen from the air and the photosynthetic rate by marine plants[23].

Salinity

A particular salinity level is required for coral reefs and seagrass survival towards attracting marine tourism objects, including snorkelling and diving. The salinity range of Mantehage Island waters occurs between 29.45-32.65 ‰, with an average value of 31.05 ‰ (Table. 1). This

estimation indicates a suitable category within the applicable quality standards. Salinity plays an essential role in supporting marine biota and the water level varies based on geography and time, where the increase in the parameter is caused by evaporation and the result of freezing sea ice, while the decrease is instigated by precipitation and freshwater input from rivers. This outcome slightly varies from the measurement results at Labuhan Haji beach, showing a salinity range of 32-35 ‰[11]. Subsequently, the value for PataiCarocokPainan waters also obtained an average range of 30-31 ‰[12] Meanwhile, Saleh Bay water occurs between 27.17-30.67 ‰ [13], and 21.6-32.3 ‰ for Prialaot, with a general average of 31.27 ‰[14]. However, the salinity value to promote coral reef life is expected to range from 30-36 ‰[11]. This difference is influenced by geographical position and water type. Furthermore, stable salinity in the archipelago tends to be achieved, due to inadequate water inflow from the mainland. In addition, the value is also greatly impacted by evaporation and precipitation rates.

Nitrate

The nitrate content in the Mantehage waters ranges from 0.004-0.068 mg/L at an average of 0.034 mg/L (Table 1). This value exceeded the quality standard of the Minister of Environment and Forestry Decree No. 51 of 2004, estimated at 0.008 mg/L. In addition, the extreme result is influenced by the mangrove ecosystem located on the coastal part of the island, where sedimentation is very extensive during the rainy season. An additional indicator is also due to poor mangrove management, leading to free waste from anthropogenic activities entering the aquatic environment. The high concentration of nitrate is probably due to input from land and surrounding factors in the form of liquid waste, both due to agricultural operations. Moreover, the primary ingredient of fertilizers is nitrogen, known to utilize a bio-physicochemical process to become a compound. In marine waters, six types of nitrogen are formed, termed N_2, NO_3, NO_2, NH_3, NH_4, organic N and particulate N. Meanwhile, in the aerobic atmosphere, the nitrogen species generated is the NO_3, as one of the constituents consumed by marine biota, including phytoplankton for growth of 3.9- 15.5 mg/L[13]. This outcome corresponds to the analysis results of the NO_3 at Labuhan Haji beach, with similar content of 0.036 mg/L. Also, the nitrate (NO3) at Labuhan Haji appears relatively high due to community activities on the coast/land, where unwanted materials are directly and inappropriately disposed into the sea. In addition, the

existence of river water flowing into the beach also serves as a transportation medium for agricultural waste and other human activities related to the sea [11].

Phosphate

The phosphate content in Mantehage waters ranges from 0.008-0.019 mg/L at an average of 0.015 mg/L (Table. 1). This value is under the specified quality standard for marine tourism at 0.015 mg/L, based on the Minister of Environment Decree No. 51 of 2004. However, the estimate varied from the measurement results in MoyoHilir and Lape sub-districts, between 0.03-0.3 mg/L. Extensive land activities are believed to trigger the phosphate content beyond the quality standard, including livestock, agricultural operations, and the landfill existence in the coastal areas. Moreover, organic waste disposal, e.g detergents, fertilizers, and degradable materials tend to generate phosphate. In marine waters, the greatest phosphate compound is ortho-phosphate as the substance undergoes hydrolysis with a percentage fraction depending on the water pH and temperature [13].

The implication of this research is that the involvement of academics through this study is very helpful for policy makers in developing strategies for developing Mantehage island tourism areas. The data of this study can be applied in determining the best location for snorkeling and diving areas, Mantehage Island is very feasible to be developed as a marine tourism location because it is supported by very good water conditions and in accordance with environmental quality standards. This study has limitations in research time, where the sample is only taken in one season, does not represent another season, besides that this study has not studied the overall condition of the oceanographic parameters.

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Table 1. Seawater Quality Parameters in Mantehage Island.

Station	Coordinate		Temperature	Turbidity	TSS	pH	Salinity	DO	NO3-N	PO4-P	Parameter
	Latitude	Longitude	28-32	< 5	80	7-8.5[d]	<34	>5	0.008	0.015	Biota quality standards
			alami	< 5	20	7-8.5[d]	alami[3](e)	>5	0.008	0.015	Tourism quality standards
			C	NTU	mg/L	pH	PSU	mg/L	mg/L	mg/L	Unit quality standards
1	1°42'49.04"N	124°43'44.57"E	29	3.21	31.20	7.2	30.21	5.23	0.005	0.010	Decree of the Minister of Environment of the Republic of Indonesia No 51 of 2004
2	1°42'27.10"N	124°44'10.46"E	30	4.25	29.25	7.6	31.26	5.47	0.025	0.011	
3	1°42'5.66"N	124°44'28.58"E	28	3.2	33.65	7.4	31.25	5.65	0.045	0.016	
4	1°41'49.04"N	124°44'54.55"E	29	2.2	35.25	7.8	30.45	5.14	0.006	0.018	
5	1°41'39.27"N	124°45'22.47"E	30	3.2	30.56	7.5	29.45	5.98	0.068	0.014	
6	1°41'29.02"N	124°45'49.90"E	28	4.7	32.00	7.4	30.87	6.12	0.065	0.013	
7	1°41'37.80"N	124°46'31.55"E	28	3.6	33.63	7.6	32.14	3.24	0.058	0.015	
8	1°41'59.04"N	124°47'4.83"E	28	2.8	32.63	7.9	30.45	6.35	0.009	0.019	
9	1°42'29.46"N	124°47'1.90"E	30	4	34.24	7.1	31.56	5.21	0.004	0.018	
10	1°43'9.12"N	124°46'41.67"E	30	4.1	32.13	7.4	30.25	5.98	0.008	0.017	
11	1°43'35.87"N	124°46'26.20"E	30	3.2	33.26	7.5	31.25	5.87	0.025	0.009	
12	1°44'29.95"N	124°46'15.18"E	29	4.5	31.00	7.6	30.87	5.46	0.054	0.008	
13	1°44'58.36"N	124°45'57.12"E	30	2.5	31.27	7.1	31.63	5.21	0.066	0.016	
14	1°45'19.63"N	124°45'38.18"E	31	3.8	33.36	7.5	32.65	5.69	0.042	0.014	
15	1°45'51.74"N	124°45'15.50"E	29	4.7	36.25	7.8	32.4	5.19	0.061	0.018	
16	1°46'14.93"N	124°44'9.69"E	28	3.5	35.21	7.5	31.25	5.38	0.019	0.016	
17	1°45'24.98"N	124°43'48.02"E	30	3.4	28.24	7.6	30.65	5.67	0.048	0.014	
18	1°44'51.67"N	124°43'41.78"E	28	2.8	29.25	7.6	31.45	5.43	0.065	0.013	
19	1°44'18.76"N	124°43'32.41"E	29	3.6	32.25	7.6	30.14	5.28	0.008	0.017	
20	1°43'37.56"N	124°43'34.43"E	29	4.5	33.25	7.5	30.86	5.17	0.007	0.014	
Average			29.15	3.58	32.39	7.51	31.052	5.43	0.034	0.015	
Minimum			28	2.2	28.24	7.1	29.45	3.24	0.004	0.008	
Maximum			31	4.7	36.25	7.9	32.65	6.35	0.068	0.019	

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CONCLUSION

Based on the values of salinity, temperature, turbidity, pH, total suspended solids, dissolved oxygen, NO_3-N, and PO_4-P, the condition of Mantehage water quality obtained a suitable category within the specified standards of the Minister of Environment Republic of Indonesia. Several parameters known to exceed these provisions, including nitrate and phosphate content, indicate the instantaneous value during measurement. Therefore, an in-depth study, sufficient interval and sampling location to represent the spatial and temporal conditions of the entire island are greatly required. This outermost island generally appears suitable as a marine tourism attraction, particularly snorkelling and diving. Furthermore, the beauty of coral reefs is believed to be a major tourist object with the need for further encouragement. Mantehage Island is very feasible to be developed as a marine tourism area, especially for snorkeling and diving activities, underwater beauty, high biodiversity, and supported by good water conditions make this island attractive to tourists.

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Significance statement

"This study discovered the condition of the seawater quality of Mantehage Island which can be developed as an underwater tourism location, the good status of coral reefs supported by underwater beauty makes Mantehage Island worthy of development, that can be beneficial for the government, researchers, and the people of Mantehage Island in developing tourism. This study will help the researchers to uncover the critical areas of the outermost small island of Indonesia that many researchers were not able to explore. Thus a new theory on the condition of seawater quality for the development of marine tourism may be arrived at".

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REFERENCES

1. Tangian, D., Djokosetiyanto, D., Kholil, K., & Munandar, A. (2015). Model of Ecotourism Management in Small Islands of Bunaken National Park, North Sulawesi. *Journal of Indonesian Tourism and Development Studies*, *3*(2), 75-84.
https://jitode.ub.ac.id/index.php/jitode/article/view/156

2. Djamaluddin, R. (2018). The mangrove flora and their physical habitat characteristics in Bunaken National Park, North Sulawesi, Indonesia. *Biodiversitas Journal of Biological Diversity*, *19*(4), 1303-1312.
https://www.smujo.id/biodiv/article/view/2787

3. Opa E. T., Kusen J. D., Kepel R. C., Jusuf A., Lumingas L. J. L., 2019 Community structure of mangrove in Mantehage Island and Paniki Island, North Sulawesi, Indonesia. AACL Bioflux 12(4):1388-1403.
http://www.bioflux.com.ro/docs/2019.1388-1403.pdf

4. Kase A., Manembu I., Schaduw J.N.W. 2019. [Condition of Mantehage Island Coral Reef, North Minahasa Regency, North Sulawesi]. Journal of coastal and tropical seas. 7 (3) : 208-212.
Https://Doi.Org/10.35800/Jplt.7.3.2019.24466
https://ejournal.unsrat.ac.id/index.php/jplt/article/view/24466/24143

5. Schaduw J.N.W., Kondoy K.I.F., Manoppo V.E.N., Luasunaung A., Mudeng J., Pelle W.E., Ngangi E.L.A., Manembu I.S., Wantasen N.S., Sumilat D.A., Rumampuk N.D.C., Tilaar S.O., Manengkey H.W.A., Lintang R., Walalangi J.Y., Tampanguma B., Pungus F., Lahabu Y., Sagai B., Wantah E., Wantania L.L., Djabar B., Oli A.P., Caroles E.A., Bachmid F., Sasauw J., Kase A., Anthoni A., Uada A.D., Ladjandu R., Coloay C., Kojongian S., Mamangkey N.N.T. 2020. Data On Percentage Coral Reef Cover In Small Islands Bunaken National Park. Data in Brief, 31, 105713.
https://doi.org/10.1016/j.dib.2020.105713
https://www.sciencedirect.com/science/article/pii/S2352340920306077?via%3Dihub

6. Wagey B. T., Boneka F. B., Mantiri R., 2020 Status of marine biodiversity and community perception on marine conservation in Mantehage Island, Bunaken National Park, North Sulawesi, Indonesia. AACL Bioflux 13(6):3830- 3839.

Commented [User13]: •Provide the reference in the English Language which also has the English language in its direct link if not then replace it with a suitable journal related reference which is in the English language both in reference and in the DOI or URL link also.

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http://www.bioflux.com.ro/docs/2020.3830-3839.pdf
7. Kalalo F. P., 2017 Law enforcement and conservation at Bunaken National Park, North Sulawesi, Indonesia as perceived by the local coastal communities. AACL Bioflux 10(6):1413-1420.
http://www.bioflux.com.ro/docs/2017.1413-1420.pdf
8. Schaduw J. N.W. and Kondoy K. F. I. 2020. Seagrass percent cover in small islands of Bunaken National Park, North Sulawesi Province, Indonesia. AACL Bioflux 13(2):951-957.
http://www.bioflux.com.ro/docs/2020.951-957.pdf
9. Schaduw J. N.W. 2018. [Distribution and Water Quality Characteristics of the Small Island Mangrove Ecosystem of Bunaken National Park]. Indonesian Geography Magazine. 32 (1) 40-49.
https://jurnal.ugm.ac.id/mgi/article/view/32204
https://doi.org/10.22146/mgi.32204
10. Kurniadi B., Sigid H., Enan M., Adiwilaga. 2015. [The waters Quality of the Buaya River in Bunyu Island, North Kalimantan in Tidal Conditions]. Indonesian Journal of Agricultural Sciences. 20 (1): 53-58.
https://journal.ipb.ac.id/index.php/JIPI/article/view/9289/7287
https://doi.org/10.35800/jasm.1.1.2013.1972
11. Haerudin and Putra A.M. 2019. Analysis of Seawater Quality Standards for the Development of Marine Tourism in Labuhan Haji Beach, East Lombok Regency. *Journal of Geodics 3(1) : 13 – 18*
https://e-journal.hamzanwadi.ac.id/index.php/gdk/article/view/1473
12. Indra N., Sari S., Rahayu G, Oktaviandra R., Handoko A., Putri V.S., Hanapi N.I. 2019. Environmental Quality and Suitability of Coastal Tourism in CarocokPainan Area, Pesisir Selatan Regency. Journal of Capita Selecta Geography 2 (5): 43- 51
http://ksgeo.ppj.unp.ac.id/index.php/ksgeo/article/view/251
https://doi.org/10.24036/ksgeo.v2i5.251
13. Saraswati N.G.R.A., Yulius., Rustam A., Hadiwijaya L., Salim., Heriati A., Mustikasari E. 2017. [Study of Water Quality for Coastal Marine Tourism, MoyoHilirSubdistrict and LapeSubdistrict, Sumbawa Regency]. Journal of Segara 13 (1) : 37-47.
http://ejournal-balitbang.kkp.go.id/index.php/segara/article/view/6421

http://dx.doi.org/10.15578/segara.v13i1.6421

14. Tanto T.A., Naelul N.H.R., Ilham. 2018. [Quality of Seawater to Support Marine Tourism and Marine Life. Case Study: Around the Sinking Ship of Sophie Rickmers, PrialaotSabang Waters]. Marine Journal, 11 (2) : 173-183.
https://journal.trunojoyo.ac.id/jurnalkelautan/article/view/4276
https://doi.org/10.21107/jk.v11i2.4276

15. Tambunan J.M., Anggoro S., Purnaweni H. 2013. [Study on Environmental Quality and Suitability of TanjungPesona Beach Tourism, Bangka Regency]. Proceedings of the National Seminar on Natural Resources and Environmental Management. pg 356-362.
https://core.ac.uk/download/pdf/18605648.pdf

16. Tomczak M. and Godfrey J. 2001. Regional Oceanography: An Introduction. Pergamon. ISBN : 9781483287614 https://www.elsevier.com/books/regional-oceanography/tomczak/978-0-08-041021-0
.

17. Tanto T. A. and Kusumah G. 2016. [Seawater Quality Standards in Different Seasons]. Maspari Journal, 8 (2) : 135–146. [in Indonesian]
https://ejournal.unsri.ac.id/index.php/maspari/article/view/3490
https://doi.org/10.36706/maspari.v8i2.3490

18. Mutmainah H. 2016.[Environmental Suitability Study for Tourism Development at Ganting Beach, Simeulue Island, Aceh Province]. Journal of DepikUnsyiah, 5 (1) : 19–30.
http://jurnal.unsyiah.ac.id/depik/article/view/3844
https://doi.org/10.13170/depik.5.1.3844

19. Wilson P.C. 2010. Water Quality Notes: Water Clarity (Turbidity, Suspended Solids, and Color). Department of Soil and Water Science. University of Florida. https://edis.ifas.ufl.edu/publication/SS526
.

20. Simanjuntak M. 2012. Seawater Quality Judging from Nutrient Aspects, Dissolved Oxygen and Ph in Banggai Waters, Central Sulawesi. Journal of Tropical Marine Science and Technology. 4(2):290-303.
https://journal.ipb.ac.id/index.php/jurnalikt/article/view/7791
https://doi.org/10.29244/jitkt.v4i2.7791

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Commented [User21]: The author is advised to replace the reference with a peer-reviewed journal reference having the correct DOI and URL.

Commented [A22R21]: Has been revised + URL

21. Arifin T., Bengen D.G., Pariwono J.I. 2002. Evaluation on the Suitability of the Palu Bay Coastal Zone for Marine Tourism Development. Coastal and Ocean Journal. 4 (2) : 25-35 https://repository.ipb.ac.id/jspui/bitstream/123456789/26592/1/Taslim%20Arifin_Herni%20%2811%20hal%29.pdf

22. Putra A., Tanto T.A., Pranowo W.S., Ilham., Damanhuri H., Suasti Y., Triyatno T. 2018. Suitability Of Coastal Ecotourism In Padang City-West Sumatera: Case Study Of Beach Recreation And Mangrove. Journal of Segara, 14 (2) : 87-94. http://ejournal-balitbang.kkp.go.id/index.php/segara/article/view/6642 http://dx.doi.org/10.15578/segara.v14i2.6642

23. Wisha U.J., Tanto T.A., Ilham. 2016. Physical and Chemical Conditions of Bayur Bay Waters on the East and West Season.Journal of Marine Science UNDIP. 22 (1) : 15–24. https://ejournal.undip.ac.id/index.php/ijms/article/view/10505 doi:10.14710/ik.ijms.22.1.15-24 https://ejournal.unsrat.ac.id/index.php/lppmsains/article/view/10692

24. Minister of Environment Decree No. 51 of 2004. Poses as a reference for the seawater quality standards. https://environmentalchemistry.files.wordpress.com/2013/08/kepmenlh-no-51-tahun-2004.pdf

Commented [User23]: The author is advised to replace the reference with a peer-reviewed journal reference having the correct DOI and URL.

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The Analysis of Seawater Quality in Small Outermost Mantehage Island for Integrated and Sustainable Marine Tourism Development in North Sulawesi Province

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Joshian Nicolas William Schaduw

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Conflict of interest: The authors declare no conflict of interest

Abstract

Background and Objective: There is a growing interest to significantly explore more opportunities in the coastal environment. For this reason, adequate progressive strategies appear very essential. The purpose of this study was to analyze seawater quality as a database for developing integrated and sustainable marine tourism in Mantehage Island, Indonesia. **Materials and Methods:** the present paper applied descriptive and quantitative methods to sample 20 observation points around the selected location. In addition, the seawater content was directly measured and stored in the laboratory for further analysis. Consequently, certain parameters were evaluated, including salinity, temperature, turbidity, pH, total suspended solids, dissolved oxygen, NO_3-N and PO_4-P. The subsequent data were also compared to the related quality standards of the Minister of Environment, Decree No. 51 of 2004. **Results**: Based on the results, Mantehage water quality demonstrated an excellent condition and is also believed to support the proposed marine tourism development. **Conclusion**: the values of salinity, temperature, turbidity, pH, total suspended solids, dissolved oxygen, NO_3-N, and PO_4-P, the condition of Mantehage water quality obtained a suitable category within the specified standards of the Minister of Environment Decree No. 51 of 2004. Several parameters known to exceed these provisions, including nitrate and phosphate content, indicate the instantaneous value during measurement

Keywords: *Seawater Quality; Mantehage: Outer Island; Marine Tourism*

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INTRODUCTION

The quality of seawater greatly determines the feasibility of an underwater tourism area, diving and snorkelling activities require good seawater conditions, this greatly affects the comfort and safety of tourists. Bunaken National Park exhibits high biodiversity, particularly in the Coral Triangle along the Asia Pacific region. The number of tourists visiting has a real connection with extensive coral cover. An increase in the number of tourist arrivals will affect the broad decline in coral cover and vice versa. Otherwise, the decline in coral cover will cause the number of tourists to decrease[1]. The underwater view is famous to foreign tourists around the world and encompasses five minor islands, including, Bunaken, Siladen, Manado Tua, Mantehage, and Nain. These 5 landmasses are divided into 2 administrative regions, including Manado city and North Minahasa regency. Mantehage is a major outermost island in Indonesia with the greatest mangrove area in North Sulawesi, the mangrove flora in Bunaken National Park was floristically rich with at least 27 species, and the broader northern distribution limit of *L. littorea and L.*

racemosa, C. philippinense, S. ovata was confirmed [2]. The mangroves community structure shows that it is unstable with low values of diversity, and evenness, while the value of domination and species richness is high. The highest density of the mangroves found in station 9 is *C. tagal*. In general, mangroves species richness is found in the moderate category [3]. Moreover, the nature of the coral reef ecosystem serves as a potential underwater tourist attraction [4,5]. The condition of the coral reefs in Mantehage Island seen from the percentage of coral cover ranging from 20-40%, the condition of hard coral substrates accompanied by good water quality will support this island as a new marine tourism area [5]. This island also has a good seagrass ecosystem with an average cover percentage of 33%, there are four species of seagrass including *Enhalus acoroides, Thalassia hemprichii, Cymodocea rotundata, Halophila pinifolia* [8]. As far as can be ascertained, the marine biodiversity of Bunaken National Park is notably high. However, there seems to be a lack of a more comprehensive assessment, especially in Mantehage Island. To date, no comprehensive studies have been done on other marine fauna such as sea snakes, turtles, shorebirds, and marine mammals [6]. Another factor might be the establishment and management histories of BNP since management was principally initiated by the Indonesian national government (top-bottom approach) unlike in other well-known cases (e.g. Apo Island Reserve in the central Philippines) where protection was initiated and even to this day actively participated by the local communities [7]. Some important water quality parameters include salinity, temperature, turbidity, pH, total suspended solids, dissolved oxygen, NO3-N and PO4-P. Information about these parameters will be very helpful in the development of tourist areas. This research is probably a consideration for policymakers in determining the direction and strategies related to the management of coastal and marine resources, particularly for marine tourism development in Mantegehe.

The purpose of this study was to analyze the seawater quality as a database for the prospective development of marine tourism. In addition, the Minister of Environment Decree No. 51 of 2004 poses as a reference for the seawater quality standards.

MATERIALS AND METHODS

Study area: This research was conducted in Mantehage Island, Wori District, North Minahasa regency, North Sulawesi province, within Bunaken National Park from March-May 2021.

Research protocol: Descriptive and quantitative methods with purposive sampling were employed in determining the observational base. Each station possesses coordinate points for easy monitoring and is evenly distributed.

Parameters measurement: the measured seawater parameters were salinity, temperature, turbidity, pH, total suspended solids, dissolved oxygen, NO_3-N and PO_4-P. However, the sampling technique and data analysis adopted the methods[9,10].

Instruments used: The instrument used in this study is horibaU-50 series multi-parameter water quality checker that enables to measure and indicate the monitoring result simultaneously up to 11 parameters with one unit. Considering user-friendly field monitoring on-site, such as rive, groundwater, drainage water, etc. bring together feature of function and performance, which makes simple operation for everybody. Multiple sensors allow for the measurement of 11 parameters simultaneously (pH, pH(mv), ORP, DO, COND, Salinity, TDS, Seawater Specific Gravity, Temperature, Turbidity, Water Depth). For NO3-N and PO4-P analysis, seawater samples were put into glass bottles, then brought to the laboratory for further analysis. Subsequently, the results were compared to the Minister of Environment Decree No. 51 of 2004 as a reference for seawater quality standards.

RESULTS AND DISCUSSION

Salinity: Salinity is described as the total amount of dissolved salt in seawater. The unit is generally accepted in mg/L but also occurs in ppt (parts per thousand) or o/oo and practical salinity unit (PSU). Freshwater salinity values are typically <0.5 o/oo, brackish waters 0.5 - 30 o/oo, and seawaters 30-40 o/oo. Meanwhile, the estimate for coastal waters is strongly influenced by freshwater input from rivers. However, salinity potentially instigates osmotic pressure in seawater biota. The salt content in the aquatic cells occurs close to the surrounding seawater salinity. As the salinity changes, an osmoregulation mechanism is then required in balancing the salt levels between the cells and the environment. Mantehage Island shows a salinity range of 28 - 31 PSU, with an average of 29.15 PSU. This value varies based on the climate/weather during measurement. In the dry season, seawater salinity rises above 30 PSU. Rainy weather condition was observed on the day before sampling, resulting in a lesser salinity value but showed good category, according to seawater quality standards. This salinity condition is not only good for tourism activities but also for the sustainability of the surrounding aquatic biota.

Temperature

Temperature influences the metabolic activity and reproduction of marine organisms. This factor is used in a certain tourist destination to determine the potential and existence of coral reef growth[11]. In marine life development, the optimal average temperature is expected in the range of 23^0-35^0C with tolerance limits between 36-40°C. The seawater temperature of Mantehage Island occurs from 28-31°C with an average value of 29.15 °C. These conditions are convenient as quality standards for tourism development activities and underwater biota sustainability. In addition, the temperatures are identical to the average value at CarocokPainan Beach between 29-31 ºC, and also show related suitability[12]. Furthermore, a similar condition was observed in the coastal waters of Labuhan Haji, East Lombok regency, with a range of 30-32 ºC[11]. The results of temperature measurements in MoyoHilir and Lape Districts occurred between 29.20-31.57 ºC[13], in contrast to the temperature of Prialaot waters at 29-31.4 °C, with an average of 29.22° C[14]. However, temperature variations tend to influence the life of coral reefs[15]. Based on the Minister of Environment Decree No. 51 of 2004, the water temperature for marine tourism is expected at natural temperature. An appropriate range for coral reef areas exists in the range of 28-30 ºC and 28-32 ºC for mangrove regions. Discontinue in situ temperature measurement is a natural temperature with a change tolerance <2° C (Minister of Environment Decree No. 51 of 2004). However, the biota in tropical waters naturally resides in the upper limit of the highest temperature. These variations possibly interfere with the physiological processes known to endanger the biota. In the value range> 28 °C, sea surface temperature in the western equator appears very warm[16]. Moreover, the condition is considered natural as Indonesia is a tropical region. Based on the water depth, extensive seawater surface temperatures are observed, in comparison to a certain depth, probably due to the high intensity of sunlight[15].

Turbidity

Lower turbidity increases the light intensity capable of penetrating the water depth[17]. Therefore, the resulting value is expected to exist under normal conditions, where water transparency is inversely proportional to the turbidity, believed to significantly influence oxygen content. Turbid water possibly interferes with the respiration process and decreases the oxygen levels[18]. The seawater turbidity condition of Mantehage Island ranges between 2.2-4.7 NTU, with an average value of 3.58 NTU, indicating an appropriate category and in line with the quality standards.

Therefore, the site is suitable as a potential tourist attraction. This condition is supported by data on Mantehage Island coral reef cover in the range of 19-30%, with an average live coral cover of 29.10%[5]. Furthermore, turbidity describes inadequate water transparency, due to colloidal and suspended materials, including mud, organic and inorganic materials as well as aquatic microorganisms[19]. This circumstance varies from the observations in Prialaot waters with an average value of 0.08 NTU[14], in addition to MoyoHilir and Lape Districts ranging from 0-23.3 NTU[13].

pH level

Inconsistencies in the water pH level probably influence biota existence to a certain extent of varying pH[20]. The water pH value depends on carbon dioxide and ion concentrations. Moreover, the parameter plays a significant role in the solubility of particular compounds, although appears minimal in the morning, compared to the afternoon period[21]. Subsequently, the pH of Mantehage Island seawater ranges from 7.1-7.9, with an average value of 7.51, indicating an appropriate category for tourism development and aquatic life support. This value also corresponds to a pH in Labuhan Haji beach between 7.6 - 7.9[11]. Meanwhile, for CarocokPainan beach, the estimate occurred between 7-8[12]. These values varied slightly from Moyo and Lape districts from 7.96 - 8.12[13], as well as in Prialaot waters by 7.64 - 8.36[14]. These variations depend on geographic position and water injection from the environment. In addition, it is also affected by the season as related to local rainfall and climate.

Total Suspended Solid (TSS)

The TSS of Mantehage Island waters ranged from 28.24-36.25 mg/L with an average value of 32.39 mg/L, corresponding to the quality standard for biota survival. However, in-depth study and sampling of other seasons are required for tourism development, particularly underwater ecotourism, considering the present research was only conducted in one season without repetition. This high TSS value is due to the greatest mangrove forest in Bunaken National Park, and therefore sedimentation in certain segments is inevitable. This varies from the TSS of Prialaot waters at the range of 14 - 31 mg/L, with an average of 21.83 mg/L. Also, the value is generally above the standards allowed for marine tourism (20 mg/L) and marine life (coral and seagrass by 20 mg/L, mangroves by 80 mg/L)[14]. Similarly, the TSS of Labuhan Haji beach also demonstrated a fairly higher content, ranging from 14 - 31 mg/L, with an average of 21.83 mg/L. This value is

also above the quality standard allowed for marine tourism (20 mg/L) and marine life (coral and seagrass at 20 mg/L, and mangroves at 80 mg/L)[11].

Dissolved Oxygen (DO)

The dissolved oxygen source in water originates from the diffusion of oxygen from the air, water currents or flow through rainwater, as well as photosynthetic activity by aquatic plants and phytoplankton. Generally, aquatic creatures, e.g fish, shrimp, shellfish, and other animals, including microorganisms, e.g bacteria, require oxygen. Dissolved oxygen (DO) regulates the metabolism of organisms to grow and reproduce. Fish need water with an oxygen content of at least 5 mg/L. The DO values in Mantehage waters ranged from 3.24-6.35 mg/L, with an average of 5.43 mg/L. This indicates a suitable oxygen content capable of supporting marine biota. Moreover, seawater quality standards for tourism and healthy ecological activities require DO values above 5mg/L. The condition supports the seagrass survival, covering 33% of the island[8], and also matches the results of dissolved oxygen (DO) measurements performed at Labuhan Haji beach, where the total stations obtained a yield range of 6 mg/L. Also, the value shows an excellent water condition and relatively suffices the seawater quality standards[11]. Furthermore, dissolved oxygen describes the relative concentration of the element in water within the range of 4.28-10 mg/L[22]. In addition, the average dissolved oxygen in PantaiCarocokPainan occurs between 5.75-9.1 mg/L, and is suitable for marine tourism activities[12]. Conversely, the DO for the entire stations in the Saleh Bay waters ranges from 4.78-6.01 mg/L[14]. The measured DO value of PrialaotSabang ranged from 4.4-4.69 mg/L, with an average of 4.53 mg/L. However, at sea level, DO values are influenced by the diffusion of oxygen from the air and the photosynthetic rate by marine plants[23].

Salinity

A particular salinity level is required for coral reefs and seagrass survival towards attracting marine tourism objects, including snorkelling and diving. The salinity range of Mantehage Island waters occurs between 29.45-32.65 ‰, with an average value of 31.05 ‰. This estimation indicates a suitable category within the applicable quality standards. Salinity plays an essential role in supporting marine biota and the water level varies based on geography and time, where the increase in the parameter is caused by evaporation and the result of freezing sea ice, while the

decrease is instigated by precipitation and freshwater input from rivers. This outcome slightly varies from the measurement results at Labuhan Haji beach, showing a salinity range of 32-35 ‰[11]. Subsequently, the value for PataiCarocokPainan waters also obtained an average range of 30-31 ‰[12] Meanwhile, Saleh Bay water occurs between 27.17-30.67 ‰ [13], and 21.6-32.3 ‰ for Prialaot, with a general average of 31.27 ‰[14]. However, the salinity value to promote coral reef life is expected to range from 30-36 ‰[11]. This difference is influenced by geographical position and water type. Furthermore, stable salinity in the archipelago tends to be achieved, due to inadequate water inflow from the mainland. In addition, the value is also greatly impacted by evaporation and precipitation rates.

Nitrate

The nitrate content in the Mantehage waters ranges from 0.004-0.068 mg/L at an average of 0.034 mg/L. This value exceeded the quality standard of the Minister of Environment and Forestry Decree No. 51 of 2004, estimated at 0.008 mg/L. In addition, the extreme result is influenced by the mangrove ecosystem located on the coastal part of the island, where sedimentation is very extensive during the rainy season. An additional indicator is also due to poor mangrove management, leading to free waste from anthropogenic activities entering the aquatic environment. The high concentration of nitrate is probably due to input from land and surrounding factors in the form of liquid waste, both due to agricultural operations. Moreover, the primary ingredient of fertilizers is nitrogen, known to utilize a bio-physicochemical process to become a compound. In marine waters, six types of nitrogen are formed, termed N_2, NO_3, NO_2, NH_3, NH_4, organic N and particulate N. Meanwhile, in the aerobic atmosphere, the nitrogen species generated is the NO_3, as one of the constituents consumed by marine biota, including phytoplankton for growth of 3.9- 15.5 mg/L[13]. This outcome corresponds to the analysis results of the NO_3 at Labuhan Haji beach, with similar content of 0.036 mg/L. Also, the nitrate (NO3) at Labuhan Haji appears relatively high due to community activities on the coast/land, where unwanted materials are directly and inappropriately disposed into the sea. In addition, the existence of river water flowing into the beach also serves as a transportation medium for agricultural waste and other human activities related to the sea [11].

Phosphate

The phosphate content in Mantehage waters ranges from 0.008-0.019 mg/L at an average of 0.015 mg/L. This value is under the specified quality standard for marine tourism at 0.015 mg/L, based on the Minister of Environment Decree No. 51 of 2004. However, the estimate varied from the measurement results in MoyoHilir and Lape sub-districts, between 0.03-0.3 mg/L. Extensive land activities are believed to trigger the phosphate content beyond the quality standard, including livestock, agricultural operations, and the landfill existence in the coastal areas. Moreover, organic waste disposal, e.g detergents, fertilizers, and degradable materials tend to generate phosphate. In marine waters, the greatest phosphate compound is ortho-phosphate as the substance undergoes hydrolysis with a percentage fraction depending on the water pH and temperature[13].

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Table 1. Seawater Quality Parameters in Mantehage Island.

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Station	Coordinate		Temperature	Turbidity	TSS	pH	Salinity	DO	NO3-N	PO4-P	Parameter
	Latitude	Longitude	28-32	< 5	80	7-8.5[(d)]	<34	>5	0.008	0.015	Biota quality standards
			alami	< 5	20	7-8.5[(d)]	alami[3](e)	>5	0.008	0.015	Tourism quality standards
			C	NTU	mg/L	pH	PSU	mg/L	mg/L	mg/L	Unit quality standards
1	1°42’49.04”N	124°43’44.57”E	29	3.21	31.20	7.2	30.21	5.23	0.005	0.010	Decree of the Minister of Environment of the Republic of Indonesia No 51 of 2004
2	1°42’27.10”N	124°44’10.46”E	30	4.25	29.25	7.6	31.26	5.47	0.025	0.011	
3	1°42’5.66”N	124°44’28.58”E	28	3.2	33.65	7.4	31.25	5.65	0.045	0.016	
4	1°41’49.04”N	124°44’54.55”E	29	2.2	35.25	7.8	30.45	5.14	0.006	0.018	
5	1°41’39.27”N	124°45’22.47”E	30	3.2	30.56	7.5	29.45	5.98	0.068	0.014	

6	1°41’29.02”N	124°45’49.90”E	28	4.7	32.00	7.4	30.87	6.12	0.065	0.013
7	1°41’37.80”N	124°46’31.55”E	28	3.6	33.63	7.6	32.14	3.24	0.058	0.015
8	1°41’59.04”N	124°47’4.83”E	28	2.8	32.63	7.9	30.45	6.35	0.009	0.019
9	1°42’29.46”N	124°47’1.90”E	30	4	34.24	7.1	31.56	5.21	0.004	0.018
10	1°43’9.12”N	124°46’41.67”E	30	4.1	32.13	7.4	30.25	5.98	0.008	0.017
11	1°43’35.87”N	124°46’26.20”E	30	3.2	33.26	7.5	31.25	5.87	0.025	0.009
12	1°44’29.95”N	124°46’15.18”E	29	4.5	31.00	7.6	30.87	5.46	0.054	0.008
13	1°44’58.36”N	124°45’57.12”E	30	2.5	31.27	7.1	31.63	5.21	0.066	0.016
14	1°45’19.63”N	124°45’38.18”E	31	3.8	33.36	7.5	32.65	5.69	0.042	0.014
15	1°45’51.74”N	124°45’15.50”E	29	4.7	36.25	7.8	32.4	5.19	0.061	0.018
16	1°46’14.93”N	124°44’9.69”E	28	3.5	35.21	7.5	31.25	5.38	0.019	0.016

17	1°45’24.98”N	124°43’48.02”E	30	3.4	28.24	7.6	30.65	5.67	0.048	0.014	
18	1°44’51.67”N	124°43’41.78”E	28	2.8	29.25	7.6	31.45	5.43	0.065	0.013	
19	1°44’18.76”N	124°43’32.41”E	29	3.6	32.25	7.6	30.14	5.28	0.008	0.017	
20	1°43’37.56”N	124°43’34.43”E	29	4.5	33.25	7.5	30.86	5.17	0.007	0.014	
Average			29.15	3.58	32.39	7.51	31.052	5.43	0.034	0.015	
Minimum			28	2.2	28.24	7.1	29.45	3.24	0.004	0.008	
Maximum			31	4.7	36.25	7.9	32.65	6.35	0.068	0.019	

CONCLUSION

Based on the values of salinity, temperature, turbidity, pH, total suspended solids, dissolved oxygen, NO_3-N, and PO_4-P, the condition of Mantehage water quality obtained a suitable category within the specified standards of the Minister of Environment Decree No. 51 of 2004[24]. Several parameters known to exceed these provisions, including nitrate and phosphate content, indicate the instantaneous value during measurement. Therefore, an in-depth study, sufficient interval and sampling location to represent the spatial and temporal conditions of the entire island are greatly required. This outermost island generally appears suitable as a marine tourism attraction, particularly snorkelling and diving. Furthermore, the beauty of coral reefs is believed to be a major tourist object with the need for further encouragement.

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Significance statement

"This study discovered the condition of the seawater quality of Mantehage Island which can be developed as an underwater tourism location, the good status of coral reefs supported by underwater beauty makes Mantehage Island worthy of development, that can be beneficial for the government, researchers, and the people of Mantehage Island in developing tourism. This study will help the researchers to uncover the critical areas of the outermost small island of Indonesia that many researchers were not able to explore. Thus a new theory on the condition of seawater quality for the development of marine tourism may be arrived at".

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REFERENCES

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1. Tangian, D., Djokosetiyanto, D., Kholil, K., & Munandar, A. (2015). Model of Ecotourism Management in Small Islands of Bunaken National Park, North Sulawesi. *Journal of Indonesian Tourism and Development Studies*, *3*(2), 75-84.
https://jitode.ub.ac.id/index.php/jitode/article/view/156

2. Djamaluddin, R. (2018). The mangrove flora and their physical habitat characteristics in Bunaken National Park, North Sulawesi, Indonesia. *Biodiversitas Journal of Biological Diversity*, *19*(4), 1303-1312.
https://www.smujo.id/biodiv/article/view/2787

3. Opa E. T., Kusen J. D., Kepel R. C., Jusuf A., Lumingas L. J. L., 2019 Community structure of mangrove in Mantehage Island and Paniki Island, North Sulawesi, Indonesia. AACL Bioflux 12(4):1388-1403.
http://www.bioflux.com.ro/docs/2019.1388-1403.pdf

4. Kase A., Manembu I., Schaduw J.N.W. 2019. [Condition of Mantehage Island Coral Reef, North Minahasa Regency, North Sulawesi]. Journal of coastal and tropical seas. 7 (3) : 208-212.
Https://Doi.Org/10.35800/Jplt.7.3.2019.24466
https://ejournal.unsrat.ac.id/index.php/jplt/article/view/24466/24143

5. Schaduw J.N.W., Kondoy K.I.F., Manoppo V.E.N., Luasunaung A., Mudeng J., Pelle W.E., Ngangi E.L.A., Manembu I.S., Wantasen N.S., Sumilat D.A., Rumampuk N.D.C., Tilaar S.O., Manengkey H.W.A., Lintang R., Walalangi J.Y., Tampanguma B., Pungus F., Lahabu Y., Sagai B., Wantah E., Wantania L.L., Djabar B., Oli A.P., Caroles E.A., Bachmid F., Sasauw J., Kase A., Anthoni A., Uada A.D., Ladjandu R., Coloay C., Kojongian S., Mamangkey N.N.T. 2020. Data On Percentage Coral Reef Cover In Small Islands Bunaken National Park. Data in Brief, 31, 105713.
https://doi.org/10.1016/j.dib.2020.105713

6. Wagey B. T., Boneka F. B., Mantiri R., 2020 Status of marine biodiversity and community perception on marine conservation in Mantehage Island, Bunaken National Park, North Sulawesi, Indonesia. AACL Bioflux 13(6):3830- 3839.
http://www.bioflux.com.ro/docs/2020.3830-3839.pdf

7. Kalalo F. P., 2017 Law enforcement and conservation at Bunaken National Park, North Sulawesi, Indonesia as perceived by the local coastal communities. AACL Bioflux 10(6):1413-1420.

Commented [User8]: The author is advised to replace the reference with a peer-reviewed journal reference having the correct DOI and URL.

http://www.bioflux.com.ro/docs/2017.1413-1420.pdf
8. Schaduw J. N.W. and Kondoy K. F. I. 2020. Seagrass percent cover in small islands of Bunaken National Park, North Sulawesi Province, Indonesia. AACL Bioflux 13(2):951-957.
http://www.bioflux.com.ro/docs/2020.951-957.pdf
9. Schaduw J. N.W. 2018. [Distribution and Water Quality Characteristics of the Small Island Mangrove Ecosystem of Bunaken National Park]. Indonesian Geography Magazine. 32 (1) 40-49.
https://jurnal.ugm.ac.id/mgi/article/view/32204
https://doi.org/10.22146/mgi.32204
10. Kurniadi B., Sigid H., Enan M., Adiwilaga. 2015. [The waters Quality of the Buaya River in Bunyu Island, North Kalimantan in Tidal Conditions]. Indonesian Journal of Agricultural Sciences. 20 (1): 53-58.
https://journal.ipb.ac.id/index.php/JIPI/article/view/9289/7287
https://doi.org/10.35800/jasm.1.1.2013.1972
11. Haerudin and Putra A.M. 2019. Analysis of Seawater Quality Standards for the Development of Marine Tourism in Labuhan Haji Beach, East Lombok Regency. *Journal of Geodics 3(1) : 13 – 18*
https://e-journal.hamzanwadi.ac.id/index.php/gdk/article/view/1473
12. Indra N., Sari S., Rahayu G, Oktaviandra R., Handoko A., Putri V.S., Hanapi N.I. 2019. Environmental Quality and Suitability of Coastal Tourism in CarocokPainan Area, Pesisir Selatan Regency. Journal of Capita Selecta Geography 2 (5): 43- 51
http://ksgeo.ppj.unp.ac.id/index.php/ksgeo/article/view/251
https://doi.org/10.24036/ksgeo.v2i5.251
13. Saraswati N.G.R.A., Yulius., Rustam A., Hadiwijaya L., Salim., Heriati A., Mustikasari E. 2017. [Study of Water Quality for Coastal Marine Tourism, MoyoHilirSubdistrict and LapeSubdistrict, Sumbawa Regency]. Journal of Segara 13 (1) : 37-47.
http://ejournal-balitbang.kkp.go.id/index.php/segara/article/view/6421
http://dx.doi.org/10.15578/segara.v13i1.6421
14. Tanto T.A., Naelul N.H.R., Ilham. 2018. [Quality of Seawater to Support Marine Tourism and Marine Life. Case Study: Around the Sinking Ship of Sophie Rickmers, PrialaotSabang

Waters]. Marine Journal, 11 (2) : 173-183. https://journal.trunojoyo.ac.id/jurnalkelautan/article/view/4276 https://doi.org/10.21107/jk.v11i2.4276

15. Tambunan J.M., Anggoro S., Purnaweni H. 2013. [Study on Environmental Quality and Suitability of TanjungPesona Beach Tourism, Bangka Regency]. Proceedings of the National Seminar on Natural Resources and Environmental Management. pg 356-362.

16. Tomczak M. and Godfrey J. 2001. Regional Oceanography: An Introduction. Published Online.

17. Tanto T. A. and Kusumah G. 2016. [Seawater Quality Standards in Different Seasons]. Maspari Journal, 8 (2) : 135–146. [in Indonesian] https://ejournal.unsri.ac.id/index.php/maspari/article/view/3490 https://doi.org/10.36706/maspari.v8i2.3490

18. Mutmainah H. 2016.[Environmental Suitability Study for Tourism Development at Ganting Beach, Simeulue Island, Aceh Province]. Journal of DepikUnsyiah, 5 (1) : 19–30. http://jurnal.unsyiah.ac.id/depik/article/view/3844 https://doi.org/10.13170/depik.5.1.3844

19. Wilson P.C. 2010. Water Quality Notes: Water Clarity (Turbidity, Suspended Solids, and Color). Department of Soil and Water Science. University of Florida.

20. Simanjuntak M. 2012. Seawater Quality Judging from Nutrient Aspects, Dissolved Oxygen and Ph in Banggai Waters, Central Sulawesi. Journal of Tropical Marine Science and Technology. 4(2):290-303. https://journal.ipb.ac.id/index.php/jurnalikt/article/view/7791 https://doi.org/10.29244/jitkt.v4i2.7791

21. Arifin T., Bengen D.G., Pariwono J.I. 2002. Evaluation on the Suitability of the Palu Bay Coastal Zone for Marine Tourism Development. Coastal and Ocean Journal. 4 (2) : 25-35 https://repository.ipb.ac.id/jspui/bitstream/123456789/26592/1/Taslim%20Arifin_Herni%20%2811%20hal%29.pdf

22. Putra A., Tanto T.A., Pranowo W.S., Ilham., Damanhuri H., Suasti Y., Triyatno T. 2018. Suitability Of Coastal Ecotourism In Padang City-West Sumatera: Case Study Of Beach Recreation And Mangrove. Journal of Segara, 14 (2) : 87-94. http://ejournal-balitbang.kkp.go.id/index.php/segara/article/view/6642

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Commented [User11]: The author is advised to replace the reference with a peer-reviewed journal reference having the correct DOI and URL.

http://dx.doi.org/10.15578/segara.v14i2.6642

23. Wisha U.J., Tanto T.A., Ilham. 2016. Physical and Chemical Conditions of Bayur Bay Waters on the East and West Season.Journal of Marine Science UNDIP. 22 (1) : 15–24. https://ejournal.undip.ac.id/index.php/ijms/article/view/10505 doi:10.14710/ik.ijms.22.1.15-24 https://ejournal.unsrat.ac.id/index.php/lppmsains/article/view/10692

24. Minister of Environment Decree No. 51 of 2004 poses as a reference for the seawater quality standards. https://environmentalchemistry.files.wordpress.com/2013/08/kepmenlh-no-51-tahun-2004.pdf

Commented [User12]: The author is advised to replace the reference with a peer-reviewed journal reference having the correct DOI and URL.

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Seawater Quality Analysis in Mantehage Island for Integrated and Sustainable Marine Tourism Development

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Running title: Marine Tourism Development base on seawater quality in Mantehage Island

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Abstract

Background and Objective: There is a growing interest to significantly explore more opportunities in the coastal environment. For this reason, adequate progressive strategies appear very essential. The purpose of this study was to analyze seawater quality as a database for developing integrated and sustainable marine tourism in Mantehage Island, Indonesia. **Materials and Methods:** the present paper applied descriptive and quantitative methods to sample 20 observation points around the selected location. In addition, the seawater content was directly measured and stored in the laboratory for further analysis. Consequently, certain parameters were evaluated, including salinity, temperature, turbidity, pH, total suspended solids, dissolved oxygen, NO_3-N and PO_4-P. The subsequent data were also compared to the related quality standards of the Minister of Environment, Decree No. 51 of 2004. **Results**: Based on the results, Mantehage water quality demonstrated an excellent condition and is also believed to support the proposed marine tourism development. **Conclusion**: the values of salinity, temperature, turbidity, pH, total suspended solids, dissolved oxygen, NO_3-N, and PO_4-P, the condition of Mantehage water quality obtained a suitable category within the specified standards of the Minister of Environment Decree No. 51 of 2004. Several parameters known to exceed these provisions, including nitrate and phosphate content, indicate the instantaneous value during measurement

Keywords: Seawater quality; mantehage; marine tourism; development; small island, turbidity, salinity, dissolved oxygen

INTRODUCTION

The quality of seawater greatly determines the feasibility of an underwater tourism area, diving and snorkelling activities require good seawater conditions, this greatly affects the comfort and safety of tourists. Bunaken National Park exhibits high biodiversity, particularly in the Coral Triangle along the Asia Pacific region. The number of tourists visiting has a real connection with extensive coral cover. An increase in the number of tourist arrivals will affect the broad decline in coral cover and vice versa. Otherwise, the decline in coral cover will cause the number of tourists to decrease[1]. The underwater view is famous to foreign tourists around the world and encompasses five minor islands, including, Bunaken, Siladen, Manado Tua, Mantehage, and Nain. These 5 landmasses are divided into 2 administrative regions, including Manado city and North Minahasa regency. Mantehage is a major outermost island in Indonesia with the greatest

mangrove area in North Sulawesi, the mangrove flora in Bunaken National Park was floristically rich with at least 27 species, and the broader northern distribution limit of *L. littorea and L. racemosa, C. philippinense, S. ovata* was confirmed [2], The mangroves community structure shows that it is unstable with low values of diversity, and evenness, while the value of domination and species richness is high. The highest density of the mangroves found in station 9 is *C. tagal*. In general, mangroves species richness is found in the moderate category [3]. Moreover, the nature of the coral reef ecosystem serves as a potential underwater tourist attraction[4,5]. The condition of the coral reefs in Mantehage Island seen from the percentage of coral cover ranging from 20-40%, the condition of hard coral substrates accompanied by good water quality will support this island as a new marine tourism area[5]. This island also has a good seagrass ecosystem with an average cover percentage of 33%, there are four species of seagrass including *Enhalus acoroides, Thalassia hemprichii, Cymodocea rotundata, Halophila pinifolia*[8]. As far as can be ascertained, the marine biodiversity of Bunaken National Park is notably high. However, there seems to be a lack of a more comprehensive assessment, especially in Mantehage Island. To date, no comprehensive studies have been done on other marine fauna such as sea snakes, turtles, shorebirds, and marine mammals [6]. Another factor might be the establishment and management histories of BNP since management was principally initiated by the Indonesian national government (top-bottom approach) unlike in other well-known cases (e.g. Apo Island Reserve in the central Philippines) where protection was initiated and even to this day actively participated by the local communities [7]. Some important water quality parameters include salinity, temperature, turbidity, pH, total suspended solids, dissolved oxygen, NO3-N and PO4-P. Information about these parameters will be very helpful in the development of tourist areas. This research is probably a consideration for policymakers in determining the direction and strategies related to the management of coastal and marine resources, particularly for marine tourism development in Mantegehe.

The purpose of this study was to analyze the seawater quality as a database for the prospective development of marine tourism. In addition, the Minister of Environment Decree No. 51 of 2004 poses as a reference for the seawater quality standards.

MATERIALS AND METHODS

Study area: This research was conducted in Mantehage Island, Wori District, North Minahasa regency, North Sulawesi province, within Bunaken National Park from March-May 2021.

Research protocol: Descriptive and quantitative methods with purposive sampling were employed in determining the observational base. Each station possesses coordinate points for easy monitoring and is evenly distributed.

Parameters measurement: the measured seawater parameters were salinity, temperature, turbidity, pH, total suspended solids, dissolved oxygen, NO_3-N and PO_4-P. However, the sampling technique and data analysis adopted the methods[9,10].

Instruments used: The instrument used in this study is horibaU-50 series multi-parameter water quality checker that enables to measure and indicate the monitoring result simultaneously up to 11 parameters with one unit. Considering user-friendly field monitoring on-site, such as rive, groundwater, drainage water, etc. bring together feature of function and performance, which makes simple operation for everybody. Multiple sensors allow for the measurement of 11 parameters simultaneously (pH, pH(mv), ORP, DO, COND, Salinity, TDS, Seawater Specific Gravity, Temperature, Turbidity, Water Depth). For NO3-N and PO4-P analysis, seawater samples were put into glass bottles, then brought to the laboratory for further analysis. Subsequently, the results were compared to the Minister of Environment Decree No. 51 of 2004 as a reference for seawater quality standards.

RESULTS AND DISCUSSION

Salinity: Salinity is described as the total amount of dissolved salt in seawater. The unit is generally accepted in mg/L but also occurs in ppt (parts per thousand) or o/oo and practical salinity unit (PSU). Freshwater salinity values are typically <0.5 o/oo, brackish waters 0.5 - 30 o/oo, and seawaters 30-40 o/oo. Meanwhile, the estimate for coastal waters is strongly influenced by freshwater input from rivers. However, salinity potentially instigates osmotic pressure in seawater biota. The salt content in the aquatic cells occurs close to the surrounding seawater salinity. As the salinity changes, an osmoregulation mechanism is then required in balancing the salt levels between the cells and the environment. Mantehage Island shows a salinity range of 28 - 31 PSU, with an average of 29.15 PSU (Table 1). This value varies based on the climate/weather during measurement. In the dry season, seawater salinity rises above 30 PSU. Rainy weather

condition was observed on the day before sampling, resulting in a lesser salinity value but showed good category, according to seawater quality standards. This salinity condition is not only good for tourism activities but also for the sustainability of the surrounding aquatic biota.

Temperature

Temperature influences the metabolic activity and reproduction of marine organisms. This factor is used in a certain tourist destination to determine the potential and existence of coral reef growth[11]. In marine life development, the optimal average temperature is expected in the range of 23^0-35^0C with tolerance limits between 36-40°C. The seawater temperature of Mantehage Island occurs from 28-31°C with an average value of 29.15 °C (Table. 1). These conditions are convenient as quality standards for tourism development activities and underwater biota sustainability. In addition, the temperatures are identical to the average value at CarocokPainan Beach between 29-31 ºC, and also show related suitability[12]. Furthermore, a similar condition was observed in the coastal waters of Labuhan Haji, East Lombok regency, with a range of 30-32 ºC[11]. The results of temperature measurements in MoyoHilir and Lape Districts occurred between 29.20-31.57 ºC[13], in contrast to the temperature of Prialaot waters at 29-31.4 °C, with an average of 29.22° C[14]. However, temperature variations tend to influence the life of coral reefs. Based on the Minister of Environment Decree No. 51 of 2004, the water temperature for marine tourism is expected at natural temperature. An appropriate range for coral reef areas exists in the range of 28-30 ºC and 28-32 ºC for mangrove regions. Discontinue in situ temperature measurement is a natural temperature with a change tolerance <2° C (Minister of Environment Decree No. 51 of 2004). However, the biota in tropical waters naturally resides in the upper limit of the highest temperature. These variations possibly interfere with the physiological processes known to endanger the biota. In the value range> 28 °C, sea surface temperature in the western equator appears very warm[15]. Moreover, the condition is considered natural as Indonesia is a tropical region. Based on the water depth, extensive seawater surface temperatures are observed, in comparison to a certain depth, probably due to the high intensity of sunlight.

Turbidity

Lower turbidity increases the light intensity capable of penetrating the water depth. Therefore, the resulting value is expected to exist under normal conditions, where water transparency is inversely proportional to the turbidity, believed to significantly influence oxygen content. Turbid

water possibly interferes with the respiration process and decreases the oxygen levels. The seawater turbidity condition of Mantehage Island ranges between 2.2-4.7 NTU, with an average value of 3.58 NTU (Table. 1), indicating an appropriate category and in line with the quality standards. Therefore, the site is suitable as a potential tourist attraction. This condition is supported by data on Mantehage Island coral reef cover in the range of 19-30%, with an average live coral cover of 29.10%[5]. Furthermore, turbidity describes inadequate water transparency, due to colloidal and suspended materials, including mud, organic and inorganic materials as well as aquatic microorganisms. This circumstance varies from the observations in Prialaot waters with an average value of 0.08 NTU[14], in addition to MoyoHilir and Lape Districts ranging from 0-23.3 NTU[13].

pH level

Inconsistencies in the water pH level probably influence biota existence to a certain extent of varying pH[16]. The water pH value depends on carbon dioxide and ion concentrations. Moreover, the parameter plays a significant role in the solubility of particular compounds, although appears minimal in the morning, compared to the afternoon period[17]. Subsequently, the pH of Mantehage Island seawater ranges from 7.1-7.9, with an average value of 7.51, indicating an appropriate category for tourism development and aquatic life support (Table. 1). This value also corresponds to a pH in Labuhan Haji beach between 7.6 - 7.9[11]. Meanwhile, for CarocokPainan beach, the estimate occurred between 7-8[12]. These values varied slightly from Moyo and Lape districts from 7.96 - 8.12[13], as well as in Prialaot waters by 7.64 - 8.36[14]. These variations depend on geographic position and water injection from the environment. In addition, it is also affected by the season as related to local rainfall and climate.

Total Suspended Solid (TSS)

The TSS of Mantehage Island waters ranged from 28.24-36.25 mg/L with an average value of 32.39 mg/L, corresponding to the quality standard for biota survival (Table 1). However, in-depth study and sampling of other seasons are required for tourism development, particularly underwater ecotourism, considering the present research was only conducted in one season without repetition. This high TSS value is due to the greatest mangrove forest in Bunaken National Park, and therefore sedimentation in certain segments is inevitable. This varies from the TSS of Prialaot waters at the range of 14 - 31 mg/L, with an average of 21.83 mg/L. Also, the

value is generally above the standards allowed for marine tourism (20 mg/L) and marine life (coral and seagrass by 20 mg/L, mangroves by 80 mg/L)[14]. Similarly, the TSS of Labuhan Haji beach also demonstrated a fairly higher content, ranging from 14 - 31 mg/L, with an average of 21.83 mg/L. This value is also above the quality standard allowed for marine tourism (20 mg/L) and marine life (coral and seagrass at 20 mg/L, and mangroves at 80 mg/L)[11].

Dissolved Oxygen (DO)

The dissolved oxygen source in water originates from the diffusion of oxygen from the air, water currents or flow through rainwater, as well as photosynthetic activity by aquatic plants and phytoplankton. Generally, aquatic creatures, e.g fish, shrimp, shellfish, and other animals, including microorganisms, e.g bacteria, require oxygen. Dissolved oxygen (DO) regulates the metabolism of organisms to grow and reproduce. Fish need water with an oxygen content of at least 5 mg/L. The DO values in Mantehage waters ranged from 3.24-6.35 mg/L, with an average of 5.43 mg/L (Table 1). This indicates a suitable oxygen content capable of supporting marine biota. Moreover, seawater quality standards for tourism and healthy ecological activities require DO values above 5mg/L. The condition supports the seagrass survival, covering 33% of the island[8], and also matches the results of dissolved oxygen (DO) measurements performed at Labuhan Haji beach, where the total stations obtained a yield range of 6 mg/L. Also, the value shows an excellent water condition and relatively suffices the seawater quality standards[11]. Furthermore, dissolved oxygen describes the relative concentration of the element in water within the range of 4.28-10 mg/L[18]. In addition, the average dissolved oxygen in PantaiCarocokPainan occurs between 5.75-9.1 mg/L, and is suitable for marine tourism activities[12]. Conversely, the DO for the entire stations in the Saleh Bay waters ranges from 4.78-6.01 mg/L[14]. The measured DO value of PrialaotSabang ranged from 4.4-4.69 mg/L, with an average of 4.53 mg/L. However, at sea level, DO values are influenced by the diffusion of oxygen from the air and the photosynthetic rate by marine plants[19].

Salinity

A particular salinity level is required for coral reefs and seagrass survival towards attracting marine tourism objects, including snorkelling and diving. The salinity range of Mantehage Island waters occurs between 29.45-32.65 ‰, with an average value of 31.05 ‰ (Table. 1). This

estimation indicates a suitable category within the applicable quality standards. Salinity plays an essential role in supporting marine biota and the water level varies based on geography and time, where the increase in the parameter is caused by evaporation and the result of freezing sea ice, while the decrease is instigated by precipitation and freshwater input from rivers. This outcome slightly varies from the measurement results at Labuhan Haji beach, showing a salinity range of 32-35 ‰[11]. Subsequently, the value for PataiCarocokPainan waters also obtained an average range of 30-31 ‰[12] Meanwhile, Saleh Bay water occurs between 27.17-30.67 ‰ [13], and 21.6-32.3 ‰ for Prialaot, with a general average of 31.27 ‰[14]. However, the salinity value to promote coral reef life is expected to range from 30-36 ‰[11]. This difference is influenced by geographical position and water type. Furthermore, stable salinity in the archipelago tends to be achieved, due to inadequate water inflow from the mainland. In addition, the value is also greatly impacted by evaporation and precipitation rates.

Nitrate

The nitrate content in the Mantehage waters ranges from 0.004-0.068 mg/L at an average of 0.034 mg/L (Table 1). This value exceeded the quality standard of the Minister of Environment and Forestry Decree No. 51 of 2004, estimated at 0.008 mg/L. In addition, the extreme result is influenced by the mangrove ecosystem located on the coastal part of the island, where sedimentation is very extensive during the rainy season. An additional indicator is also due to poor mangrove management, leading to free waste from anthropogenic activities entering the aquatic environment. The high concentration of nitrate is probably due to input from land and surrounding factors in the form of liquid waste, both due to agricultural operations. Moreover, the primary ingredient of fertilizers is nitrogen, known to utilize a bio-physicochemical process to become a compound. In marine waters, six types of nitrogen are formed, termed N_2, NO_3, NO_2, NH_3, NH_4, organic N and particulate N. Meanwhile, in the aerobic atmosphere, the nitrogen species generated is the NO_3, as one of the constituents consumed by marine biota, including phytoplankton for growth of 3.9- 15.5 mg/L[13]. This outcome corresponds to the analysis results of the NO_3 at Labuhan Haji beach, with similar content of 0.036 mg/L. Also, the nitrate (NO3) at Labuhan Haji appears relatively high due to community activities on the coast/land, where unwanted materials are directly and inappropriately disposed into the sea. In addition, the

existence of river water flowing into the beach also serves as a transportation medium for agricultural waste and other human activities related to the sea [11].

Phosphate

The phosphate content in Mantehage waters ranges from 0.008-0.019 mg/L at an average of 0.015 mg/L (Table. 1). This value is under the specified quality standard for marine tourism at 0.015 mg/L, based on the Minister of Environment Decree No. 51 of 2004. However, the estimate varied from the measurement results in MoyoHilir and Lape sub-districts, between 0.03-0.3 mg/L. Extensive land activities are believed to trigger the phosphate content beyond the quality standard, including livestock, agricultural operations, and the landfill existence in the coastal areas. Moreover, organic waste disposal, e.g detergents, fertilizers, and degradable materials tend to generate phosphate. In marine waters, the greatest phosphate compound is ortho-phosphate as the substance undergoes hydrolysis with a percentage fraction depending on the water pH and temperature[13].

This research implies that the involvement of academics through this study is very helpful for policymakers in developing strategies for developing Mantehage island tourism areas. The data of this study can be applied in determining the best location for snorkelling and diving areas, Mantehage Island is very feasible to be developed as a marine tourism location because it is supported by very good water conditions and following environmental quality standards. This study has limitations in research time, where the sample is only taken in one season, does not represent another season, besides that this study has not studied the overall condition of the oceanographic parameters.

Table 1. Seawater Quality Parameters in Mantehage Island.

Station	Coordinate		Temperature	Turbidity	TSS	pH	Salinity	DO	NO3-N	PO4-P	Parameter
	Latitude	Longitude	28-32	< 5	80	7-8.5[(d)]	<34	>5	0.008	0.015	Biota quality standards
			alami	< 5	20	7-8.5[(d)]	alami[3](e)	>5	0.008	0.015	Tourism quality standards
			C	NTU	mg/L	pH	PSU	mg/L	mg/L	mg/L	Unit quality standards
1	1°42'49.04"N	124°43'44.57"E	29	3.21	31.20	7.2	30.21	5.23	0.005	0.010	Decree of the Minister of Environment of the Republic of Indonesia No 51 of 2004
2	1°42'27.10"N	124°44'10.46"E	30	4.25	29.25	7.6	31.26	5.47	0.025	0.011	
3	1°42'5.66"N	124°44'28.58"E	28	3.2	33.65	7.4	31.25	5.65	0.045	0.016	
4	1°41'49.04"N	124°44'54.55"E	29	2.2	35.25	7.8	30.45	5.14	0.006	0.018	
5	1°41'39.27"N	124°45'22.47"E	30	3.2	30.56	7.5	29.45	5.98	0.068	0.014	
6	1°41'29.02"N	124°45'49.90"E	28	4.7	32.00	7.4	30.87	6.12	0.065	0.013	
7	1°41'37.80"N	124°46'31.55"E	28	3.6	33.63	7.6	32.14	3.24	0.058	0.015	
8	1°41'59.04"N	124°47'4.83"E	28	2.8	32.63	7.9	30.45	6.35	0.009	0.019	
9	1°42'29.46"N	124°47'1.90"E	30	4	34.24	7.1	31.56	5.21	0.004	0.018	
10	1°43'9.12"N	124°46'41.67"E	30	4.1	32.13	7.4	30.25	5.98	0.008	0.017	
11	1°43'35.87"N	124°46'26.20"E	30	3.2	33.26	7.5	31.25	5.87	0.025	0.009	
12	1°44'29.95"N	124°46'15.18"E	29	4.5	31.00	7.6	30.87	5.46	0.054	0.008	
13	1°44'58.36"N	124°45'57.12"E	30	2.5	31.27	7.1	31.63	5.21	0.066	0.016	
14	1°45'19.63"N	124°45'38.18"E	31	3.8	33.36	7.5	32.65	5.69	0.042	0.014	
15	1°45'51.74"N	124°45'15.50"E	29	4.7	36.25	7.8	32.4	5.19	0.061	0.018	
16	1°46'14.93"N	124°44'9.69"E	28	3.5	35.21	7.5	31.25	5.38	0.019	0.016	
17	1°45'24.98"N	124°43'48.02"E	30	3.4	28.24	7.6	30.65	5.67	0.048	0.014	
18	1°44'51.67"N	124°43'41.78"E	28	2.8	29.25	7.6	31.45	5.43	0.065	0.013	
19	1°44'18.76"N	124°43'32.41"E	29	3.6	32.25	7.6	30.14	5.28	0.008	0.017	
20	1°43'37.56"N	124°43'34.43"E	29	4.5	33.25	7.5	30.86	5.17	0.007	0.014	
Average			29.15	3.58	32.39	7.51	31.052	5.43	0.034	0.015	
Minimum			28	2.2	28.24	7.1	29.45	3.24	0.004	0.008	
Maximum			31	4.7	36.25	7.9	32.65	6.35	0.068	0.019	

CONCLUSION

Based on the values of salinity, temperature, turbidity, pH, total suspended solids, dissolved oxygen, NO_3-N, and PO_4-P, the condition of Mantehage water quality obtained a suitable category within the specified standards of the Minister of the Environment Republic of Indonesia. Several parameters known to exceed these provisions, including nitrate and phosphate content, indicate the instantaneous value during measurement. Therefore, an in-depth study, sufficient interval and sampling location to represent the spatial and temporal conditions of the entire island are greatly required. This outermost island generally appears suitable as a marine tourism attraction, particularly snorkelling and diving. Furthermore, the beauty of coral reefs is believed to be a major tourist object with the need for further encouragement. Mantehage Island is very feasible to be developed as a marine tourism area, especially for snorkelling and diving activities, underwater beauty, high biodiversity and supported by good water conditions make this island attractive to tourists.

Significance statement

"This study discovered the condition of the seawater quality of Mantehage Island which can be developed as an underwater tourism location, the good status of coral reefs supported by underwater beauty makes Mantehage Island worthy of development, that can be beneficial for the government, researchers, and the people of Mantehage Island in developing tourism. This study will help the researchers to uncover the critical areas of the outermost small island of Indonesia that many researchers were not able to explore. Thus a new theory on the condition of seawater quality for the development of marine tourism may be arrived at".

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REFERENCES

1. Tangian, D., Djokosetiyanto, D., Kholil, K., & Munandar, A. (2015). Model of Ecotourism Management in Small Islands of Bunaken National Park, North Sulawesi. *Journal of Indonesian Tourism and Development Studies*, *3*(2), 75-84.
https://jitode.ub.ac.id/index.php/jitode/article/view/156

2. Djamaluddin, R. (2018). The mangrove flora and their physical habitat characteristics in Bunaken National Park, North Sulawesi, Indonesia. *Biodiversitas Journal of Biological Diversity*, *19*(4), 1303-1312.
https://www.smujo.id/biodiv/article/view/2787

3. Opa E. T., Kusen J. D., Kepel R. C., Jusuf A., Lumingas L. J. L., 2019 Community structure of mangrove in Mantehage Island and Paniki Island, North Sulawesi, Indonesia. AACL Bioflux 12(4):1388-1403.
http://www.bioflux.com.ro/docs/2019.1388-1403.pdf

4. Kase A., Manembu I., Schaduw J.N.W. 2019. [Condition of Mantehage Island Coral Reef, North Minahasa Regency, North Sulawesi]. Journal of coastal and tropical seas. 7 (3) : 208-212.
Https://Doi.Org/10.35800/Jplt.7.3.2019.24466
https://ejournal.unsrat.ac.id/index.php/jplt/article/view/24466/24143

5. Schaduw J.N.W., Kondoy K.I.F., Manoppo V.E.N., Luasunaung A., Mudeng J., Pelle W.E., Ngangi E.L.A., Manembu I.S., Wantasen N.S., Sumilat D.A., Rumampuk N.D.C., Tilaar S.O., Manengkey H.W.A., Lintang R., Walalangi J.Y., Tampanguma B., Pungus F., Lahabu Y., Sagai B., Wantah E., Wantania L.L., Djabar B., Oli A.P., Caroles E.A., Bachmid F., Sasauw J., Kase A., Anthoni A., Uada A.D., Ladjandu R., Coloay C., Kojongian S., Mamangkey N.N.T. 2020. Data On Percentage Coral Reef Cover In Small Islands Bunaken National Park. Data in Brief, 31, 105713.
https://doi.org/10.1016/j.dib.2020.105713
https://www.sciencedirect.com/science/article/pii/S2352340920306077?via%3Dihub

6. Wagey B. T., Boneka F. B., Mantiri R., 2020 Status of marine biodiversity and community perception on marine conservation in Mantehage Island, Bunaken National Park, North Sulawesi, Indonesia. AACL Bioflux 13(6):3830- 3839.

http://www.bioflux.com.ro/docs/2020.3830-3839.pdf

7. Kalalo F. P., 2017 Law enforcement and conservation at Bunaken National Park, North Sulawesi, Indonesia as perceived by the local coastal communities. AACL Bioflux 10(6):1413-1420.

http://www.bioflux.com.ro/docs/2017.1413-1420.pdf

8. Schaduw J. N.W. and Kondoy K. F. I. 2020. Seagrass percent cover in small islands of Bunaken National Park, North Sulawesi Province, Indonesia. AACL Bioflux 13(2):951-957.

http://www.bioflux.com.ro/docs/2020.951-957.pdf

9. Schaduw J. N.W. 2018. [Distribution and Water Quality Characteristics of the Small Island Mangrove Ecosystem of Bunaken National Park]. Indonesian Geography Magazine. 32 (1) 40-49.

https://jurnal.ugm.ac.id/mgi/article/view/32204

https://doi.org/10.22146/mgi.32204

10. Kurniadi B., Sigid H., Enan M., Adiwilaga. 2015. [The waters Quality of the Buaya River in Bunyu Island, North Kalimantan in Tidal Conditions]. Indonesian Journal of Agricultural Sciences. 20 (1): 53-58.

https://journal.ipb.ac.id/index.php/JIPI/article/view/9289/7287

https://doi.org/10.35800/jasm.1.1.2013.1972

11. Haerudin and Putra A.M. 2019. Analysis of Seawater Quality Standards for the Development of Marine Tourism in Labuhan Haji Beach, East Lombok Regency. *Journal of Geodics 3(1) : 13 – 18*

https://e-journal.hamzanwadi.ac.id/index.php/gdk/article/view/1473

12. Indra N., Sari S., Rahayu G, Oktaviandra R., Handoko A., Putri V.S., Hanapi N.I. 2019. Environmental Quality and Suitability of Coastal Tourism in CarocokPainan Area, Pesisir Selatan Regency. Journal of Capita Selecta Geography 2 (5): 43- 51

http://ksgeo.ppj.unp.ac.id/index.php/ksgeo/article/view/251

https://doi.org/10.24036/ksgeo.v2i5.251

13. Saraswati N.G.R.A., Yulius., Rustam A., Hadiwijaya L., Salim., Heriati A., Mustikasari E. 2017. [Study of Water Quality for Coastal Marine Tourism, MoyoHilirSubdistrict and LapeSubdistrict, Sumbawa Regency]. Journal of Segara 13 (1) : 37-47.

http://ejournal-balitbang.kkp.go.id/index.php/segara/article/view/6421

http://dx.doi.org/10.15578/segara.v13i1.6421

14. Tanto T.A., Naelul N.H.R., Ilham. 2018. [Quality of Seawater to Support Marine Tourism and Marine Life. Case Study: Around the Sinking Ship of Sophie Rickmers, PrialaotSabang Waters]. Marine Journal, 11 (2) : 173-183.
https://journal.trunojoyo.ac.id/jurnalkelautan/article/view/4276
https://doi.org/10.21107/jk.v11i2.4276

15. Tomczak M. and Godfrey J. 2001. Regional Oceanography: An Introduction. Pergamon. ISBN : 9781483287614 https://www.elsevier.com/books/regional-oceanography/tomczak/978-0-08-041021-0

16. Simanjuntak M. 2012. Seawater Quality Judging from Nutrient Aspects, Dissolved Oxygen and Ph in Banggai Waters, Central Sulawesi. Journal of Tropical Marine Science and Technology. 4(2):290-303.
https://journal.ipb.ac.id/index.php/jurnalikt/article/view/7791
https://doi.org/10.29244/jitkt.v4i2.7791

17. Arifin T., Bengen D.G., Pariwono J.I. 2002. Evaluation on the Suitability of the Palu Bay Coastal Zone for Marine Tourism Development. Coastal and Ocean Journal. 4 (2) : 25-35
https://repository.ipb.ac.id/jspui/bitstream/123456789/26592/1/Taslim%20Arifin_Herni%20%2811%20hal%29.pdf

18. Putra A., Tanto T.A., Pranowo W.S., Ilham., Damanhuri H., Suasti Y., Triyatno T. 2018. Suitability Of Coastal Ecotourism In Padang City-West Sumatera: Case Study Of Beach Recreation And Mangrove. Journal of Segara, 14 (2) : 87-94.
http://ejournal-balitbang.kkp.go.id/index.php/segara/article/view/6642
http://dx.doi.org/10.15578/segara.v14i2.6642

19. Wisha U.J., Tanto T.A., Ilham. 2016. Physical and Chemical Conditions of Bayur Bay Waters on the East and West Season.Journal of Marine Science UNDIP. 22 (1) : 15–24.
https://ejournal.undip.ac.id/index.php/ijms/article/view/10505
doi:10.14710/ik.ijms.22.1.15-24
https://ejournal.unsrat.ac.id/index.php/lppmsains/article/view/10692

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Seawater Quality Analysis in Mantehage Island for Integrated and Sustainable Marine Tourism Development

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Abstract

Background and Objective: There is a growing interest to significantly explore more opportunities in the coastal environment. For this reason, adequate progressive strategies appear very essential. The purpose of this study was to analyze seawater quality as a database for developing integrated and sustainable marine tourism in Mantehage Island, Indonesia. **Materials and Methods:** the present paper applied descriptive and quantitative methods to sample 20 observation points around the selected location. In addition, the seawater content was directly measured and stored in the laboratory for further analysis. Consequently, certain parameters were evaluated, including salinity, temperature, turbidity, pH, total suspended solids, dissolved oxygen, NO_3-N and PO_4-P. The subsequent data were also compared to the related quality standards of the Minister of Environment, Decree No. 51 of 2004. **Results**: Based on the results, Mantehage water quality demonstrated an excellent condition and is also believed to support the proposed marine tourism development. **Conclusion**: the values of salinity, temperature, turbidity, pH, total suspended solids, dissolved oxygen, NO_3-N, and PO_4-P, the condition of Mantehage water quality obtained a suitable category within the specified standards of the Minister of Environment Decree No. 51 of 2004. Several parameters known to exceed these provisions, including nitrate and phosphate content, indicate the instantaneous value during measurement

Keywords: Seawater quality; mantehage; marine tourism; development; small island, turbidity, salinity, dissolved oxygen

INTRODUCTION

The quality of seawater greatly determines the feasibility of an underwater tourism area, diving and snorkelling activities require good seawater conditions, this greatly affects the comfort and safety of tourists. Bunaken National Park exhibits high biodiversity, particularly in the Coral Triangle along the Asia Pacific region. The number of tourists visiting has a real connection with extensive coral cover. An increase in the number of tourist arrivals will affect the broad decline in coral cover and vice versa. Otherwise, the decline in coral cover will cause the number of tourists to decrease[1]. The underwater view is famous to foreign tourists around the world and encompasses five minor islands, including, Bunaken, Siladen, Manado Tua, Mantehage, and Nain. These 5 landmasses are divided into 2 administrative regions, including Manado city and North Minahasa regency. Mantehage is a major outermost island in Indonesia with the greatest mangrove area in North Sulawesi, the mangrove flora in Bunaken National Park was floristically

rich with at least 27 species, and the broader northern distribution limit of *L. littorea and L. racemosa, C. philippinense, S. ovata* was confirmed [2]. The mangroves community structure shows that it is unstable with low values of diversity, and evenness, while the value of domination and species richness is high. The highest density of the mangroves found in station 9 is *C. tagal*. In general, mangroves species richness is found in the moderate category [3]. Moreover, the nature of the coral reef ecosystem serves as a potential underwater tourist attraction [4,5]. The condition of the coral reefs in Mantehage Island seen from the percentage of coral cover ranging from 20-40%, the condition of hard coral substrates accompanied by good water quality will support this island as a new marine tourism area [5]. This island also has a good seagrass ecosystem with an average cover percentage of 33%, there are four species of seagrass including *Enhalus acoroides, Thalassia hemprichii, Cymodocea rotundata, Halophila pinifolia* [8]. As far as can be ascertained, the marine biodiversity of Bunaken National Park is notably high. However, there seems to be a lack of a more comprehensive assessment, especially in Mantehage Island. To date, no comprehensive studies have been done on other marine fauna such as sea snakes, turtles, shorebirds, and marine mammals [6]. Another factor might be the establishment and management histories of BNP since management was principally initiated by the Indonesian national government (top-bottom approach) unlike in other well-known cases (e.g. Apo Island Reserve in the central Philippines) where protection was initiated and even to this day actively participated by the local communities [7]. Some important water quality parameters include salinity, temperature, turbidity, pH, total suspended solids, dissolved oxygen, NO3-N and PO4-P. Information about these parameters will be very helpful in the development of tourist areas. This research is probably a consideration for policymakers in determining the direction and strategies related to the management of coastal and marine resources, particularly for marine tourism development in Mantegehe.

The purpose of this study was to analyze the seawater quality as a database for the prospective development of marine tourism. In addition, the Minister of Environment Decree No. 51 of 2004 poses as a reference for the seawater quality standards.

MATERIALS AND METHODS

Study area: This research was conducted in Mantehage Island, Wori District, North Minahasa regency, North Sulawesi province, within Bunaken National Park from March-May 2021.

Research protocol: Descriptive and quantitative methods with purposive sampling were employed in determining the observational base. Each station possesses coordinate points for easy monitoring and is evenly distributed.

Parameters measurement: the measured seawater parameters were salinity, temperature, turbidity, pH, total suspended solids, dissolved oxygen, NO_3-N and PO_4-P. However, the sampling technique and data analysis adopted the methods[9,10].

Instruments used: The instrument used in this study is horibaU-50 series multi-parameter water quality checker that enables to measure and indicate the monitoring result simultaneously up to 11 parameters with one unit. Considering user-friendly field monitoring on-site, such as rive, groundwater, drainage water, etc. bring together feature of function and performance, which makes simple operation for everybody. Multiple sensors allow for the measurement of 11 parameters simultaneously (pH, pH(mv), ORP, DO, COND, Salinity, TDS, Seawater Specific Gravity, Temperature, Turbidity, Water Depth). For NO3-N and PO4-P analysis, seawater samples were put into glass bottles, then brought to the laboratory for further analysis. Subsequently, the results were compared to the Minister of Environment Decree No. 51 of 2004 as a reference for seawater quality standards.

RESULTS AND DISCUSSION

Salinity: Salinity is described as the total amount of dissolved salt in seawater. The unit is generally accepted in mg/L but also occurs in ppt (parts per thousand) or o/oo and practical salinity unit (PSU). Freshwater salinity values are typically <0.5 o/oo, brackish waters 0.5 - 30 o/oo, and seawaters 30-40 o/oo. Meanwhile, the estimate for coastal waters is strongly influenced by freshwater input from rivers. However, salinity potentially instigates osmotic pressure in seawater biota. The salt content in the aquatic cells occurs close to the surrounding seawater salinity. As the salinity changes, an osmoregulation mechanism is then required in balancing the salt levels between the cells and the environment. Mantehage Island shows a salinity range of 28 - 31 PSU, with an average of 29.15 PSU (Table 1). This value varies based on the climate/weather during measurement. In the dry season, seawater salinity rises above 30 PSU. Rainy weather condition was observed on the day before sampling, resulting in a lesser salinity value but showed good category, according to seawater quality standards. This salinity condition is not only good for tourism activities but also for the sustainability of the surrounding aquatic biota.

Temperature

Temperature influences the metabolic activity and reproduction of marine organisms. This factor is used in a certain tourist destination to determine the potential and existence of coral reef growth[11]. In marine life development, the optimal average temperature is expected in the range of 23^0-35^0C with tolerance limits between 36-40°C. The seawater temperature of Mantehage Island occurs from 28-31°C with an average value of 29.15 °C (Table. 1). These conditions are convenient as quality standards for tourism development activities and underwater biota sustainability. In addition, the temperatures are identical to the average value at CarocokPainan Beach between 29-31 ºC, and also show related suitability[12]. Furthermore, a similar condition was observed in the coastal waters of Labuhan Haji, East Lombok regency, with a range of 30-32 ºC[11]. The results of temperature measurements in MoyoHilir and Lape Districts occurred between 29.20-31.57 ºC[13], in contrast to the temperature of Prialaot waters at 29-31.4 °C, with an average of 29.22° C[14]. However, temperature variations tend to influence the life of coral reefs[15]. Based on the Minister of Environment Decree No. 51 of 2004, the water temperature for marine tourism is expected at natural temperature. An appropriate range for coral reef areas exists in the range of 28-30 ºC and 28-32 ºC for mangrove regions. Discontinue in situ temperature measurement is a natural temperature with a change tolerance <2° C (Minister of Environment Decree No. 51 of 2004). However, the biota in tropical waters naturally resides in the upper limit of the highest temperature. These variations possibly interfere with the physiological processes known to endanger the biota. In the value range> 28 °C, sea surface temperature in the western equator appears very warm[16]. Moreover, the condition is considered natural as Indonesia is a tropical region. Based on the water depth, extensive seawater surface temperatures are observed, in comparison to a certain depth, probably due to the high intensity of sunlight[15].

Turbidity

Lower turbidity increases the light intensity capable of penetrating the water depth[17]. Therefore, the resulting value is expected to exist under normal conditions, where water transparency is inversely proportional to the turbidity, believed to significantly influence oxygen content. Turbid water possibly interferes with the respiration process and decreases the oxygen levels[18]. The seawater turbidity condition of Mantehage Island ranges between 2.2-4.7 NTU, with an average value of 3.58 NTU (Table. 1), indicating an appropriate category and in line with the quality

standards. Therefore, the site is suitable as a potential tourist attraction. This condition is supported by data on Mantehage Island coral reef cover in the range of 19-30%, with an average live coral cover of 29.10%[5]. Furthermore, turbidity describes inadequate water transparency, due to colloidal and suspended materials, including mud, organic and inorganic materials as well as aquatic microorganisms[19]. This circumstance varies from the observations in Prialaot waters with an average value of 0.08 NTU[14], in addition to MoyoHilir and Lape Districts ranging from 0-23.3 NTU[13].

pH level

Inconsistencies in the water pH level probably influence biota existence to a certain extent of varying pH[20]. The water pH value depends on carbon dioxide and ion concentrations. Moreover, the parameter plays a significant role in the solubility of particular compounds, although appears minimal in the morning, compared to the afternoon period[21]. Subsequently, the pH of Mantehage Island seawater ranges from 7.1-7.9, with an average value of 7.51, indicating an appropriate category for tourism development and aquatic life support (Table. 1). This value also corresponds to a pH in Labuhan Haji beach between 7.6 - 7.9[11]. Meanwhile, for CarocokPainan beach, the estimate occurred between 7-8[12]. These values varied slightly from Moyo and Lape districts from 7.96 - 8.12[13], as well as in Prialaot waters by 7.64 - 8.36[14]. These variations depend on geographic position and water injection from the environment. In addition, it is also affected by the season as related to local rainfall and climate.

Total Suspended Solid (TSS)

The TSS of Mantehage Island waters ranged from 28.24-36.25 mg/L with an average value of 32.39 mg/L, corresponding to the quality standard for biota survival (Table 1). However, in-depth study and sampling of other seasons are required for tourism development, particularly underwater ecotourism, considering the present research was only conducted in one season without repetition. This high TSS value is due to the greatest mangrove forest in Bunaken National Park, and therefore sedimentation in certain segments is inevitable. This varies from the TSS of Prialaot waters at the range of 14 - 31 mg/L, with an average of 21.83 mg/L. Also, the value is generally above the standards allowed for marine tourism (20 mg/L) and marine life (coral and seagrass by 20 mg/L, mangroves by 80 mg/L)[14]. Similarly, the TSS of Labuhan Haji beach also demonstrated a fairly higher content, ranging from 14 - 31 mg/L, with an average of

21.83 mg/L. This value is also above the quality standard allowed for marine tourism (20 mg/L) and marine life (coral and seagrass at 20 mg/L, and mangroves at 80 mg/L)[11].

Dissolved Oxygen (DO)

The dissolved oxygen source in water originates from the diffusion of oxygen from the air, water currents or flow through rainwater, as well as photosynthetic activity by aquatic plants and phytoplankton. Generally, aquatic creatures, e.g fish, shrimp, shellfish, and other animals, including microorganisms, e.g bacteria, require oxygen. Dissolved oxygen (DO) regulates the metabolism of organisms to grow and reproduce. Fish need water with an oxygen content of at least 5 mg/L. The DO values in Mantehage waters ranged from 3.24-6.35 mg/L, with an average of 5.43 mg/L (Table 1). This indicates a suitable oxygen content capable of supporting marine biota. Moreover, seawater quality standards for tourism and healthy ecological activities require DO values above 5mg/L. The condition supports the seagrass survival, covering 33% of the island[8], and also matches the results of dissolved oxygen (DO) measurements performed at Labuhan Haji beach, where the total stations obtained a yield range of 6 mg/L. Also, the value shows an excellent water condition and relatively suffices the seawater quality standards[11]. Furthermore, dissolved oxygen describes the relative concentration of the element in water within the range of 4.28-10 mg/L[22]. In addition, the average dissolved oxygen in PantaiCarocokPainan occurs between 5.75-9.1 mg/L, and is suitable for marine tourism activities[12]. Conversely, the DO for the entire stations in the Saleh Bay waters ranges from 4.78-6.01 mg/L[14]. The measured DO value of PrialaotSabang ranged from 4.4-4.69 mg/L, with an average of 4.53 mg/L. However, at sea level, DO values are influenced by the diffusion of oxygen from the air and the photosynthetic rate by marine plants[23].

Salinity

A particular salinity level is required for coral reefs and seagrass survival towards attracting marine tourism objects, including snorkelling and diving. The salinity range of Mantehage Island waters occurs between 29.45-32.65 ‰, with an average value of 31.05 ‰ (Table. 1). This estimation indicates a suitable category within the applicable quality standards. Salinity plays an essential role in supporting marine biota and the water level varies based on geography and time, where the increase in the parameter is caused by evaporation and the result of freezing sea ice,

while the decrease is instigated by precipitation and freshwater input from rivers. This outcome slightly varies from the measurement results at Labuhan Haji beach, showing a salinity range of 32-35 ‰[11]. Subsequently, the value for PataiCarocokPainan waters also obtained an average range of 30-31 ‰[12] Meanwhile, Saleh Bay water occurs between 27.17-30.67 ‰ [13], and 21.6-32.3 ‰ for Prialaot, with a general average of 31.27 ‰[14]. However, the salinity value to promote coral reef life is expected to range from 30-36 ‰[11]. This difference is influenced by geographical position and water type. Furthermore, stable salinity in the archipelago tends to be achieved, due to inadequate water inflow from the mainland. In addition, the value is also greatly impacted by evaporation and precipitation rates.

Nitrate

The nitrate content in the Mantehage waters ranges from 0.004-0.068 mg/L at an average of 0.034 mg/L (Table 1). This value exceeded the quality standard of the Minister of Environment and Forestry Decree No. 51 of 2004, estimated at 0.008 mg/L. In addition, the extreme result is influenced by the mangrove ecosystem located on the coastal part of the island, where sedimentation is very extensive during the rainy season. An additional indicator is also due to poor mangrove management, leading to free waste from anthropogenic activities entering the aquatic environment. The high concentration of nitrate is probably due to input from land and surrounding factors in the form of liquid waste, both due to agricultural operations. Moreover, the primary ingredient of fertilizers is nitrogen, known to utilize a bio-physicochemical process to become a compound. In marine waters, six types of nitrogen are formed, termed N_2, NO_3, NO_2, NH_3, NH_4, organic N and particulate N. Meanwhile, in the aerobic atmosphere, the nitrogen species generated is the NO_3, as one of the constituents consumed by marine biota, including phytoplankton for growth of 3.9- 15.5 mg/L[13]. This outcome corresponds to the analysis results of the NO_3 at Labuhan Haji beach, with similar content of 0.036 mg/L. Also, the nitrate (NO3) at Labuhan Haji appears relatively high due to community activities on the coast/land, where unwanted materials are directly and inappropriately disposed into the sea. In addition, the existence of river water flowing into the beach also serves as a transportation medium for agricultural waste and other human activities related to the sea [11].

Phosphate

The phosphate content in Mantehage waters ranges from 0.008-0.019 mg/L at an average of 0.015 mg/L (Table. 1). This value is under the specified quality standard for marine tourism at 0.015 mg/L, based on the Minister of Environment Decree No. 51 of 2004. However, the estimate varied from the measurement results in MoyoHilir and Lape sub-districts, between 0.03-0.3 mg/L. Extensive land activities are believed to trigger the phosphate content beyond the quality standard, including livestock, agricultural operations, and the landfill existence in the coastal areas. Moreover, organic waste disposal, e.g detergents, fertilizers, and degradable materials tend to generate phosphate. In marine waters, the greatest phosphate compound is ortho-phosphate as the substance undergoes hydrolysis with a percentage fraction depending on the water pH and temperature[13].

This research implies that the involvement of academics through this study is very helpful for policymakers in developing strategies for developing Mantehage island tourism areas. The data of this study can be applied in determining the best location for snorkelling and diving areas, Mantehage Island is very feasible to be developed as a marine tourism location because it is supported by very good water conditions and following environmental quality standards. This study has limitations in research time, where the sample is only taken in one season, does not represent another season, besides that this study has not studied the overall condition of the oceanographic parameters.

Table 1. Seawater Quality Parameters in Mantehage Island.

Station	Coordinate		Temperature	Turbidity	TSS	pH	Salinity	DO	NO3-N	PO4-P	Parameter
	Latitude	Longitude	28-32	< 5	80	7-8.5[(d)]	<34	>5	0.008	0.015	Biota quality standards
			alami	< 5	20	7-8.5[(d)]	alami[3](e)	>5	0.008	0.015	Tourism quality standards
			C	NTU	mg/L	pH	PSU	mg/L	mg/L	mg/L	Unit quality standards
1	1°42’49.04”N	124°43’44.57”E	29	3.21	31.20	7.2	30.21	5.23	0.005	0.010	Decree of the Minister of Environment of the Republic of Indonesia No 51 of 2004
2	1°42’27.10”N	124°44’10.46”E	30	4.25	29.25	7.6	31.26	5.47	0.025	0.011	
3	1°42’5.66”N	124°44’28.58”E	28	3.2	33.65	7.4	31.25	5.65	0.045	0.016	
4	1°41’49.04”N	124°44’54.55”E	29	2.2	35.25	7.8	30.45	5.14	0.006	0.018	
5	1°41’39.27”N	124°45’22.47”E	30	3.2	30.56	7.5	29.45	5.98	0.068	0.014	
6	1°41’29.02”N	124°45’49.90”E	28	4.7	32.00	7.4	30.87	6.12	0.065	0.013	
7	1°41’37.80”N	124°46’31.55”E	28	3.6	33.63	7.6	32.14	3.24	0.058	0.015	
8	1°41’59.04”N	124°47’4.83”E	28	2.8	32.63	7.9	30.45	6.35	0.009	0.019	
9	1°42’29.46”N	124°47’1.90”E	30	4	34.24	7.1	31.56	5.21	0.004	0.018	
10	1°43’9.12”N	124°46’41.67”E	30	4.1	32.13	7.4	30.25	5.98	0.008	0.017	
11	1°43’35.87”N	124°46’26.20”E	30	3.2	33.26	7.5	31.25	5.87	0.025	0.009	
12	1°44’29.95”N	124°46’15.18”E	29	4.5	31.00	7.6	30.87	5.46	0.054	0.008	
13	1°44’58.36”N	124°45’57.12”E	30	2.5	31.27	7.1	31.63	5.21	0.066	0.016	
14	1°45’19.63”N	124°45’38.18”E	31	3.8	33.36	7.5	32.65	5.69	0.042	0.014	
15	1°45’51.74”N	124°45’15.50”E	29	4.7	36.25	7.8	32.4	5.19	0.061	0.018	
16	1°46’14.93”N	124°44’9.69”E	28	3.5	35.21	7.5	31.25	5.38	0.019	0.016	
17	1°45’24.98”N	124°43’48.02”E	30	3.4	28.24	7.6	30.65	5.67	0.048	0.014	
18	1°44’51.67”N	124°43’41.78”E	28	2.8	29.25	7.6	31.45	5.43	0.065	0.013	
19	1°44’18.76”N	124°43’32.41”E	29	3.6	32.25	7.6	30.14	5.28	0.008	0.017	
20	1°43’37.56”N	124°43’34.43”E	29	4.5	33.25	7.5	30.86	5.17	0.007	0.014	
Average			29.15	3.58	32.39	7.51	31.052	5.43	0.034	0.015	
Minimum			28	2.2	28.24	7.1	29.45	3.24	0.004	0.008	
Maximum			31	4.7	36.25	7.9	32.65	6.35	0.068	0.019	

CONCLUSION

Based on the values of salinity, temperature, turbidity, pH, total suspended solids, dissolved oxygen, NO_3-N, and PO_4-P, the condition of Mantehage water quality obtained a suitable category within the specified standards of the Minister of the Environment Republic of Indonesia. Several parameters known to exceed these provisions, including nitrate and phosphate content, indicate the instantaneous value during measurement. Therefore, an in-depth study, sufficient interval and sampling location to represent the spatial and temporal conditions of the entire island are greatly required. This outermost island generally appears suitable as a marine tourism attraction, particularly snorkelling and diving. Furthermore, the beauty of coral reefs is believed to be a major tourist object with the need for further encouragement. Mantehage Island is very feasible to be developed as a marine tourism area, especially for snorkelling and diving activities, underwater beauty, high biodiversity and supported by good water conditions make this island attractive to tourists.

Significance statement

"This study discovered the condition of the seawater quality of Mantehage Island which can be developed as an underwater tourism location, the good status of coral reefs supported by underwater beauty makes Mantehage Island worthy of development, that can be beneficial for the government, researchers, and the people of Mantehage Island in developing tourism. This study will help the researchers to uncover the critical areas of the outermost small island of Indonesia that many researchers were not able to explore. Thus a new theory on the condition of seawater quality for the development of marine tourism may be arrived at".

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REFERENCES

1. Tangian, D., Djokosetiyanto, D., Kholil, K., & Munandar, A. (2015). Model of Ecotourism Management in Small Islands of Bunaken National Park, North Sulawesi. *Journal of Indonesian Tourism and Development Studies*, *3*(2), 75-84.
https://jitode.ub.ac.id/index.php/jitode/article/view/156

2. Djamaluddin, R. (2018). The mangrove flora and their physical habitat characteristics in Bunaken National Park, North Sulawesi, Indonesia. *Biodiversitas Journal of Biological Diversity*, *19*(4), 1303-1312.
https://www.smujo.id/biodiv/article/view/2787

3. Opa E. T., Kusen J. D., Kepel R. C., Jusuf A., Lumingas L. J. L., 2019 Community structure of mangrove in Mantehage Island and Paniki Island, North Sulawesi, Indonesia. AACL Bioflux 12(4):1388-1403.
http://www.bioflux.com.ro/docs/2019.1388-1403.pdf

4. Kase A., Manembu I., Schaduw J.N.W. 2019. [Condition of Mantehage Island Coral Reef, North Minahasa Regency, North Sulawesi]. Journal of coastal and tropical seas. 7 (3) : 208-212.
Https://Doi.Org/10.35800/Jplt.7.3.2019.24466
https://ejournal.unsrat.ac.id/index.php/jplt/article/view/24466/24143

5. Schaduw J.N.W., Kondoy K.I.F., Manoppo V.E.N., Luasunaung A., Mudeng J., Pelle W.E., Ngangi E.L.A., Manembu I.S., Wantasen N.S., Sumilat D.A., Rumampuk N.D.C., Tilaar S.O., Manengkey H.W.A., Lintang R., Walalangi J.Y., Tampanguma B., Pungus F., Lahabu Y., Sagai B., Wantah E., Wantania L.L., Djabar B., Oli A.P., Caroles E.A., Bachmid F., Sasauw J., Kase A., Anthoni A., Uada A.D., Ladjandu R., Coloay C., Kojongian S., Mamangkey N.N.T. 2020. Data On Percentage Coral Reef Cover In Small Islands Bunaken National Park. Data in Brief, 31, 105713.
https://doi.org/10.1016/j.dib.2020.105713
https://www.sciencedirect.com/science/article/pii/S2352340920306077?via%3Dihub

6. Wagey B. T., Boneka F. B., Mantiri R., 2020 Status of marine biodiversity and community perception on marine conservation in Mantehage Island, Bunaken National Park, North Sulawesi, Indonesia. AACL Bioflux 13(6):3830- 3839.

http://www.bioflux.com.ro/docs/2020.3830-3839.pdf
7. Kalalo F. P., 2017 Law enforcement and conservation at Bunaken National Park, North Sulawesi, Indonesia as perceived by the local coastal communities. AACL Bioflux 10(6):1413-1420.
http://www.bioflux.com.ro/docs/2017.1413-1420.pdf
8. Schaduw J. N.W. and Kondoy K. F. I. 2020. Seagrass percent cover in small islands of Bunaken National Park, North Sulawesi Province, Indonesia. AACL Bioflux 13(2):951-957.
http://www.bioflux.com.ro/docs/2020.951-957.pdf
9. Schaduw J. N.W. 2018. [Distribution and Water Quality Characteristics of the Small Island Mangrove Ecosystem of Bunaken National Park]. Indonesian Geography Magazine. 32 (1) 40-49.
https://jurnal.ugm.ac.id/mgi/article/view/32204
https://doi.org/10.22146/mgi.32204
10. Kurniadi B., Sigid H., Enan M., Adiwilaga. 2015. [The waters Quality of the Buaya River in Bunyu Island, North Kalimantan in Tidal Conditions]. Indonesian Journal of Agricultural Sciences. 20 (1): 53-58.
https://journal.ipb.ac.id/index.php/JIPI/article/view/9289/7287
https://doi.org/10.35800/jasm.1.1.2013.1972
11. Haerudin and Putra A.M. 2019. Analysis of Seawater Quality Standards for the Development of Marine Tourism in Labuhan Haji Beach, East Lombok Regency. *Journal of Geodics 3(1) : 13 – 18*
https://e-journal.hamzanwadi.ac.id/index.php/gdk/article/view/1473
12. Indra N., Sari S., Rahayu G, Oktaviandra R., Handoko A., Putri V.S., Hanapi N.I. 2019. Environmental Quality and Suitability of Coastal Tourism in CarocokPainan Area, Pesisir Selatan Regency. Journal of Capita Selecta Geography 2 (5): 43- 51
http://ksgeo.ppj.unp.ac.id/index.php/ksgeo/article/view/251
https://doi.org/10.24036/ksgeo.v2i5.251
13. Saraswati N.G.R.A., Yulius., Rustam A., Hadiwijaya L., Salim., Heriati A., Mustikasari E. 2017. [Study of Water Quality for Coastal Marine Tourism, MoyoHilirSubdistrict and LapeSubdistrict, Sumbawa Regency]. Journal of Segara 13 (1) : 37-47.
http://ejournal-balitbang.kkp.go.id/index.php/segara/article/view/6421

http://dx.doi.org/10.15578/segara.v13i1.6421

14. Tanto T.A., Naelul N.H.R., Ilham. 2018. [Quality of Seawater to Support Marine Tourism and Marine Life. Case Study: Around the Sinking Ship of Sophie Rickmers, PrialaotSabang Waters]. Marine Journal, 11 (2) : 173-183.
https://journal.trunojoyo.ac.id/jurnalkelautan/article/view/4276
https://doi.org/10.21107/jk.v11i2.4276

15. Tambunan J.M., Anggoro S., Purnaweni H. 2013. [Study on Environmental Quality and Suitability of TanjungPesona Beach Tourism, Bangka Regency]. Proceedings of the National Seminar on Natural Resources and Environmental Management. pg 356-362.
https://core.ac.uk/download/pdf/18605648.pdf

16. Tomczak M. and Godfrey J. 2001. Regional Oceanography: An Introduction. Pergamon. ISBN : 9781483287614 https://www.elsevier.com/books/regional-oceanography/tomczak/978-0-08-041021-0

17. Tanto T. A. and Kusumah G. 2016. [Seawater Quality Standards in Different Seasons]. Maspari Journal, 8 (2) : 135–146. [in Indonesian]
https://ejournal.unsri.ac.id/index.php/maspari/article/view/3490
https://doi.org/10.36706/maspari.v8i2.3490

18. Mutmainah H. 2016.[Environmental Suitability Study for Tourism Development at Ganting Beach, Simeulue Island, Aceh Province]. Journal of DepikUnsyiah, 5 (1) : 19–30.
http://jurnal.unsyiah.ac.id/depik/article/view/3844
https://doi.org/10.13170/depik.5.1.3844

19. Wilson P.C. 2010. Water Quality Notes: Water Clarity (Turbidity, Suspended Solids, and Color). Department of Soil and Water Science. University of Florida. https://edis.ifas.ufl.edu/publication/SS526
.

20. Simanjuntak M. 2012. Seawater Quality Judging from Nutrient Aspects, Dissolved Oxygen and Ph in Banggai Waters, Central Sulawesi. Journal of Tropical Marine Science and Technology. 4(2):290-303.
https://journal.ipb.ac.id/index.php/jurnalikt/article/view/7791
https://doi.org/10.29244/jitkt.v4i2.7791

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21. Arifin T., Bengen D.G., Pariwono J.I. 2002. Evaluation on the Suitability of the Palu Bay Coastal Zone for Marine Tourism Development. Coastal and Ocean Journal. 4 (2) : 25-35 https://repository.ipb.ac.id/jspui/bitstream/123456789/26592/1/Taslim%20Arifin_Herni%20%2811%20hal%29.pdf

22. Putra A., Tanto T.A., Pranowo W.S., Ilham., Damanhuri H., Suasti Y., Triyatno T. 2018. Suitability Of Coastal Ecotourism In Padang City-West Sumatera: Case Study Of Beach Recreation And Mangrove. Journal of Segara, 14 (2) : 87-94. http://ejournal-balitbang.kkp.go.id/index.php/segara/article/view/6642 http://dx.doi.org/10.15578/segara.v14i2.6642

23. Wisha U.J., Tanto T.A., Ilham. 2016. Physical and Chemical Conditions of Bayur Bay Waters on the East and West Season.Journal of Marine Science UNDIP. 22 (1) : 15–24. https://ejournal.undip.ac.id/index.php/ijms/article/view/10505 doi:10.14710/ik.ijms.22.1.15-24 https://ejournal.unsrat.ac.id/index.php/lppmsains/article/view/10692

24. Minister of Environment Decree No. 51 of 2004. Poses as a reference for the seawater quality standards. https://environmentalchemistry.files.wordpress.com/2013/08/kepmenlh-no-51-tahun-2004.pdf

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The Analysis of Seawater Quality in Small Outermost Mantehage Island for Integrated and Sustainable Marine Tourism Development in North Sulawesi Province

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Author contribution: Principal investigator; data collection; data analysis; author

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Abstract

Background and Objective: There is a growing interest to significantly explore more opportunities in the coastal environment. For this reason, adequate progressive strategies appear very essential. The purpose of this study was to analyze seawater quality as a database for developing integrated and sustainable marine tourism in Mantehage Island, Indonesia. Materials and Methods: the present paper applied descriptive and quantitative methods to sample 20 observation points around the selected location. In addition, the seawater content was directly measured and stored in the laboratory for further analysis. Consequently, certain parameters were evaluated, including salinity, temperature, turbidity, pH, total suspended solids, dissolved oxygen, NO_3-N and PO_4-P. The subsequent data were also compared to the related quality standards of the Minister of Environment, Decree No. 51 of 2004. Results: Based on the results, Mantehage water quality demonstrated an excellent condition and is also believed to support the proposed marine tourism development. Conclusion: the values of salinity, temperature, turbidity, pH, total suspended solids, dissolved oxygen, NO_3-N, and PO_4-P, the condition of Mantehage water quality obtained a suitable category within the specified standards of the Minister of

Environment Decree No. 51 of 2004. Several parameters known to exceed these provisions, including nitrate and phosphate content, indicate the instantaneous value during measurement

Keywords: *Seawater Quality; Mantehage: Outer Island; Marine Tourism*

INTRODUCTION

The quality of sea water greatly determines the feasibility of an underwater tourism area, diving and snorkeling activities require good sea water conditions, this greatly affects the comfort and safety of tourists. Bunaken National Park exhibits high biodiversity, particularly in the Coral Triangle along the Asia Pacific region. The underwater view is famous to foreign tourists around the world and encompasses five minor islands, including, Bunaken, Siladen, Manado Tua, Mantehage, and Nain. These 5 landmasses are divided into 2 administrative regions, including Manado city and North Minahasa regency. Mantehage is a major outermost island in Indonesia with the greatest mangrove area in North Sulawesi[1]. Moreover, the nature of the coral reef ecosystem serves as a potential underwater tourist attraction[2,3]. The condition of the coral reefs in Mantehage Island seen from the percentage of coral cover ranging from 20-40%, the condition of hard coral substrates accompanied by good water quality will support this island as a new marine tourism area[3]. This island also has a good seagrass ecosystem with an average cover percentage of 33%, there are four species of seagrass including *Enhalusacoroides, Thalassiahemprichii, Cymodocearotundata, Halophila pinifolia*[4]. Some important water quality parameters include salinity, temperature, turbidity, pH, total suspended solids, dissolved oxygen, NO3-N and PO4-P. Information about these parameters will be very helpful in the development of tourist areas. This research is probably a consideration for policymakers in determining the direction and strategies related to the management of coastal and marine resources, particularly for marine tourism development in Mantegehe. The purpose of this study was to analyze the seawater quality as a database for the prospective development of marine tourism. In addition, the Minister of Environment Decree No. 51 of 2004 poses as a reference for the seawater quality standards.

MATERIALS AND METHODS

Study area: This research was conducted in Mantehage Island, Wori District, North Minahasa regency, North Sulawesi province, within Bunaken National Park from March to May 2021.

Research protocol: Descriptive and quantitative methods with purposive sampling were employed in determining the observational base. Each station possesses coordinate points for easy monitoring and is evenly distributed.

Parameters measurement: the measured seawater parameters were salinity, temperature, turbidity, pH, total suspended solids, dissolved oxygen, NO_3-N and PO_4-P. However, the sampling technique and data analysis adopted the methods by[5] and[6].

Instruments used: The instruments used in this study is horibaU-50 series multi-parameter water quality checker enables to measure and indicate the monitoring result simultaneously up to 11 parameters with one unit. Considering user friendly field monitoring on site, such as rive, ground water, drainage water, etc. bring together feature of function and performance, which makes simple operation for everybody. Multiple sensors allow for the measurement of 11 parameters simultaneously (pH, pH(mv), ORP, DO, COND, Salinity, TDS, Seawater Specific Gravity, Temperature, Turbidity, Water Depth).For NO3-N and PO4-P analysis, seawater samples were put into glass bottles, then brought to the laboratory for further analysis. Subsequently, the results were compared to the Minister of Environment Decree No. 51 of 2004 as a reference for seawater quality standards.

RESULT AND DISCUSSION

Salinity: Salinity is described as the total amount of dissolved salt in seawater. The unit is generally accepted in mg/L, but also occurs in ppt (parts per thousand) or o/oo and practical salinity unit (PSU). Freshwater salinity values are typically <0.5 o/oo, brackish waters 0.5 - 30 o/oo, and seawaters 30-40 o/oo. Meanwhile, the estimate for coastal waters is strongly influenced by freshwater input from rivers. However, salinity potentially instigates osmotic pressure in seawater biota. The salt content in the aquatic cells occur in close proximity to the surrounding seawater salinity. As the salinity changes, osmoregulation mechanism is then required in balancing the salt levels between the cells and the environment[7]. Mantehage Island shows a salinity range of 28 - 31 PSU, with an average of 29.15 PSU. This value varies based on the

climate/weather during measurement. In the dry season, seawater salinity rises above 30 PSU. Rainy weather condition was observed on the day prior to sampling, resulting in a lesser salinity value but showed good category, according to seawater quality standards. This salinity condition is not only good for tourism activities but also for the sustainability of the surrounding aquatic biota.

Temperature

Temperature influences the metabolic activity and reproduction of marine organisms. This factor is used in certain tourist destination to determine the potential and existence of coral reef growth[8]. In marine life development, the optimal average temperature is expected in the range of 23^0-35^0C with tolerance limits between 36-40°C. The seawater temperature of Mantehage Island occurs from 28-31°C with an average value of 29.15 °C. These conditions are convenient as quality standards for tourism development activities and underwater biota sustainability. In addition, the temperatures are identical to the average value at CarocokPainan Beach between 29-31 ºC, and also show related suitability[9]. Furthermore, similar condition was observed in the coastal waters of Labuhan Haji, East Lombok regency, with a range of 30-32 ºC[8]. The results of temperature measurements in MoyoHilir and Lape Districts occurred between 29.20-31.57 ºC[10], in contrast to the temperature of Prialaot waters at 29-31.4 °C, with an average of 29.22° C[11]. However, temperature variations tend to influence the life of coral reefs[12]. Based on the Minister of Environment Decree No. 51 of 2004, the water temperature for marine tourism is expected at natural temperature. An appropriate range for coral reef areas exist in the range of 28-30 ºC and 28-32 ºC for mangrove regions. Discontinue in situ temperature measurement is a natural temperature with a change tolerance <2° C (Minister of Environment Decree No. 51 of 2004). However, the biota in tropical waters naturally reside in the upper limit of the highest temperature. This variations possibly interfere with the physiological processes known to endanger the biota. In the value range> 28 °C, sea surface temperature in the western equator appears very warm[13]. Moreover, the condition is considered natural as Indonesia is a tropical region. Based on the water depth, extensive seawater surface temperatures are observed, in comparison to a certain depth, probably due to the high intensity of sunlight[12].

Turbidity

Lower turbidity increases the light intensity capable of penetrating the water depth[14]. Therefore, the resulting value is expected to exist under normal condition, where water transparency is inversely proportional to the turbidity, believed to significantly influence oxygen content. Turbid water possibly interfere with the respiration process and decreases the oxygen levels[15]. The seawater turbidity condition of Mantehage Island ranges between 2.2-4.7 NTU, with an average value of 3.58 NTU, indicating an appropriate category and in line with the quality standards. Therefore, the site is suitable as a potential tourist attraction. This condition is supported by data on Mantehage Island coral reef cover in the range of 19-30%, with an average live coral cover of 29.10%[3]. Furthermore, turbidity describes an inadequate water transparency, due to colloidal and suspended materials, including mud, organic and inorganic materials as well as aquatic microorganisms[16]. This circumstance varies from the observations in Prialaot waters with an average value of 0.08 NTU[11], in addition to MoyoHilir and Lape Districts ranging from 0-23.3 NTU[10].

pH level

Inconsistencies in the water pH level probably influences biota existence to a certain extent of varying pH[17]. The water pH value depends on carbon dioxide and ion concentrations. Moreover, the parameter plays a significant role in the solubility of particular compounds, although appears minimal in the morning, compared to afternoon period[18]. Subsequently, the pH of Mantehage Island seawater ranges from 7.1-7.9, with an average value of 7.51, indicating an appropriate category for tourism development and aquatic life support. This value is also corresponds to a pH in Labuhan Haji beach between 7.6 - 7.9[8]. Meanwhile, for CarocokPainan beach, the estimate occurred between 7-8[9]. These values varied slightly from Moyo and Lape districts from 7.96 - 8.12[10], as well as in Prialaot waters by 7.64 - 8.36[11]. These variations depend on geographic position and water injection from the environment. In addition, it is also affected by the season as related to local rainfall and climate.

Total Suspended Solid (TSS)

The TSS of Mantehage Island waters ranged from 28.24-36.25 mg/L with an average value of 32.39 mg/L, corresponding to the quality standard for biota survival. However, in-depth study and sampling of other seasons are required for tourism development, particularly underwater ecotourism, considering the present research was only conducted in one season without repetition. This high TSS value is due to the greatest mangrove forest in Bunaken National Park, and therefore sedimentation in certain segments is inevitable. This varies from the TSS of Prialaot waters at the range of 14 - 31 mg/L, with an average of 21.83 mg/L. Also, the value is generally above the standards allowed for marine tourism (20 mg/L) and marine life (coral and seagrass by 20 mg/L, mangroves by 80 mg/L)[11]. Similarly, the TSS of Labuhan Haji beach also demonstrated a fairly higher content, ranging from 14 - 31 mg/L, with an average of 21.83 mg/L. This value is also above the quality standard allowed for marine tourism (20 mg/L) and marine life (coral and seagrass at 20 mg/L, and mangroves at 80 mg/L)[8].

Dissolved Oxygen (DO)

The dissolved oxygen source in water originates from the diffusion of oxygen from air, water currents or flow through rainwater, as well as photosynthetic activity by aquatic plants and phytoplankton. Generally, aquatic creatures, e.g fish, shrimp, shellfish, and other animals, including microorganisms, e.g bacteria, require oxygen. Dissolved oxygen (DO) regulates the metabolism of organisms to grow and reproduce. Fish need water with an oxygen content of at least 5 mg/L[7]. The DO values in Mantehage waters ranged from 3.24-6.35 mg/L, with an average of 5.43 mg/L. This indicates a suitable oxygen content capable of supporting marine biota. Moreover, seawater quality standards for tourism and healthy ecological activities require DO values above 5mg/L. The condition supports the seagrass survival, covering 33% of the island[4], and also matches the results of dissolved oxygen (DO) measurements performed at Labuhan Haji beach, where the total stations obtained a yield range of 6 mg/L. Also, the value shows an excellent water condition, and relatively suffices the seawater quality standards[8]. Furthermore, dissolved oxygen describes the relative concentration of the element in water within the range of 4.28-10 mg/L[19]. In addition, the average dissolved oxygen in PantaiCarocokPainan occurs

between 5.75-9.1 mg/L, and is suitable for marine tourism activities[9]. Conversely, the DO for the entire stations in the Saleh Bay waters ranges from 4.78-6.01 mg/L[11]. The measured DO value of PrialaotSabang ranged from 4.4-4.69 mg/L, with an average of 4.53 mg/L. However, at sea level, DO values are influenced by the diffusion of oxygen from air and the photosynthetic rate by marine plants[20].

Salinity

A particular salinity level is required for coral reefs and seagrass survival towards attracting marine tourism objects, including snorkeling and diving. The salinity range of Mantehage Island waters occurs between 29.45-32.65 ‰, with an average value of 31.05 ‰. This estimation indicates a suitable category within the applicable quality standards. Salinity plays an essential role in supporting marine biota and the water level varies based on geography and time, where the increase in the parameter is caused by evaporation and the result of freezing sea ice, while the decrease is instigated by precipitation and freshwater input from rivers. This outcome slightly varies from the measurement results at Labuhan Haji beach, showing a salinity range of 32-35 ‰[8]. Subsequently, the value for PataiCarocokPainan waters also obtained an average range of 30-31 ‰[9]. Meanwhile, Saleh Bay water occurs between 27.17-30.67 ‰ [10], and 21.6-32.3 ‰ for Prialaot, with a general average of 31.27 ‰[11]. However, the salinity value to promote coral reef life is expected to range from 30-36 ‰[8]. This difference is influenced by geographical position and water type. Furthermore, stable salinity in the archipelago tends to be achieved, due to inadequate water inflow from the mainland. In addition, the value is also greatly impacted by evaporation and precipitation rates.

Nitrate

The nitrate content in the Mantehage waters ranges from 0.004-0.068 mg/L at an average of 0.034 mg/L. This value exceeded the quality standard of the Minister of Environment and Forestry Decree No. 51 of 2004, estimated at 0.008 mg/L. In addition, the extreme result is influenced by the mangrove ecosystem located on the coastal part of the island, where sedimentation is very extensive during the rainy season. Additional indicator is also due to poor mangrove management, leading to free waste from anthropogenic activities entering the aquatic environment[21]. The high concentration of nitrate is probably due to input from land and

surrounding factors in the form of liquid waste, both due to agricultural operations. Moreover, the primary ingredient of fertilizers is nitrogen, known to utilize a bio-physicochemical process to become a compound. In marine waters, six types of nitrogen are formed, termed N_2, NO_3, NO_2, NH_3, NH_4, organic N and particulate N. Meanwhile, in aerobic atmosphere, the nitrogen species generated is the NO_3, as one of the constituents consumed by marine biota, including phytoplankton for growth of 3.9- 15.5 mg/L[10]. This outcome corresponds to the analysis results of the NO_3 at Labuhan Haji beach, with similar content of 0.036 mg/L. Also, the nitrate (NO3) at Labuhan Haji appears relatively high due to community activities on the coast/land, where unwanted materials are directly and inappropriately disposed into the sea. In addition, the existence of river water flowing into the beach also serves as a transportation medium for agricultural waste and other human activities related to the sea [8].

Phosphate

The phosphate content in Mantehage waters ranges from 0.008-0.019 mg/L at an average of 0.015 mg/L. This value is under the specified quality standard for marine tourism at 0.015 mg/L, based on the Minister of Environment Decree No. 51 of 2004. However, the estimate varied from the measurement results in MoyoHilir and Lape sub-districts, between 0.03-0.3 mg/L. Extensive land activities is believed to trigger the phosphate content beyond the quality standard, including livestock, agricultural operations, and the landfill existence in the coastal areas. Moreover, organic waste disposal, e.g detergents, fertilizers, and degradable materials tend to generate phosphate. In marine waters, the greatest phosphate compound is ortho-phosphate as the substance undergoes hydrolysis with a percentage fraction depending on the water pH and temperature[10].

Table 1. Seawater Quality Parameters in Mantehage Island.

Station	Coordinate		Temperature	Turbidity	TSS	pH	Salinity	DO	NO3-N	PO4-P	Parameter
	Latitude	Longitude	28-32	< 5	80	7-8.5[(d)]	<34	>5	0.008	0.015	Biota quality standards
			alami	< 5	20	7-8.5[(d)]	alami[3](e)	>5	0.008	0.015	Tourism quality standards
			C	NTU	mg/L	pH	PSU	mg/L	mg/L	mg/L	Unit quality standards
1	1°42'49.04"N	124°43'44.57"E	29	3.21	31.20	7.2	30.21	5.23	0.005	0.010	Decree of the Minister of Environment of the Republic of Indonesia No 51 of 2004
2	1°42'27.10"N	124°44'10.46"E	30	4.25	29.25	7.6	31.26	5.47	0.025	0.011	
3	1°42'5.66"N	124°44'28.58"E	28	3.2	33.65	7.4	31.25	5.65	0.045	0.016	
4	1°41'49.04"N	124°44'54.55"E	29	2.2	35.25	7.8	30.45	5.14	0.006	0.018	
5	1°41'39.27"N	124°45'22.47"E	30	3.2	30.56	7.5	29.45	5.98	0.068	0.014	
6	1°41'29.02"N	124°45'49.90"E	28	4.7	32.00	7.4	30.87	6.12	0.065	0.013	
7	1°41'37.80"N	124°46'31.55"E	28	3.6	33.63	7.6	32.14	3.24	0.058	0.015	
8	1°41'59.04"N	124°47'4.83"E	28	2.8	32.63	7.9	30.45	6.35	0.009	0.019	
9	1°42'29.46"N	124°47'1.90"E	30	4	34.24	7.1	31.56	5.21	0.004	0.018	
10	1°43'9.12"N	124°46'41.67"E	30	4.1	32.13	7.4	30.25	5.98	0.008	0.017	
11	1°43'35.87"N	124°46'26.20"E	30	3.2	33.26	7.5	31.25	5.87	0.025	0.009	
12	1°44'29.95"N	124°46'15.18"E	29	4.5	31.00	7.6	30.87	5.46	0.054	0.008	
13	1°44'58.36"N	124°45'57.12"E	30	2.5	31.27	7.1	31.63	5.21	0.066	0.016	
14	1°45'19.63"N	124°45'38.18"E	31	3.8	33.36	7.5	32.65	5.69	0.042	0.014	
15	1°45'51.74"N	124°45'15.50"E	29	4.7	36.25	7.8	32.4	5.19	0.061	0.018	
16	1°46'14.93"N	124°44'9.69"E	28	3.5	35.21	7.5	31.25	5.38	0.019	0.016	
17	1°45'24.98"N	124°43'48.02"E	30	3.4	28.24	7.6	30.65	5.67	0.048	0.014	
18	1°44'51.67"N	124°43'41.78"E	28	2.8	29.25	7.6	31.45	5.43	0.065	0.013	
19	1°44'18.76"N	124°43'32.41"E	29	3.6	32.25	7.6	30.14	5.28	0.008	0.017	
20	1°43'37.56"N	124°43'34.43"E	29	4.5	33.25	7.5	30.86	5.17	0.007	0.014	
Average			29.15	3.58	32.39	7.51	31.052	5.43	0.034	0.015	
Minimum			28	2.2	28.24	7.1	29.45	3.24	0.004	0.008	
Maximum			31	4.7	36.25	7.9	32.65	6.35	0.068	0.019	

CONCLUSION

Based on the values of salinity, temperature, turbidity, pH, total suspended solids, dissolved oxygen, NO_3-N, and PO_4-P, the condition of Mantehage water quality obtained a suitable category within the specified standards of the Minister of Environment Decree No. 51 of 2004[22]. Several parameters known to exceed these provisions, including nitrate and phosphate content, indicate the instantaneous value during measurement. Therefore, an in-depth study, sufficient interval and sampling location to represent the spatial and temporal conditions of the entire island are greatly required. This outermost island generally appears suitable as a marine tourism attraction, particularly snorkeling and diving. Furthermore, the beauty of coral reefs is believed to be a major tourist object with the need for further encouragement.

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Significance statement

This study discovered the condition of the sea water quality of Mantehage Island which can be developed as an underwater tourism location, the good status of coral reefs supported by underwater beauty makes Mantehage Island worthy of development, that can be beneficial for for the government, researchers, and the people of Mantehage Island in developing tourism.This study will help the researchers to uncover the critical areas of of the outermost small island of Indonesia that many researchers were not able to explore. Thus a new theory on the condition of sea water quality for the development of marine tourism may be arrived at.

REFERENCES

1. Schaduw J. N. W. 2020. Land suitability of the Marine Ecotourism in Mantehage Village, Wori District, North Minahasa Regency, North Sulawesi Province. Journal of SPATIAL Wahana Komunikasi Dan InformasiGeografi, 20 (1) [in Indonesian]
   http://journal.unj.ac.id/unj/index.php/spatial/article/view/14347
   135540op
2. Kase A., Manembu I., Schaduw J.N.W. 2019. [Condition of Mantehage Island Coral Reef, North Minahasa Regency, North Sulawesi]. Journal of coastal and tropical seas. 7 (3) : 208-212[in Indonesian]
   Https://Doi.Org/10.35800/Jplt.7.3.2019.24466
   https://ejournal.unsrat.ac.id/index.php/jplt/article/view/24466/24143
3. Schaduw J.N.W., Kondoy K.I.F., Manoppo V.E.N., Luasunaung A., Mudeng J., Pelle W.E., Ngangi E.L.A., Manembu I.S., Wantasen N.S., Sumilat D.A., Rumampuk N.D.C., Tilaar S.O., Manengkey H.W.A., Lintang R., Walalangi J.Y., Tampanguma B., Pungus F., Lahabu Y., Sagai B., Wantah E., Wantania L.L., Djabar B., Oli A.P., Caroles E.A., Bachmid F., Sasauw J., Kase A., Anthoni A., Uada A.D., Ladjandu R., Coloay C., Kojongian S., Mamangkey N.N.T. 2020. Data On Percentage Coral Reef Cover In Small Islands Bunaken National Park. Data in Brief, 31, 105713.
   https://doi.org/10.1016/j.dib.2020.105713
   135541op
4. Schaduw J. N.W. and Kondoy K. F. I. 2020. Seagrass percent cover in small islands of Bunaken National Park, North Sulawesi Province, Indonesia. AACL Bioflux 13(2):951-957.
   http://www.bioflux.com.ro/docs/2020.951-957.pdf
   2233174ja
5. Schaduw J. N.W. 2018. [Distribution and Water Quality Characteristics of the Small Island Mangrove Ecosystem of Bunaken National Park]. Indonesian Geography Magazine. 32 (1) 40-49 [in Indonesian]
   https://jurnal.ugm.ac.id/mgi/article/view/32204
   https://doi.org/10.22146/mgi.32204
6. Kurniadi B., Sigid H., Enan M., Adiwilaga. 2015. [The waters Quality of the Buaya River in Bunyu Island, North Kalimantan in Tidal Conditions]. Indonesian Journal of Agricultural Sciences. 20 (1): 53-58. [in Indonesian]
   https://journal.ipb.ac.id/index.php/JIPI/article/view/9289/7287
   2233175ja
7. Schaduw J.N.W., Ngangi E.D., Mudeng J. 2013. Land suitability of seaweed farming in Minahasa Regency, North Sulawesi Province. Aquatic Science & Management. 1 (1) : 72-81[in Indonesian]
   https://ejournal.unsrat.ac.id/index.php/jasm/article/view/1972
   https://doi.org/10.35800/jasm.1.1.2013.1972
8. Haerudin and Putra A.M. 2019. Analysis of Seawater Quality Standards for the Development of Marine Tourism in Labuhan Haji Beach, East Lombok Regency. *Journal of Geodics 3(1) : 13 – 18* [in Indonesian]
   https://e-journal.hamzanwadi.ac.id/index.php/gdk/article/view/1473
9. Indra N., Sari S., Rahayu G, Oktaviandra R., Handoko A., Putri V.S., Hanapi N.I. 2019. Environmental Quality and Suitability of Coastal Tourism in CarocokPainan Area,

Pesisir Selatan Regency. Journal of Capita Selecta Geography 2 (5): 43- 51[in Indonesian]
http://ksgeo.ppj.unp.ac.id/index.php/ksgeo/article/view/251
https://doi.org/10.24036/ksgeo.v2i5.251

10. Saraswati N.G.R.A., Yulius., Rustam A., Hadiwijaya L., Salim., Heriati A., Mustikasari E. 2017. [Study of Water Quality for Coastal Marine Tourism, MoyoHilirSubdistrict and LapeSubdistrict, Sumbawa Regency]. Journal of Segara 13 (1) : 37-47. [in Indonesian]
http://ejournal-balitbang.kkp.go.id/index.php/segara/article/view/6421
http://dx.doi.org/10.15578/segara.v13i1.6421
11. Tanto T.A., Naelul N.H.R., Ilham. 2018. [Quality of Seawater to Support Marine Tourism and Marine Life. Case Study: Around the Sinking Ship of Sophie Rickmers, PrialaotSabang Waters]. Marine Journal, 11 (2) : 173-183. [in Indonesian]
https://journal.trunojoyo.ac.id/jurnalkelautan/article/view/4276
https://doi.org/10.21107/jk.v11i2.4276
12. Tambunan J.M., Anggoro S., Purnaweni H. 2013. [Study on Environmental Quality and Suitability of TanjungPesona Beach Tourism, Bangka Regency]. Proceedings of the National Seminar on Natural Resources and Environmental Management. pg 356-362. [in Indonesian]
13. Tomczak M. and Godfrey J. 2001. Regional Oceanography: An Introduction. Published Online.
14. Tanto T. A. and Kusumah G. 2016. [Seawater Quality Standards in Different Seasons]. Maspari Journal, 8 (2) : 135–146. [in Indonesian]
https://ejournal.unsri.ac.id/index.php/maspari/article/view/3490
https://doi.org/10.36706/maspari.v8i2.3490
15. Mutmainah H. 2016.[Environmental Suitability Study for Tourism Development at Ganting Beach, Simeulue Island, Aceh Province]. Journal of DepikUnsyiah, 5 (1) : 19–30. [in Indonesian]
http://jurnal.unsyiah.ac.id/depik/article/view/3844
https://doi.org/10.13170/depik.5.1.3844
16. Wilson P.C. 2010. Water Quality Notes: Water Clarity (Turbidity, Suspended Solids, and Color). Department of Soil and Water Science. University of Florida.
17. Simanjuntak M. 2012. Seawater Quality Judging from Nutrient Aspects, Dissolved Oxygen and Ph in Banggai Waters, Central Sulawesi. Journal of Tropical Marine Science and Technology. 4(2):290-303.
https://journal.ipb.ac.id/index.php/jurnalikt/article/view/7791
https://doi.org/10.29244/jitkt.v4i2.7791
2233177ja
18. Arifin T., Bengen D.G., Pariwono J.I. 2002. Evaluation on the Suitability of the Palu Bay Coastal Zone for Marine Tourism Development. Coastal and Ocean Journal. 4 (2) : 25-35 [in Indonesian]
https://repository.ipb.ac.id/jspui/bitstream/123456789/26592/1/Taslim%20Arifin_Herni%20%2811%20hal%29.pdf
19. Putra A., Tanto T.A., Pranowo W.S., Ilham., Damanhuri H., Suasti Y., Triyatno T. 2018. Suitability Of Coastal Ecotourism In Padang City-West Sumatera: Case Study Of Beach Recreation And Mangrove. Journal of Segara, 14 (2) : 87-94.
http://ejournal-balitbang.kkp.go.id/index.php/segara/article/view/6642

http://dx.doi.org/10.15578/segara.v14i2.6642
2233178ja

20. Wisha U.J., Tanto T.A., Ilham. 2016. Physical and Chemical Conditions of Bayur Bay Waters on the East and West Season. Journal of Marine Science UNDIP. 22(1) : 15–24. https://ejournal.undip.ac.id/index.php/ijms/article/view/10505 doi:10.14710/ik.ijms.22.1.15-24
2233179ja
21. Schaduw J.N.W. 2015. [Sustainable Management of the Mantehage Island Mangrove Ecosystem, Wori Subdistrict, North Minahasa District, North Sulawesi Province]. Journal of the LPPM (Institute for Research and Community Service) UNSRAT in the field of Science and Technology, 2 (2) : 60-70. [in Indonesian] https://ejournal.unsrat.ac.id/index.php/lppmsains/article/view/10692
22. Minister of Environment Decree No. 51 of 2004 poses as a reference for the seawater quality standards. https://environmentalchemistry.files.wordpress.com/2013/08/kepmenlh-no-51-tahun-2004.pdf

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Seawater Quality Analysis in Mantehage Island for Integrated and Sustainable Marine Tourism Development

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CONFLICT OF INTEREST: The authors declare no conflict of interest

ABSTRACT

Background and Objective: There is a growing interest to significantly explore more opportunities in the coastal environment. For this reason, adequate progressive strategies appear very essential. The purpose of this study was to analyze seawater quality as a database for developing integrated and sustainable marine tourism in Mantehage Island, Indonesia. **Materials and Methods:** The present paper applied descriptive and quantitative methods to sample 20 observation points around the selected location. In addition, the seawater content was directly measured and stored in the laboratory for further analysis. Consequently, certain parameters were evaluated, including salinity, temperature, turbidity, pH, total suspended solids, dissolved oxygen, NO_3-N and PO_4-P. The subsequent data were also compared to the related quality standards of the Minister of Environment, Decree No. 51 of 2004. **Results**: Based on the results, Mantehage water quality demonstrated an excellent condition and is also believed to support the proposed marine tourism development. **Conclusion**: the values of salinity, temperature, turbidity, pH, total suspended solids, dissolved oxygen, NO_3-N, and PO_4-P, the condition of Mantehage water quality obtained a suitable category within the specified standards of the Minister of Environment Decree No. 51 of 2004. Several parameters known to exceed these provisions, including nitrate and phosphate content, indicate the instantaneous value during measurement

KEYWORDS: Seawater quality, marine tourism, development, biodiversity, turbidity, salinity, dissolved oxygen

INTRODUCTION

The quality of seawater greatly determines the feasibility of an underwater tourism area, diving and snorkelling activities require good seawater conditions, this greatly affects the comfort and safety of tourists. Bunaken National Park exhibits high biodiversity, particularly in the Coral Triangle along the Asia Pacific region. The number of tourists visiting has a real connection with extensive coral cover. An increase in the number of tourist arrivals will affect the broad decline in coral cover and vice versa. Otherwise, the decline in coral cover will cause the number of tourists to decrease[1]. The underwater view is famous to foreign tourists around the world and encompasses five minor islands, including, Bunaken, Siladen, Manado Tua, Mantehage, and Nain. These 5 landmasses are divided into 2 administrative regions, including Manado city and North Minahasa regency. Mantehage is a major outermost island in Indonesia with the greatest

mangrove area in North Sulawesi, the mangrove flora in Bunaken National Park was floristically rich with at least 27 species, and the broader northern distribution limit of *L. littorea and L. racemosa, C. philippinense, S. ovata* was confirmed [2], The mangroves community structure shows that it is unstable with low values of diversity, and evenness, while the value of domination and species richness is high. The highest density of the mangroves found in station 9 is *C. tagal*. In general, mangroves species richness is found in the moderate category [3]. Moreover, the nature of the coral reef ecosystem serves as a potential underwater tourist attraction[4,5]. The condition of the coral reefs in Mantehage Island seen from the percentage of coral cover ranging from 20-40%, the condition of hard coral substrates accompanied by good water quality will support this island as a new marine tourism area[5]. This island also has a good seagrass ecosystem with an average cover percentage of 33%, there are four species of seagrass including *Enhalus acoroides, Thalassia hemprichii, Cymodocea rotundata, Halophila pinifolia*[8]. As far as can be ascertained, the marine biodiversity of Bunaken National Park is notably high. However, there seems to be a lack of a more comprehensive assessment, especially in Mantehage Island. To date, no comprehensive studies have been done on other marine fauna such as sea snakes, turtles, shorebirds, and marine mammals [6]. Another factor might be the establishment and management histories of BNP since management was principally initiated by the Indonesian national government (top-bottom approach) unlike in other well-known cases (e.g. Apo Island Reserve in the central Philippines) where protection was initiated and even to this day actively participated by the local communities [7]. Some important water quality parameters include salinity, temperature, turbidity, pH, total suspended solids, dissolved oxygen, NO3-N and PO4-P. Information about these parameters will be very helpful in the development of tourist areas. This research is probably a consideration for policymakers in determining the direction and strategies related to the management of coastal and marine resources, particularly for marine tourism development in Mantegehe.

The purpose of this study was to analyze the seawater quality as a database for the prospective development of marine tourism. In addition, the Minister of Environment Decree No. 51 of 2004 poses as a reference for the seawater quality standards.

MATERIALS AND METHODS

Study area: This research was conducted in Mantehage Island, Wori District, North Minahasa regency, North Sulawesi province, within Bunaken National Park from March-May 2021.

Research protocol: Descriptive and quantitative methods with purposive sampling were employed in determining the observational base. Each station possesses coordinate points for easy monitoring and is evenly distributed.

Parameters measurement: the measured seawater parameters were salinity, temperature, turbidity, pH, total suspended solids, dissolved oxygen, NO_3-N and PO_4-P. However, the sampling technique and data analysis adopted the methods[9,10].

Instruments used: The instrument used in this study is horibaU-50 series multi-parameter water quality checker that enables to measure and indicate the monitoring result simultaneously up to 11 parameters with one unit. Considering user-friendly field monitoring on-site, such as rive, groundwater, drainage water, etc. bring together feature of function and performance, which makes simple operation for everybody. Multiple sensors allow for the measurement of 11 parameters simultaneously (pH, pH(mv), Oxidation-Reduction Potential (ORP), Dissolved Oxygen (DO), Conductivity (COND), Salinity, Total dissolved solids (TDS), Seawater Specific Gravity, Temperature, Turbidity, Water Depth). For NO_3-N and PO_4-P analysis, seawater samples were put into glass bottles, then brought to the laboratory for further analysis. Subsequently, the results were compared to the Minister of Environment Decree No. 51 of 2004 as a reference for seawater quality standards.

RESULTS AND DISCUSSION

Salinity: Salinity is described as the total amount of dissolved salt in seawater. The unit is generally accepted in mg L^{-1} but also occurs in ppt (parts per thousand) or % and Practical Salinity Unit (PSU). Freshwater salinity values are typically <0.5%, brackish waters 0.5-30%, and seawaters 30-40%. Meanwhile, the estimate for coastal waters is strongly influenced by freshwater input from rivers. However, salinity potentially instigates osmotic pressure in seawater biota. The salt content in the aquatic cells occurs close to the surrounding seawater salinity. As the salinity changes, an osmoregulation mechanism is then required in balancing the salt levels between the cells and the environment. Mantehage Island shows a salinity range of 28-31 PSU, with an average of 29.15 PSU (Table 1). This value varies based on the climate/weather during

measurement. In the dry season, seawater salinity rises above 30 PSU. Rainy weather condition was observed on the day before sampling, resulting in a lesser salinity value but showing a good category, according to seawater quality standards. This salinity condition is not only good for tourism activities but also for the sustainability of the surrounding aquatic biota.

Temperature:

Temperature influences the metabolic activity and reproduction of marine organisms. This factor is used in a certain tourist destination to determine the potential and existence of coral reef growth[11]. In marine life development, the optimal average temperature is expected in the range of 23-35℃ with tolerance limits between 36-40°C. The seawater temperature of Mantehage Island occurs from 28-31°C with an average value of 29.15°C (Table 1). These conditions are convenient as quality standards for tourism development activities and underwater biota sustainability. In addition, the temperatures are identical to the average value at CarocokPainan Beach between 29-31ºC, and also show related suitability[12]. Furthermore, a similar condition was observed in the coastal waters of Labuhan Haji, East Lombok regency, with a range of 30-32ºC[11]. The results of temperature measurements in MoyoHilir and Lape Districts occurred between 29.20-31.57ºC[13], in contrast to the temperature of Prialaot waters at 29-31.4°C, with an average of 29.22°C[14]. However, temperature variations tend to influence the life of coral reefs. Based on the Minister of Environment Decree No. 51 of 2004, the water temperature for marine tourism is expected at natural temperature. An appropriate range for coral reef areas exists in the range of 28-30 and 28-32ºC for mangrove regions. Discontinue in situ temperature measurement is a natural temperature with a change tolerance <2°C (Minister of Environment Decree No. 51 of 2004). However, the biota in tropical waters naturally resides in the upper limit of the highest temperature. These variations possibly interfere with the physiological processes known to endanger the biota. In the value range >28°C, sea surface temperature in the western equator appears very warm[15]. Moreover, the condition is considered natural as Indonesia is a tropical region. Based on the water depth, extensive seawater surface temperatures are observed, in comparison to a certain depth, probably due to the high intensity of sunlight.

Turbidity:

Lower turbidity increases the light intensity capable of penetrating the water depth. Therefore, the resulting value is expected to exist under normal conditions, where water transparency is

inversely proportional to the turbidity, believed to significantly influence oxygen content. Turbid water possibly interferes with the respiration process and decreases oxygen levels. The seawater turbidity condition of Mantehage Island ranges between 2.2-4.7 NTU (Nephelometric Turbidity Unit), with an average value of 3.58 NTU (Table 1), indicating an appropriate category and in line with the quality standards. Therefore, the site is suitable as a potential tourist attraction. This condition is supported by data on Mantehage Island coral reef cover in the range of 19-30%, with an average live coral cover of 29.10%[5]. Furthermore, turbidity describes inadequate water transparency, due to colloidal and suspended materials, including mud, organic and inorganic materials as well as aquatic microorganisms. This circumstance varies from the observations in Prialaot waters with an average value of 0.08 NTU[14], in addition to MoyoHilir and Lape Districts ranging from 0-23.3 NTU[13].

pH level:

Inconsistencies in the water pH level probably influence biota existence to a certain extent of varying pH[16]. The water pH value depends on carbon dioxide and ion concentrations. Moreover, the parameter plays a significant role in the solubility of particular compounds, although appears minimal in the morning, compared to the afternoon period[17]. Subsequently, the pH of Mantehage Island seawater ranges from 7.1-7.9, with an average value of 7.51, indicating an appropriate category for tourism development and aquatic life support (Table 1). This value also corresponds to a pH in Labuhan Haji beach between 7.6-7.9[11]. Meanwhile, for CarocokPainan beach, the estimate occurred between 7-8[12]. These values varied slightly from Moyo and Lape districts from 7.96-8.12[13], as well as in Prialaot waters by 7.64-8.36[14]. These variations depend on geographic position and water injection from the environment. In addition, it is also affected by the season as related to local rainfall and climate.

Total Suspended Solid (TSS):

The TSS of Mantehage Island waters ranged from 28.24-36.25 mg L^{-1} with an average value of 32.39 mg L^{-1}, corresponding to the quality standard for biota survival (Table 1). However, in-depth study and sampling of other seasons are required for tourism development, particularly underwater ecotourism, considering the present research was only conducted in one season without repetition. This high TSS value is due to the greatest mangrove forest in Bunaken National Park, and therefore sedimentation in certain segments is inevitable. This varies from the

TSS of Prialaot waters at the range of 14-31 mg L^{-1}, with an average of 21.83 mg L^{-1}. Also, the value is generally above the standards allowed for marine tourism (20 mg L^{-1}) and marine life (coral and seagrass by 20 mg L^{-1}, mangroves by 80 mg L^{-1})[14]. Similarly, the TSS of Labuhan Haji beach also demonstrated a fairly higher content, ranging from 14-31 mg L^{-1}, with an average of 21.83 mg L^{-1}. This value is also above the quality standard allowed for marine tourism (20 mg L^{-1}) and marine life (coral and seagrass at 20 mg L^{-1}, and mangroves at 80 mg L^{-1})[11].

Dissolved Oxygen (DO):

The dissolved oxygen source in water originates from the diffusion of oxygen from the air, water currents or flow through rainwater, as well as photosynthetic activity by aquatic plants and phytoplankton. Generally, aquatic creatures, e.g fish, shrimp, shellfish, and other animals, including microorganisms, e.g bacteria, require oxygen. Dissolved Oxygen (DO) regulates the metabolism of organisms to grow and reproduce. Fish need water with an oxygen content of at least 5 mg L^{-1}. The DO values in Mantehage waters ranged from 3.24-6.35 mg L^{-1}, with an average of 5.43 mg L^{-1} (Table 1). This indicates a suitable oxygen content capable of supporting marine biota. Moreover, seawater quality standards for tourism and healthy ecological activities require DO values above 5 mg L^{-1}. The condition supports the seagrass survival, covering 33% of the island[8], and also matches the results of Dissolved Oxygen (DO) measurements performed at Labuhan Haji beach, where the total stations obtained a yield range of 6 mg L^{-1}. Also, the value shows an excellent water condition and relatively suffices the seawater quality standards[11]. Furthermore, dissolved oxygen describes the relative concentration of the element in water within the range of 4.28-10 mg L^{-1}[18]. In addition, the average dissolved oxygen in PantaiCarocokPainan occurs between 5.75-9.1 mg L^{-1} and is suitable for marine tourism activities[12]. Conversely, the DO for the entire stations in the Saleh Bay waters ranges from 4.78-6.01 mg L^{-1}[14]. The measured DO value of PrialaotSabang ranged from 4.4-4.69 mg L^{-1}, with an average of 4.53 mg L^{-1}. However, at sea level, DO values are influenced by the diffusion of oxygen from the air and the photosynthetic rate by marine plants[19].

Salinity:

A particular salinity level is required for coral reefs and seagrass survival towards attracting marine tourism objects, including snorkelling and diving. The salinity range of Mantehage Island

waters occurs between 29.45-32.65%, with an average value of 31.05% (Table 1). This estimation indicates a suitable category within the applicable quality standards. Salinity plays an essential role in supporting marine biota and the water level varies based on geography and time, where the increase in the parameter is caused by evaporation and the result of freezing sea ice, while the decrease is instigated by precipitation and freshwater input from rivers. This outcome slightly varies from the measurement results at Labuhan Haji beach, showing a salinity range of 32-35%[11]. Subsequently, the value for PataiCarocokPainan waters also obtained an average range of 30-31%[12] Meanwhile, Saleh Bay water occurs between 27.17-30.67%[13], and 21.6-32.3% for Prialaot, with a general average of 31.27%[14]. However, the salinity value to promote coral reef life is expected to range from 30-36%[11]. This difference is influenced by geographical position and water type. Furthermore, stable salinity in the archipelago tends to be achieved, due to inadequate water inflow from the mainland. In addition, the value is also greatly impacted by evaporation and precipitation rates.

Nitrate:

The nitrate content in the Mantehage waters ranges from 0.004-0.068 mg L^{-1} at an average of 0.034 mg L^{-1} (Table 1). This value exceeded the quality standard of the Minister of Environment and Forestry Decree No. 51 of 2004, estimated at 0.008 mg L^{-1}. In addition, the extreme result is influenced by the mangrove ecosystem located on the coastal part of the island, where sedimentation is very extensive during the rainy season. An additional indicator is also due to poor mangrove management, leading to free waste from anthropogenic activities entering the aquatic environment. The high concentration of nitrate is probably due to input from land and surrounding factors in the form of liquid waste, both due to agricultural operations. Moreover, the primary ingredient of fertilizers is nitrogen, known to utilize a bio-physicochemical process to become a compound. In marine waters, six types of nitrogen are formed, termed N_2, NO_3, NO_2, NH_3, NH_4, organic N and particulate N. Meanwhile, in the aerobic atmosphere, the nitrogen species generated is the NO_3, as one of the constituents consumed by marine biota, including phytoplankton for growth of 3.9-15.5 mg L^{-1}[13]. This outcome corresponds to the analysis results of the NO_3 at Labuhan Haji beach, with similar content of 0.036 mg/L. Also, the nitrate (NO_3) at Labuhan Haji appears relatively high due to community activities on the coast/land, where unwanted materials are directly and inappropriately disposed into the sea. In addition, the

existence of river water flowing into the beach also serves as a transportation medium for agricultural waste and other human activities related to the sea [11].

Phosphate:

The phosphate content in Mantehage waters ranges from 0.008-0.019 mg L^{-1} at an average of 0.015 mg L^{-1} (Table 1). This value is under the specified quality standard for marine tourism at 0.015 mg L^{-1}, based on the Minister of Environment Decree No. 51 of 2004. However, the estimate varied from the measurement results in MoyoHilir and Lape sub-districts, between 0.03-0.3 mg L^{-1}. Extensive land activities are believed to trigger the phosphate content beyond the quality standard, including livestock, agricultural operations, and the landfill existence in the coastal areas. Moreover, organic waste disposal, e.g detergents, fertilizers, and degradable materials tend to generate phosphate. In marine waters, the greatest phosphate compound is ortho-phosphate as the substance undergoes hydrolysis with a percentage fraction depending on the water pH and temperature [13].

This research implies that the involvement of academics through this study is very helpful for policymakers in developing strategies for developing Mantehage island tourism areas. The data of this study can be applied in determining the best location for snorkelling and diving areas, Mantehage Island is very feasible to be developed as a marine tourism location because it is supported by very good water conditions and follows environmental quality standards. This study has limitations in research time, where the sample is only taken in one season, does not represent another season, besides that this study has not studied the overall condition of the oceanographic parameters.

Table 1. Seawater Quality Parameters in Mantehage Island.

Station	Coordinate		Temperature	Turbidity	TSS	pH	Salinity	DO	NO_3-N	PO_4-P	Parameter
	Latitude	Longitude	28-32	< 5	80	7-8.5[(d)]	<34	>5	0.008	0.015	Biota quality standards
			alami	< 5	20	7-8.5[(d)]	alami[3](e)	>5	0.008	0.015	Tourism quality standards
			C	NTU	mg L^{-1}	pH	PSU	mg L^{-1}	mg L^{-1}	mg L^{-1}	Unit quality standards
1	1°42'49.04"N	124°43'44.57"E	29	3.21	31.20	7.2	30.21	5.23	0.005	0.010	Decree of the Minister of Environment of the Republic of Indonesia No 51 of 2004
2	1°42'27.10"N	124°44'10.46"E	30	4.25	29.25	7.6	31.26	5.47	0.025	0.011	
3	1°42'5.66"N	124°44'28.58"E	28	3.2	33.65	7.4	31.25	5.65	0.045	0.016	
4	1°41'49.04"N	124°44'54.55"E	29	2.2	35.25	7.8	30.45	5.14	0.006	0.018	
5	1°41'39.27"N	124°45'22.47"E	30	3.2	30.56	7.5	29.45	5.98	0.068	0.014	
6	1°41'29.02"N	124°45'49.90"E	28	4.7	32.00	7.4	30.87	6.12	0.065	0.013	
7	1°41'37.80"N	124°46'31.55"E	28	3.6	33.63	7.6	32.14	3.24	0.058	0.015	
8	1°41'59.04"N	124°47'4.83"E	28	2.8	32.63	7.9	30.45	6.35	0.009	0.019	
9	1°42'29.46"N	124°47'1.90"E	30	4	34.24	7.1	31.56	5.21	0.004	0.018	
10	1°43'9.12"N	124°46'41.67"E	30	4.1	32.13	7.4	30.25	5.98	0.008	0.017	
11	1°43'35.87"N	124°46'26.20"E	30	3.2	33.26	7.5	31.25	5.87	0.025	0.009	
12	1°44'29.95"N	124°46'15.18"E	29	4.5	31.00	7.6	30.87	5.46	0.054	0.008	
13	1°44'58.36"N	124°45'57.12"E	30	2.5	31.27	7.1	31.63	5.21	0.066	0.016	
14	1°45'19.63"N	124°45'38.18"E	31	3.8	33.36	7.5	32.65	5.69	0.042	0.014	
15	1°45'51.74"N	124°45'15.50"E	29	4.7	36.25	7.8	32.4	5.19	0.061	0.018	
16	1°46'14.93"N	124°44'9.69"E	28	3.5	35.21	7.5	31.25	5.38	0.019	0.016	
17	1°45'24.98"N	124°43'48.02"E	30	3.4	28.24	7.6	30.65	5.67	0.048	0.014	
18	1°44'51.67"N	124°43'41.78"E	28	2.8	29.25	7.6	31.45	5.43	0.065	0.013	
19	1°44'18.76"N	124°43'32.41"E	29	3.6	32.25	7.6	30.14	5.28	0.008	0.017	
20	1°43'37.56"N	124°43'34.43"E	29	4.5	33.25	7.5	30.86	5.17	0.007	0.014	
Average			29.15	3.58	32.39	7.51	31.052	5.43	0.034	0.015	
Minimum			28	2.2	28.24	7.1	29.45	3.24	0.004	0.008	
Maximum			31	4.7	36.25	7.9	32.65	6.35	0.068	0.019	

Footnote: Total Suspended Solid (TSS), NTU (Nephelometric Turbidity Unit), Practical Salinity Unit (PSU), Dissolved Oxygen (DO)

CONCLUSION

Based on the values of salinity, temperature, turbidity, pH, total suspended solids, dissolved oxygen, NO_3-N, and PO_4-P, the condition of Mantehage water quality obtained a suitable category within the specified standards of the Minister of the Environment Republic of Indonesia. Several parameters known to exceed these provisions, including nitrate and phosphate content, indicate the instantaneous value during measurement. Therefore, an in-depth study, sufficient interval and sampling location to represent the spatial and temporal conditions of the entire island are greatly required. This outermost island generally appears suitable as a marine tourism attraction, particularly snorkelling and diving. Furthermore, the beauty of coral reefs is believed to be a major tourist object with the need for further encouragement. Mantehage Island is very feasible to be developed as a marine tourism area, especially for snorkelling and diving activities, underwater beauty, high biodiversity and supported by good water conditions make this island attractive to tourists.

SIGNIFICANCE STATEMENT

"This study discovered the condition of the seawater quality of Mantehage Island which can be developed as an underwater tourism location, the good status of coral reefs supported by underwater beauty makes Mantehage Island worthy of development, that can be beneficial for the government, researchers, and the people of Mantehage Island in developing tourism. This study will help the researchers to uncover the critical areas of the outermost small island of Indonesia that many researchers were not able to explore. Thus a new theory on the condition of seawater quality for the development of marine tourism may be arrived at".

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REFERENCES

1. Tangian, D., Djokosetiyanto, D., Kholil, K., & Munandar, A. (2015). Model of Ecotourism Management in Small Islands of Bunaken National Park, North Sulawesi. *Journal of Indonesian Tourism and Development Studies*, *3*(2), 75-84. **2242870ja**

https://jitode.ub.ac.id/index.php/jitode/article/view/156

2. Djamaluddin, R. (2018). The mangrove flora and their physical habitat characteristics in Bunaken National Park, North Sulawesi, Indonesia. *Biodiversitas Journal of Biological Diversity*, *19*(4), 1303-1312. **2242871ja**

vhttps://www.smujo.id/biodiv/article/view/2787

3. Opa E. T., Kusen J. D., Kepel R. C., Jusuf A., Lumingas L. J. L., 2019 Community structure of mangrove in Mantehage Island and Paniki Island, North Sulawesi, Indonesia. AACL Bioflux 12(4):1388-1403. **2242872ja**

http://www.bioflux.com.ro/docs/2019.1388-1403.pdf

4. Kase A., Manembu I., Schaduw J.N.W. 2019. [Condition of Mantehage Island Coral Reef, North Minahasa Regency, North Sulawesi]. Journal of coastal and tropical seas. 7 (3) : 208-212. Https://Doi.Org/10.35800/Jplt.7.3.2019.24466 **2245750ja**

https://ejournal.unsrat.ac.id/index.php/jplt/article/view/24466/24143

5. Schaduw J.N.W., Kondoy K.I.F., Manoppo V.E.N., Luasunaung A., Mudeng J., Pelle W.E., Ngangi E.L.A., Manembu I.S., Wantasen N.S., Sumilat D.A., Rumampuk N.D.C., Tilaar S.O., Manengkey H.W.A., Lintang R., Walalangi J.Y., Tampanguma B., Pungus F., Lahabu Y., Sagai B., Wantah E., Wantania L.L., Djabar B., Oli A.P., Caroles E.A., Bachmid F., Sasauw J., Kase A., Anthoni A., Uada A.D., Ladjandu R., Coloay C., Kojongian S., Mamangkey N.N.T. 2020. Data On Percentage Coral Reef Cover In Small Islands Bunaken National Park. Data in Brief, 31, 105713.

https://doi.org/10.1016/j.dib.2020.105713 **135541op**

https://www.sciencedirect.com/science/article/pii/S2352340920306077?via%3Dihub

6. Wagey B. T., Boneka F. B., Mantiri R., 2020 Status of marine biodiversity and community perception on marine conservation in Mantehage Island, Bunaken National Park, North Sulawesi, Indonesia. AACL Bioflux 13(6):3830- 3839. **2242873ja**

http://www.bioflux.com.ro/docs/2020.3830-3839.pdf

7. Kalalo F. P., 2017 Law enforcement and conservation at Bunaken National Park, North Sulawesi, Indonesia as perceived by the local coastal communities. AACL Bioflux 10(6):1413-1420. **2242874ja**

http://www.bioflux.com.ro/docs/2017.1413-1420.pdf

8. Schaduw J. N.W. and Kondoy K. F. I. 2020. Seagrass percent cover in small islands of Bunaken National Park, North Sulawesi Province, Indonesia. AACL Bioflux 13(2):951-957. **2233174ja**

http://www.bioflux.com.ro/docs/2020.951-957.pdf

9. Schaduw J. N.W. 2018. [Distribution and Water Quality Characteristics of the Small Island Mangrove Ecosystem of Bunaken National Park]. Indonesian Geography Magazine. 32 (1) 40-49. **2245751ja**

https://jurnal.ugm.ac.id/mgi/article/view/32204

https://doi.org/10.22146/mgi.32204

10. Kurniadi B., Sigid H., Enan M., Adiwilaga. 2015. [The waters Quality of the Buaya River in Bunyu Island, North Kalimantan in Tidal Conditions]. Indonesian Journal of Agricultural Sciences. 20 (1): 53-58. **2245754ja**

https://journal.ipb.ac.id/index.php/JIPI/article/view/9289/7287

https://doi.org/10.35800/jasm.1.1.2013.1972

11. Haerudin and Putra A.M. 2019. Analysis of Seawater Quality Standards for the Development of Marine Tourism in Labuhan Haji Beach, East Lombok Regency. *Journal of Geodics 3(1) : 13 – 18* **2245755ja**

https://e-journal.hamzanwadi.ac.id/index.php/gdk/article/view/1473

12. Indra N., Sari S., Rahayu G, Oktaviandra R., Handoko A., Putri V.S., Hanapi N.I. 2019. Environmental Quality and Suitability of Coastal Tourism in CarocokPainan Area, Pesisir Selatan Regency. Journal of Capita Selecta Geography 2 (5): 43- 51

http://ksgeo.ppj.unp.ac.id/index.php/ksgeo/article/view/251

https://doi.org/10.24036/ksgeo.v2i5.251

13. Saraswati N.G.R.A., Yulius., Rustam A., Hadiwijaya L., Salim., Heriati A., Mustikasari E. 2017. [Study of Water Quality for Coastal Marine Tourism, MoyoHilirSubdistrict and LapeSubdistrict, Sumbawa Regency]. Journal of Segara 13 (1) : 37-47.

http://ejournal-balitbang.kkp.go.id/index.php/segara/article/view/6421
http://dx.doi.org/10.15578/segara.v13i1.6421
14. Tanto T.A., Naelul N.H.R., Ilham. 2018. [Quality of Seawater to Support Marine Tourism and Marine Life. Case Study: Around the Sinking Ship of Sophie Rickmers, PrialaotSabang Waters]. Marine Journal, 11 (2) : 173-183.
https://journal.trunojoyo.ac.id/jurnalkelautan/article/view/4276
https://doi.org/10.21107/jk.v11i2.4276
15. Tomczak M. and Godfrey J. 2001. Regional Oceanography: An Introduction. Pergamon. ISBN : 9781483287614 https://www.elsevier.com/books/regional-oceanography/tomczak/978-0-08-041021-0_50342b
16. Simanjuntak M. 2012. Seawater Quality Judging from Nutrient Aspects, Dissolved Oxygen and Ph in Banggai Waters, Central Sulawesi. Journal of Tropical Marine Science and Technology. 4(2):290-303. 2233177ja
https://journal.ipb.ac.id/index.php/jurnalikt/article/view/7791
https://doi.org/10.29244/jitkt.v4i2.7791
17. Arifin T., Bengen D.G., Pariwono J.I. 2002. Evaluation on the Suitability of the Palu Bay Coastal Zone for Marine Tourism Development. Coastal and Ocean Journal. 4 (2) : 25-35
https://repository.ipb.ac.id/jspui/bitstream/123456789/26592/1/Taslim%20Arifin_Herni%20%2811%20hal%29.pdf_2242878ja
18. Putra A., Tanto T.A., Pranowo W.S., Ilham., Damanhuri H., Suasti Y., Triyatno T. 2018. Suitability Of Coastal Ecotourism In Padang City-West Sumatera: Case Study Of Beach Recreation And Mangrove. Journal of Segara, 14 (2) : 87-94.
http://ejournal-balitbang.kkp.go.id/index.php/segara/article/view/6642
http://dx.doi.org/10.15578/segara.v14i2.6642_2242879ja
19. Wisha U.J., Tanto T.A., Ilham. 2016. Physical and Chemical Conditions of Bayur Bay Waters on the East and West Season.Journal of Marine Science UNDIP. 22 (1) : 15–24.
https://ejournal.undip.ac.id/index.php/ijms/article/view/10505
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Seawater Quality Analysis in Mantehage Island for Integrated and Sustainable Marine Tourism Development

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RUNNING TITLE: Marine Tourism Development Base on Seawater Quality in Mantehage Island

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ABSTRACT

Background and Objective: There is a growing interest to significantly explore more opportunities in the coastal environment. For this reason, adequate progressive strategies appear very essential. The purpose of this study was to analyze seawater quality as a database for developing integrated and sustainable marine tourism in Mantehage Island, Indonesia. **Materials and Methods:** The present paper applied descriptive and quantitative methods to sample 20 observation points around the selected location. In addition, the seawater content was directly measured and stored in the laboratory for further analysis. Consequently, certain parameters were evaluated, including salinity, temperature, turbidity, pH, total suspended solids, dissolved oxygen, NO_3-N and PO_4-P. The subsequent data were also compared to the related quality standards of the Minister of Environment, Decree No. 51 of 2004. **Results**: Based on the results, Mantehage water quality demonstrated an excellent condition and is also believed to support the proposed marine tourism development. **Conclusion**: the values of salinity, temperature, turbidity, pH, total suspended solids, dissolved oxygen, NO_3-N, and PO_4-P, the condition of Mantehage water quality obtained a suitable category within the specified standards of the Minister of Environment Decree No. 51 of 2004. Several parameters known to exceed these provisions, including nitrate and phosphate content, indicate the instantaneous value during measurement

KEYWORDS: Seawater quality, marine tourism, development, biodiversity, turbidity, salinity, dissolved oxygen

INTRODUCTION

The quality of seawater greatly determines the feasibility of an underwater tourism area, diving and snorkelling activities require good seawater conditions, this greatly affects the comfort and safety of tourists. Bunaken National Park exhibits high biodiversity, particularly in the Coral Triangle along the Asia Pacific region. The number of tourists visiting has a real connection with extensive coral cover. An increase in the number of tourist arrivals will affect the broad decline in coral cover and vice versa. Otherwise, the decline in coral cover will cause the number of tourists to decrease[1]. The underwater view is famous to foreign tourists around the world and encompasses five minor islands, including, Bunaken, Siladen, Manado Tua, Mantehage, and Nain. These 5 landmasses are divided into 2 administrative regions, including Manado city and North Minahasa regency. Mantehage is a major outermost island in Indonesia with the greatest mangrove area in North Sulawesi, the mangrove flora in Bunaken National Park was floristically rich with at least 27 species, and the broader northern distribution limit of *L. littorea and L. racemosa, C. philippinense, S. ovata* was confirmed [2], The mangroves community structure shows that it is unstable with low values of diversity, and evenness, while the value of domination and species richness is high. The highest density of the mangroves found in station 9 is *C. tagal*. In general, mangroves species richness is found in the moderate category [3]. Moreover, the nature of the coral reef ecosystem serves as a potential underwater tourist attraction[4,5]. The condition of the coral reefs in Mantehage Island seen from the percentage of coral cover ranging from 20-40%, the condition of hard coral substrates accompanied by good water quality will support this island as a new marine tourism area[5]. This island also has a good seagrass ecosystem with an average cover percentage of 33%, there are four species of seagrass including *Enhalus acoroides, Thalassia hemprichii, Cymodocea rotundata, Halophila pinifolia*[8]. As far as can be ascertained, the marine biodiversity of Bunaken National Park is notably high. However, there seems to be a lack of a more comprehensive assessment, especially in Mantehage Island. To date, no comprehensive studies have been done on other marine fauna such as sea snakes, turtles, shorebirds, and marine mammals [6]. Another factor might be the establishment and management histories of BNP since management was principally initiated by the Indonesian national government (top-bottom approach) unlike in other well-known cases (e.g. Apo Island Reserve in

the central Philippines) where protection was initiated and even to this day actively participated by the local communities [7]. Some important water quality parameters include salinity, temperature, turbidity, pH, total suspended solids, dissolved oxygen, NO3-N and PO4-P. Information about these parameters will be very helpful in the development of tourist areas. This research is probably a consideration for policymakers in determining the direction and strategies related to the management of coastal and marine resources, particularly for marine tourism development in Mantegehe.

The purpose of this study was to analyze the seawater quality as a database for the prospective development of marine tourism. In addition, the Minister of Environment Decree No. 51 of 2004 poses as a reference for the seawater quality standards.

MATERIALS AND METHODS

Study area: This research was conducted in Mantehage Island, Wori District, North Minahasa regency, North Sulawesi province, within Bunaken National Park from March-May 2021.

Research protocol: Descriptive and quantitative methods with purposive sampling were employed in determining the observational base. Each station possesses coordinate points for easy monitoring and is evenly distributed.

Parameters measurement: the measured seawater parameters were salinity, temperature, turbidity, pH, total suspended solids, dissolved oxygen, NO_3-N and PO_4-P. However, the sampling technique and data analysis adopted the methods[9,10].

Instruments used: The instrument used in this study is horibaU-50 series multi-parameter water quality checker that enables to measure and indicate the monitoring result simultaneously up to 11 parameters with one unit. Considering user-friendly field monitoring on-site, such as rive, groundwater, drainage water, etc. bring together feature of function and performance, which makes simple operation for everybody. Multiple sensors allow for the measurement of 11 parameters simultaneously (pH, pH(mv), Oxidation-Reduction Potential (ORP), Dissolved Oxygen (DO), Conductivity (COND), Salinity, Total dissolved solids (TDS), Seawater Specific Gravity, Temperature, Turbidity, Water Depth). For NO_3-N and PO_4-P analysis, seawater samples were put into glass bottles, then brought to the laboratory for further analysis. Subsequently, the

results were compared to the Minister of Environment Decree No. 51 of 2004 as a reference for seawater quality standards.

RESULTS AND DISCUSSION

Salinity: Salinity is described as the total amount of dissolved salt in seawater. The unit is generally accepted in mg L^{-1} but also occurs in ppt (parts per thousand) or % and Practical Salinity Unit (PSU). Freshwater salinity values are typically <0.5%, brackish waters 0.5-30%, and seawaters 30-40%. Meanwhile, the estimate for coastal waters is strongly influenced by freshwater input from rivers. However, salinity potentially instigates osmotic pressure in seawater biota. The salt content in the aquatic cells occurs close to the surrounding seawater salinity. As the salinity changes, an osmoregulation mechanism is then required in balancing the salt levels between the cells and the environment. Mantehage Island shows a salinity range of 28-31 PSU, with an average of 29.15 PSU (Table 1). This value varies based on the climate/weather during measurement. In the dry season, seawater salinity rises above 30 PSU. Rainy weather condition was observed on the day before sampling, resulting in a lesser salinity value but showing a good category, according to seawater quality standards. This salinity condition is not only good for tourism activities but also for the sustainability of the surrounding aquatic biota.

Temperature:

Temperature influences the metabolic activity and reproduction of marine organisms. This factor is used in a certain tourist destination to determine the potential and existence of coral reef growth[11]. In marine life development, the optimal average temperature is expected in the range of 23-35℃ with tolerance limits between 36-40°C. The seawater temperature of Mantehage Island occurs from 28-31°C with an average value of 29.15°C (Table 1). Furthermore, a similar condition was observed in the coastal waters of Labuhan Haji, East Lombok regency, with a range of 30-32ºC[11] . However, temperature variations tend to influence the life of coral reefs. Based on the Minister of Environment Decree No. 51 of 2004, the water temperature for marine tourism is expected at natural temperature. An appropriate range for coral reef areas exists in the range of 28-30 and 28-32ºC for mangrove regions. Discontinue in situ temperature measurement is a natural temperature with a change tolerance <2°C (Minister of Environment Decree No. 51 of 2004). However, the biota in tropical waters naturally resides in the upper limit of the highest

temperature. These variations possibly interfere with the physiological processes known to endanger the biota. In the value range >28°C, sea surface temperature in the western equator appears very warm[12]. Moreover, the condition is considered natural as Indonesia is a tropical region. Based on the water depth, extensive seawater surface temperatures are observed, in comparison to a certain depth, probably due to the high intensity of sunlight.

Turbidity:

Lower turbidity increases the light intensity capable of penetrating the water depth. Therefore, the resulting value is expected to exist under normal conditions, where water transparency is inversely proportional to the turbidity, believed to significantly influence oxygen content. Turbid water possibly interferes with the respiration process and decreases oxygen levels. The seawater turbidity condition of Mantehage Island ranges between 2.2-4.7 NTU (Nephelometric Turbidity Unit), with an average value of 3.58 NTU (Table 1), indicating an appropriate category and in line with the quality standards. Therefore, the site is suitable as a potential tourist attraction. This condition is supported by data on Mantehage Island coral reef cover in the range of 19-30%, with an average live coral cover of 29.10%[5]. Furthermore, turbidity describes inadequate water transparency, due to colloidal and suspended materials, including mud, organic and inorganic materials as well as aquatic microorganisms.

pH level:

Inconsistencies in the water pH level probably influence biota existence to a certain extent of varying pH[13]. Subsequently, the pH of Mantehage Island seawater ranges from 7.1-7.9, with an average value of 7.51, indicating an appropriate category for tourism development and aquatic life support (Table 1). This value also corresponds to a pH in Labuhan Haji beach between 7.6-7.9[11]. These variations depend on geographic position and water injection from the environment. In addition, it is also affected by the season as related to local rainfall and climate.

Total Suspended Solid (TSS):

The TSS of Mantehage Island waters ranged from 28.24-36.25 mg L^{-1} with an average value of 32.39 mg L^{-1}, corresponding to the quality standard for biota survival (Table 1). However, in-depth study and sampling of other seasons are required for tourism development, particularly underwater ecotourism, considering the present research was only conducted in one season without repetition. This high TSS value is due to the greatest mangrove forest in Bunaken National Park, and therefore sedimentation in certain segments is inevitable. This varies from the TSS of Prialaot waters at the range of 14-31 mg L^{-1}, with an average of 21.83 mg L^{-1}. Similarly, the TSS of Labuhan Haji beach also demonstrated a fairly higher content, ranging from 14-31 mg L^{-1}, with an average of 21.83 mg L^{-1}. This value is also above the quality standard allowed for marine tourism (20 mg L^{-1}) and marine life (coral and seagrass at 20 mg L^{-1}, and mangroves at 80 mg L^{-1})[11].

Dissolved Oxygen (DO):

The dissolved oxygen source in water originates from the diffusion of oxygen from the air, water currents or flow through rainwater, as well as photosynthetic activity by aquatic plants and phytoplankton. Generally, aquatic creatures, e.g fish, shrimp, shellfish, and other animals, including microorganisms, e.g bacteria, require oxygen. Dissolved Oxygen (DO) regulates the metabolism of organisms to grow and reproduce. Fish need water with an oxygen content of at least 5 mg L^{-1}. The DO values in Mantehage waters ranged from 3.24-6.35 mg L^{-1}, with an average of 5.43 mg L^{-1} (Table 1). This indicates a suitable oxygen content capable of supporting marine biota. Moreover, seawater quality standards for tourism and healthy ecological activities require DO values above 5 mg L^{-1}. The condition supports the seagrass survival, covering 33% of the island[8], and also matches the results of Dissolved Oxygen (DO) measurements performed at Labuhan Haji beach, where the total stations obtained a yield range of 6 mg L^{-1}. Also, the value shows an excellent water condition and relatively suffices the seawater quality standards[11]. Furthermore, dissolved oxygen describes the relative concentration of the element in water within the range of 4.28-10 mg L^{-1}[14]. The measured DO value of PrialaotSabang ranged from 4.4-4.69 mg L^{-1}, with an average of 4.53 mg L^{-1}. However, at sea level, DO values are influenced by the diffusion of oxygen from the air and the photosynthetic rate by marine plants[15].

Salinity:

A particular salinity level is required for coral reefs and seagrass survival towards attracting marine tourism objects, including snorkelling and diving. The salinity range of Mantehage Island waters occurs between 29.45-32.65%, with an average value of 31.05% (Table 1). This estimation indicates a suitable category within the applicable quality standards. Salinity plays an essential role in supporting marine biota and the water level varies based on geography and time, where the increase in the parameter is caused by evaporation and the result of freezing sea ice, while the decrease is instigated by precipitation and freshwater input from rivers. This outcome slightly varies from the measurement results at Labuhan Haji beach, showing a salinity range of 32-35%[11]. However, the salinity value to promote coral reef life is expected to range from 30-36%[11]. This difference is influenced by geographical position and water type. Furthermore, stable salinity in the archipelago tends to be achieved, due to inadequate water inflow from the mainland. In addition, the value is also greatly impacted by evaporation and precipitation rates.

Nitrate:

The nitrate content in the Mantehage waters ranges from 0.004-0.068 mg L^{-1} at an average of 0.034 mg L^{-1} (Table 1). This value exceeded the quality standard of the Minister of Environment and Forestry Decree No. 51 of 2004, estimated at 0.008 mg L^{-1}. In addition, the extreme result is influenced by the mangrove ecosystem located on the coastal part of the island, where sedimentation is very extensive during the rainy season. An additional indicator is also due to poor mangrove management, leading to free waste from anthropogenic activities entering the aquatic environment. The high concentration of nitrate is probably due to input from land and surrounding factors in the form of liquid waste, both due to agricultural operations. Moreover, the primary ingredient of fertilizers is nitrogen, known to utilize a bio-physicochemical process to become a compound. In marine waters, six types of nitrogen are formed, termed N_2, NO_3, NO_2, NH_3, NH_4, organic N and particulate N. This outcome corresponds to the analysis results of the NO_3 at Labuhan Haji beach, with similar content of 0.036 mg/L. Also, the nitrate (NO_3) at Labuhan Haji appears relatively high due to community activities on the coast/land, where unwanted materials are directly and inappropriately disposed into the sea. In addition, the existence of river water flowing into the beach also serves as a transportation medium for agricultural waste and other human activities related to the sea [11].

Phosphate:

The phosphate content in Mantehage waters ranges from 0.008-0.019 mg L^{-1} at an average of 0.015 mg L^{-1} (Table 1). This value is under the specified quality standard for marine tourism at 0.015 mg L^{-1}, based on the Minister of Environment Decree No. 51 of 2004. However, the estimate varied from the measurement results in MoyoHilir and Lape sub-districts, between 0.03-0.3 mg L^{-1}. Extensive land activities are believed to trigger the phosphate content beyond the quality standard, including livestock, agricultural operations, and the landfill existence in the coastal areas. This research implies that the involvement of academics through this study is very helpful for policymakers in developing strategies for developing Mantehage island tourism areas. The data of this study can be applied in determining the best location for snorkelling and diving areas, Mantehage Island is very feasible to be developed as a marine tourism location because it is supported by very good water conditions and follows environmental quality standards. This study has limitations in research time, where the sample is only taken in one season, does not represent another season, besides that this study has not studied the overall condition of the oceanographic parameters.

Table 1. Seawater Quality Parameters in Mantehage Island.

Station	Coordinate		Temperature	Turbidity	TSS	pH	Salinity	DO	NO_3-N	PO_4-P	Parameter
	Latitude	Longitude	28-32	< 5	80	7-8.5[(d)]	<34	>5	0.008	0.015	Biota quality standards
			alami	< 5	20	7-8.5[(d)]	alami[3](e)	>5	0.008	0.015	Tourism quality standards
			C	NTU	mg L^{-1}	pH	PSU	mg L^{-1}	mg L^{-1}	mg L^{-1}	Unit quality standards
1	1°42'49.04"N	124°43'44.57"E	29	3.21	31.20	7.2	30.21	5.23	0.005	0.010	Decree of the Minister of Environment of the Republic of Indonesia No 51 of 2004
2	1°42'27.10"N	124°44'10.46"E	30	4.25	29.25	7.6	31.26	5.47	0.025	0.011	
3	1°42'5.66"N	124°44'28.58"E	28	3.2	33.65	7.4	31.25	5.65	0.045	0.016	
4	1°41'49.04"N	124°44'54.55"E	29	2.2	35.25	7.8	30.45	5.14	0.006	0.018	
5	1°41'39.27"N	124°45'22.47"E	30	3.2	30.56	7.5	29.45	5.98	0.068	0.014	
6	1°41'29.02"N	124°45'49.90"E	28	4.7	32.00	7.4	30.87	6.12	0.065	0.013	
7	1°41'37.80"N	124°46'31.55"E	28	3.6	33.63	7.6	32.14	3.24	0.058	0.015	
8	1°41'59.04"N	124°47'4.83"E	28	2.8	32.63	7.9	30.45	6.35	0.009	0.019	
9	1°42'29.46"N	124°47'1.90"E	30	4	34.24	7.1	31.56	5.21	0.004	0.018	
10	1°43'9.12"N	124°46'41.67"E	30	4.1	32.13	7.4	30.25	5.98	0.008	0.017	
11	1°43'35.87"N	124°46'26.20"E	30	3.2	33.26	7.5	31.25	5.87	0.025	0.009	
12	1°44'29.95"N	124°46'15.18"E	29	4.5	31.00	7.6	30.87	5.46	0.054	0.008	
13	1°44'58.36"N	124°45'57.12"E	30	2.5	31.27	7.1	31.63	5.21	0.066	0.016	
14	1°45'19.63"N	124°45'38.18"E	31	3.8	33.36	7.5	32.65	5.69	0.042	0.014	
15	1°45'51.74"N	124°45'15.50"E	29	4.7	36.25	7.8	32.4	5.19	0.061	0.018	
16	1°46'14.93"N	124°44'9.69"E	28	3.5	35.21	7.5	31.25	5.38	0.019	0.016	
17	1°45'24.98"N	124°43'48.02"E	30	3.4	28.24	7.6	30.65	5.67	0.048	0.014	
18	1°44'51.67"N	124°43'41.78"E	28	2.8	29.25	7.6	31.45	5.43	0.065	0.013	
19	1°44'18.76"N	124°43'32.41"E	29	3.6	32.25	7.6	30.14	5.28	0.008	0.017	
20	1°43'37.56"N	124°43'34.43"E	29	4.5	33.25	7.5	30.86	5.17	0.007	0.014	
Average			29.15	3.58	32.39	7.51	31.052	5.43	0.034	0.015	
Minimum			28	2.2	28.24	7.1	29.45	3.24	0.004	0.008	
Maximum			31	4.7	36.25	7.9	32.65	6.35	0.068	0.019	

Footnote: Total Suspended Solid (TSS), NTU (Nephelometric Turbidity Unit), Practical Salinity Unit (PSU), Dissolved Oxygen (DO)

CONCLUSION

Based on the values of salinity, temperature, turbidity, pH, total suspended solids, dissolved oxygen, NO_3-N, and PO_4-P, the condition of Mantehage water quality obtained a suitable category within the specified standards of the Minister of the Environment Republic of Indonesia. Several parameters known to exceed these provisions, including nitrate and phosphate content, indicate the instantaneous value during measurement. Therefore, an in-depth study, sufficient interval and sampling location to represent the spatial and temporal conditions of the entire island are greatly required. This outermost island generally appears suitable as a marine tourism attraction, particularly snorkelling and diving. Furthermore, the beauty of coral reefs is believed to be a major tourist object with the need for further encouragement. Mantehage Island is very feasible to be developed as a marine tourism area, especially for snorkelling and diving activities, underwater beauty, high biodiversity and supported by good water conditions make this island attractive to tourists.

SIGNIFICANCE STATEMENT

"This study discovered the condition of the seawater quality of Mantehage Island which can be developed as an underwater tourism location, the good status of coral reefs supported by underwater beauty makes Mantehage Island worthy of development, that can be beneficial for the government, researchers, and the people of Mantehage Island in developing tourism. This study will help the researchers to uncover the critical areas of the outermost small island of Indonesia that many researchers were not able to explore. Thus a new theory on the condition of seawater quality for the development of marine tourism may be arrived at".

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REFERENCES

1. Tangian, D., Djokosetiyanto, D., Kholil, K., & Munandar, A. (2015). Model of Ecotourism Management in Small Islands of Bunaken National Park, North Sulawesi. *Journal of Indonesian Tourism and Development Studies*, *3*(2), 75-84. **2242870ja**

https://jitode.ub.ac.id/index.php/jitode/article/view/156

2. Djamaluddin, R. (2018). The mangrove flora and their physical habitat characteristics in Bunaken National Park, North Sulawesi, Indonesia. *Biodiversitas Journal of Biological Diversity*, *19*(4), 1303-1312. **2242871ja**

vhttps://www.smujo.id/biodiv/article/view/2787

3. Opa E. T., Kusen J. D., Kepel R. C., Jusuf A., Lumingas L. J. L., 2019 Community structure of mangrove in Mantehage Island and Paniki Island, North Sulawesi, Indonesia. AACL Bioflux 12(4):1388-1403. **2242872ja**

http://www.bioflux.com.ro/docs/2019.1388-1403.pdf

4. Kase A., Manembu I., Schaduw J.N.W. 2019. [Condition of Mantehage Island Coral Reef, North Minahasa Regency, North Sulawesi]. Journal of coastal and tropical seas. 7 (3) : 208-212. Https://Doi.Org/10.35800/Jplt.7.3.2019.24466 **2245750ja**

https://ejournal.unsrat.ac.id/index.php/jplt/article/view/24466/24143

5. Schaduw J.N.W., Kondoy K.I.F., Manoppo V.E.N., Luasunaung A., Mudeng J., Pelle W.E., Ngangi E.L.A., Manembu I.S., Wantasen N.S., Sumilat D.A., Rumampuk N.D.C., Tilaar S.O., Manengkey H.W.A., Lintang R., Walalangi J.Y., Tampanguma B., Pungus F., Lahabu Y., Sagai B., Wantah E., Wantania L.L., Djabar B., Oli A.P., Caroles E.A., Bachmid F., Sasauw J., Kase A., Anthoni A., Uada A.D., Ladjandu R., Coloay C., Kojongian S., Mamangkey N.N.T. 2020. Data On Percentage Coral Reef Cover In Small Islands Bunaken National Park. Data in Brief, 31, 105713.

https://doi.org/10.1016/j.dib.2020.105713 **135541op**

https://www.sciencedirect.com/science/article/pii/S2352340920306077?via%3Dihub

6. Wagey B. T., Boneka F. B., Mantiri R., 2020 Status of marine biodiversity and community perception on marine conservation in Mantehage Island, Bunaken National Park, North Sulawesi, Indonesia. AACL Bioflux 13(6):3830- 3839. **2242873ja**

http://www.bioflux.com.ro/docs/2020.3830-3839.pdf

7. Kalalo F. P., 2017 Law enforcement and conservation at Bunaken National Park, North Sulawesi, Indonesia as perceived by the local coastal communities. AACL Bioflux 10(6):1413-1420. **2242874ja**

http://www.bioflux.com.ro/docs/2017.1413-1420.pdf

8. Schaduw J. N.W. and Kondoy K. F. I. 2020. Seagrass percent cover in small islands of Bunaken National Park, North Sulawesi Province, Indonesia. AACL Bioflux 13(2):951-957. **2233174ja**

http://www.bioflux.com.ro/docs/2020.951-957.pdf

9. Schaduw J. N.W. 2018. [Distribution and Water Quality Characteristics of the Small Island Mangrove Ecosystem of Bunaken National Park]. Indonesian Geography Magazine. 32 (1) 40-49. **2245751ja**

https://jurnal.ugm.ac.id/mgi/article/view/32204

https://doi.org/10.22146/mgi.32204

10. Kurniadi B., Sigid H., Enan M., Adiwilaga. 2015. [The waters Quality of the Buaya River in Bunyu Island, North Kalimantan in Tidal Conditions]. Indonesian Journal of Agricultural Sciences. 20 (1): 53-58. **2245754ja**

https://journal.ipb.ac.id/index.php/JIPI/article/view/9289/7287

https://doi.org/10.35800/jasm.1.1.2013.1972

11. Haerudin and Putra A.M. 2019. Analysis of Seawater Quality Standards for the Development of Marine Tourism in Labuhan Haji Beach, East Lombok Regency. *Journal of Geodics 3(1) : 13 – 18* **2245755ja**

https://e-journal.hamzanwadi.ac.id/index.php/gdk/article/view/1473

12. Tomczak M. and Godfrey J. 2001. Regional Oceanography: An Introduction. Pergamon. ISBN : 9781483287614 https://www.elsevier.com/books/regional-oceanography/tomczak/978-0-08-041021-0_**50342b**

13. Simanjuntak M. 2012. Seawater Quality Judging from Nutrient Aspects, Dissolved Oxygen and Ph in Banggai Waters, Central Sulawesi. Journal of Tropical Marine Science and Technology. 4(2):290-303. **2233177ja**

https://journal.ipb.ac.id/index.php/jurnalikt/article/view/7791

https://doi.org/10.29244/jitkt.v4i2.7791

14. Putra A., Tanto T.A., Pranowo W.S., Ilham., Damanhuri H., Suasti Y., Triyatno T. 2018. Suitability Of Coastal Ecotourism In Padang City-West Sumatera: Case Study Of Beach Recreation And Mangrove. Journal of Segara, 14 (2) : 87-94.
http://ejournal-balitbang.kkp.go.id/index.php/segara/article/view/6642
http://dx.doi.org/10.15578/segara.v14i2.6642_2242879ja
15. Wisha U.J., Tanto T.A., Ilham. 2016. Physical and Chemical Conditions of Bayur Bay Waters on the East and West Season.Journal of Marine Science UNDIP. 22 (1) : 15–24.
https://ejournal.undip.ac.id/index.php/ijms/article/view/10505
doi:10.14710/ik.ijms.22.1.15-24_2242880ja
https://ejournal.unsrat.ac.id/index.php/lppmsains/article/view/10692

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Research Article
Seawater Quality Analysis in Mantehage Island for Integrated and Sustainable Marine Tourism Development

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Abstract

Background and Objective: There is a growing interest to significantly explore more opportunities in the coastal environment. For this reason, adequate progressive strategies appear very essential. The purpose of this study was to analyze seawater quality as a database for developing integrated and sustainable marine tourism in Mantehage Island, Indonesia. **Materials and Methods:** The present paper applied descriptive and quantitative methods to sample 20 observation points around the selected location. In addition, the seawater content was directly measured and stored in the laboratory for further analysis. Consequently, certain parameters were evaluated, including salinity, temperature, turbidity, pH, total suspended solids, dissolved oxygen, NO_3-N and PO_4-P. The subsequent data were also compared to the related quality standards of the Minister of Environment, Decree No. 51 of 2004. **Results:** Based on the results, Mantehage water quality demonstrated an excellent condition and is also believed to support the proposed marine tourism development. **Conclusion:** The values of salinity, temperature, turbidity, pH, total suspended solids, dissolved oxygen, NO_3-N and PO_4-P, the condition of Mantehage water quality obtained a suitable category within the specified standards of the Minister of Environment Decree No. 51 of 2004. Several parameters known to exceed these provisions, including nitrate and phosphate content, indicate the instantaneous value during measurement.

Key words: Seawater quality, marine tourism, development, biodiversity, turbidity, salinity, dissolved oxygen

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

The quality of seawater greatly determines the feasibility of an underwater tourism area, diving and snorkelling activities require good seawater conditions, this greatly affects the comfort and safety of tourists. Bunaken National Park exhibits high biodiversity, particularly in the Coral Triangle along the Asia Pacific region. The number of tourists visiting has a real connection with extensive coral cover. An increase in the number of tourist arrivals will affect the broad decline in coral cover and vice versa. Otherwise, the decline in coral cover will cause the number of tourists to decrease[1]. The underwater view is famous to foreign tourists around the world and encompasses 5 minor islands, including, Bunaken, Siladen, Manado Tua, Mantehage and Nain. These 5 landmasses are divided into 2 administrative regions, including Manado city and North Minahasa Regency. Mantehage is a major outermost island in Indonesia with the greatest mangrove area in North Sulawesi, the mangrove flora in Bunaken National Park was floristically rich with at least 27 species and the broader northern distribution limit of *L. littorea* and *L. racemosa, C. philippinense, S. ovata* was confirmed[2]. The mangroves community structure shows that it is unstable with low values of diversity and evenness, while the value of domination and species richness is high. The highest density of the mangroves found in station 9 is *C. tagal*. In general, mangroves species richness is found in the moderate category[3]. Moreover, the nature of the coral reef ecosystem serves as a potential underwater tourist attraction[4,5]. The condition of the coral reefs in Mantehage island seen from the percentage of coral cover ranging from 20-40%, the condition of hard coral substrates accompanied by good water quality will support this island as a new marine tourism area[5]. This island also has a good seagrass ecosystem with an average cover percentage of 33%, there are 4 species of seagrass including *Enhalus acoroides, Thalassia hemprichii, Cymodocea rotundata, Halophila pinifolia*[6]. As far as can be ascertained, the marine biodiversity of Bunaken National Park is notably high. However, there seems to be a lack of a more comprehensive assessment, especially in Mantehage Island. To date, no comprehensive studies have been done on other marine fauna such as sea snakes, turtles, shorebirds and marine mammals[7]. Another factor might be the establishment and management histories of BNP since management was principally initiated by the Indonesian National Government (top-bottom approach) unlike in other well-known cases (e.g. Apo Island Reserve in the Central Philippines) where protection was initiated and even to this day actively participated by the local communities[8]. Some important water quality parameters include salinity, temperature, turbidity, pH, total suspended solids, dissolved oxygen, NO_3-N and PO_4-P. Information about these parameters will be very helpful in the development of tourist areas. This research is probably a consideration for policymakers in determining the direction and strategies related to the management of coastal and marine resources, particularly for marine tourism development in Mantegehe.

The purpose of this study was to analyze the seawater quality as a database for the prospective development of marine tourism. In addition, The Minister of Environment Decree No. 51 of 2004 poses as a reference for the seawater quality standards.

MATERIALS AND METHODS

Study area: This research was conducted in Mantehage Island, Wori District, North Minahasa Regency, North Sulawesi Province, within Bunaken National Park from March-May, 2021.

Research protocol: Descriptive and quantitative methods with purposive sampling were employed in determining the observational base. Each station possesses coordinate points for easy monitoring and is evenly distributed.

Parameters measurement: The measured seawater parameters were salinity, temperature, turbidity, pH, total suspended solids, dissolved oxygen, NO_3-N and PO_4-P. However, the sampling technique and data analysis adopted the methods[9,10].

Instruments used: The instrument used in this study is Horiba U-50 series multi-parameter water quality checker that enables to measure and indicate the monitoring result simultaneously up to 11 parameters with one unit. Considering user-friendly field monitoring on-site, such as rive, groundwater, drainage water, etc. bring together feature of function and performance, which makes simple operation for everybody. Multiple sensors allow for the measurement of 11 parameters simultaneously (pH, pH (mv), Oxidation-Reduction Potential (ORP), Dissolved Oxygen (DO), Conductivity (COND), Salinity, Total dissolved solids (TDS), Seawater Specific Gravity, Temperature, Turbidity, Water Depth). For NO_3-N and PO_4-P analysis, seawater samples were put into glass bottles, then brought to the laboratory for further analysis. Subsequently, the results were compared to the Minister of Environment Decree No. 51 of 2004 as a reference for seawater quality standards.

RESULTS AND DISCUSSION

Salinity: Salinity is described as the total amount of dissolved salt in seawater. The unit is generally accepted in mg L^{-1} but also occurs in ppt (parts per thousand) or percentage and Practical Salinity Unit (PSU). Freshwater salinity values are typically <0.5%, brackish waters 0.5-30% and seawaters 30-40%. Meanwhile, the estimate for coastal waters is strongly influenced by freshwater input from rivers. However, salinity potentially instigates osmotic pressure in seawater biota. The salt content in the aquatic cells occurs close to the surrounding seawater salinity. As the salinity changes, an osmoregulation mechanism is then required in balancing the salt levels between the cells and the environment. Mantehage Island shows a salinity range of 28-31 PSU, with an average of 29.15 PSU (Table 1). This value varies based on the climate/weather during measurement. In the dry season, seawater salinity rises above 30 PSU. Rainy weather condition was observed on the day before sampling, resulting in a lesser salinity value but showing a good category, according to seawater quality standards. This salinity condition is not only good for tourism activities but also for the sustainability of the surrounding aquatic biota.

Temperature: Temperature influences the metabolic activity and reproduction of marine organisms. This factor is used in a certain tourist destination to determine the potential and existence of coral reef growth[11]. In marine life development, the optimal average temperature is expected in the range of 23-35 with tolerance limits between 36-40°C. The seawater temperature of Mantehage Island occurs from 28-31°C with an average value of 29.15°C (Table 1). Furthermore, a similar condition was observed in the coastal waters of Labuhan Haji, East Lombok Regency, with a range of 30-32°C[11] . However, temperature variations tend to influence the life of coral reefs. Based on the Minister of Environment Decree No. 51 of 2004, the water temperature for marine tourism is expected at natural temperature. An appropriate range for coral reef areas exists in the range of 28-30 and 28-32°C for Mangrove regions. Discontinue *in situ* temperature measurement is a natural temperature with a change tolerance <2°C (Minister of Environment Decree No. 51 of 2004). However, the biota in tropical waters naturally resides in the upper limit of the highest temperature. These variations possibly interfere with the physiological processes known to endanger the biota. In the value range >28°C, sea surface temperature in the western equator appears very warm[12]. Moreover, the condition is considered natural as Indonesia is a tropical region. Based on the water depth, extensive seawater surface temperatures are observed, in comparison to a certain depth, probably due to the high intensity of sunlight.

Turbidity: Lower turbidity increases the light intensity capable of penetrating the water depth. Therefore, the resulting value is expected to exist under normal conditions, where water transparency is inversely proportional to the turbidity, believed to significantly influence oxygen content. Turbid water possibly interferes with the respiration process and decreases oxygen levels. The seawater turbidity condition of Mantehage Island ranges between 2.2-4.7 NTU (Nephelometric Turbidity Unit), with an average value of 3.58 NTU (Table 1), indicating an appropriate category and in line with the quality standards. Therefore, the site is suitable as a potential tourist attraction. This condition is supported by data on Mantehage Island coral reef cover in the range of 19-30%, with an average live coral cover of 29.10%[5]. Furthermore, turbidity describes inadequate water transparency, due to colloidal and suspended materials, including mud, organic and inorganic materials as well as aquatic microorganisms.

pH level: Inconsistencies in the water pH level probably influence biota existence to a certain extent of varying pH[13]. The water pH value depends on carbon dioxide and ion concentrations. Moreover, the parameter plays a significant role in the solubility of particular compounds, although appears minimal in the morning, compared to the afternoon period. Subsequently, the pH of Mantehage Island seawater ranges from 7.1-7.9, with an average value of 7.51, indicating an appropriate category for tourism development and aquatic life support (Table 1). This value also corresponds to a pH in Labuhan Haji beach between 7.6-7.9[11]. These variations depend on geographic position and water injection from the environment. In addition, it is also affected by the season as related to local rainfall and climate.

Total Suspended Solid (TSS): The TSS of Mantehage Island waters ranged from 28.24-36.25 mg L^{-1} with an average value of 32.39 mg L^{-1}, corresponding to the quality standard for biota survival (Table 1). However, in-depth study and sampling of other seasons are required for tourism development, particularly underwater ecotourism, considering the present research was only conducted in one season without repetition. This high TSS value is due to the greatest mangrove forest in Bunaken National Park and therefore sedimentation in certain segments is inevitable. This varies from the TSS of Pria Laot waters at the range of 14-31 mg L^{-1}, with an average

Table 1: Seawater quality parameters in Mantehage Island

				Turbidity	TSS	pH	Salinity	DO	NO_3-N	PO_4-P	Parameters
	Coordinate			<5	80	7-8.5[d]	<34	>5	0.008	0.015	Biota quality standards
	----------		Temperature	<5	20	7-8.5[d]	alami[3] (e)	>5	0.008	0.015	Tourism quality standards
Stations	Latitude	Longitude	28-32 alami C	NTU	(mg L^{-1})	pH	PSU	(mg L^{-1})	(mg L^{-1})	(mg L^{-1})	Unit quality standards
1	1°42′49.04″N	124°43′44.57″E	29	3.21	31.20	7.2	30.21	5.23	0.005	0.010	Decree of the Minister of Environment
2	1°42′27.10″N	124°44′10.46″E	30	4.25	29.25	7.6	31.26	5.47	0.025	0.011	of the Republic of Indonesia No 51 of 2004
3	1°42′5.66″N	124°44′28.58″E	28	3.2	33.65	7.4	31.25	5.65	0.045	0.016	
4	1°41′49.04″N	124°44′54.55″E	29	2.2	35.25	7.8	30.45	5.14	0.006	0.018	
5	1°41′39.27″N	124°45′22.47″E	30	3.2	30.56	7.5	29.45	5.98	0.068	0.014	
6	1°41′29.02″N	124°45′49.90″E	28	4.7	32.00	7.4	30.87	6.12	0.065	0.013	
7	1°41′37.80″N	124°46′31.55″E	28	3.6	33.63	7.6	32.14	3.24	0.058	0.015	
8	1°41′59.04″N	124°47′4.83″E	28	2.8	32.63	7.9	30.45	6.35	0.009	0.019	
9	1°42′29.46″N	124°47′1.90″E	30	4	34.24	7.1	31.56	5.21	0.004	0.018	
10	1°43′9.12″N	124°46′41.67″E	30	4.1	32.13	7.4	30.25	5.98	0.008	0.017	
11	1°43′35.87″N	124°46′26.20″E	30	3.2	33.26	7.5	31.25	5.87	0.025	0.009	
12	1°44′29.95″N	124°46′15.18″E	29	4.5	31.00	7.6	30.87	5.46	0.054	0.008	
13	1°44′58.36″N	124°45′57.12″E	30	2.5	31.27	7.1	31.63	5.21	0.066	0.016	
14	1°45′19.63″N	124°45′38.18″E	31	3.8	33.36	7.5	32.65	5.69	0.042	0.014	
15	1°45′51.74″N	124°45′15.50″E	29	4.7	36.25	7.8	32.4	5.19	0.061	0.018	
16	1°46′14.93″N	124°44′9.69″E	28	3.5	35.21	7.5	31.25	5.38	0.019	0.016	
17	1°45′24.98″N	124°43′48.02″E	30	3.4	28.24	7.6	30.65	5.67	0.048	0.014	
18	1°44′51.67″N	124°43′41.78″E	28	2.8	29.25	7.6	31.45	5.43	0.065	0.013	
19	1°44′18.76″N	124°43′32.41″E	29	3.6	32.25	7.6	30.14	5.28	0.008	0.017	
20	1°43′37.56″N	124°43′34.43″E	29	4.5	33.25	7.5	30.86	5.17	0.007	0.014	
Average			29.15	3.58	32.39	7.51	31.052	5.43	0.034	0.015	
Minimum			28	2.2	28.24	7.1	29.45	3.24	0.004	0.008	
Maximum			31	4.7	36.25	7.9	32.65	6.35	0.068	0.019	

TSS: Total suspended solid, NTU: Nephelometric Turbidity Unit, PSU: Practical Salinity Unit and DO: Dissolved Oxygen

of 21.83 mg L^{-1}. Similarly, the TSS of Labuhan Haji beach also demonstrated a fairly higher content, ranging from 14-31 mg L^{-1}, with an average of 21.83 mg L^{-1}. This value is also above the quality standard allowed for marine tourism (20 mg L^{-1}) and marine life (coral and seagrass at 20 mg L^{-1} and mangroves at 80 mg L^{-1})[11].

Dissolved Oxygen (DO): The dissolved oxygen source in water originates from the diffusion of oxygen from the air, water currents or flow through rainwater, as well as photosynthetic activity by aquatic plants and phytoplankton. Generally, aquatic creatures, e.g fish, shrimp, shellfish and other animals, including microorganisms, e.g bacteria, require oxygen. Dissolved Oxygen (DO) regulates the metabolism of organisms to grow and reproduce. Fish need water with an oxygen content of at least 5 mg L^{-1}. The DO values in Mantehage waters ranged from 3.24-6.35 mg L^{-1}, with an average of 5.43 mg L^{-1} (Table 1). This indicates a suitable oxygen content capable of supporting marine biota. Moreover, seawater quality standards for tourism and healthy ecological activities require DO values above 5 mg L^{-1}. The condition supports the seagrass survival, covering 33% of the island[8] and also matches the results of Dissolved Oxygen (DO) measurements performed at Labuhan Haji beach, where the total stations obtained a yield range of 6 mg L^{-1}. Also, the value shows an excellent water condition and relatively suffices the seawater quality standards[11]. Furthermore, dissolved oxygen describes the relative concentration of the element in water within the range of 4.28-10 mg L^{-1} [14]. The measured DO value of Pria Laot Sabang ranged from 4.4-4.69 mg L^{-1}, with an average of 4.53 mg L^{-1}. However, at sea level, DO values are influenced by the diffusion of oxygen from the air and the photosynthetic rate by marine plants[15].

Salinity: A particular salinity level is required for coral reefs and seagrass survival towards attracting marine tourism objects, including snorkelling and diving. The salinity range of Mantehage Island waters occurs between 29.45-32.65%, with an average value of 31.05% (Table 1). This estimation indicates a suitable category within the applicable quality standards. Salinity plays an essential role in supporting marine biota and the water level varies based on geography and time, where the increase in the parameter is caused by evaporation and the result of freezing sea ice, while the decrease is instigated by precipitation and freshwater input from rivers. This outcome slightly varies from the measurement results at Labuhan Haji beach, showing a salinity range of 32-35%[11]. However, the salinity value to promote coral reef life is expected to range from 30-36%[11]. This difference is influenced by geographical position and water type. Furthermore, stable salinity in the archipelago tends to be achieved, due to inadequate water inflow from the mainland. In addition, the value is also greatly impacted by evaporation and precipitation rates.

Nitrate: The nitrate content in the Mantehage waters ranges from 0.004-0.068 mg L^{-1} at an average of 0.034 mg L^{-1} (Table 1). This value exceeded the quality standard of the Minister of Environment and Forestry Decree No. 51 of 2004, estimated at 0.008 mg L^{-1}. In addition, the extreme result is influenced by the mangrove ecosystem located on the coastal part of the island, where sedimentation is very extensive during the rainy season. An additional indicator is also due to poor mangrove management, leading to free waste from anthropogenic activities entering the aquatic environment. The high concentration of nitrate is probably due to input from land and surrounding factors in the form of liquid waste, both due to agricultural operations. Moreover, the primary ingredient of fertilizers is nitrogen, known to utilize a bio-physicochemical process to become a compound. In marine waters, six types of nitrogen are formed, termed N_2, NO_3, NO_2, NH_3, NH_4, organic N and particulate N. This outcome corresponds to the analysis results of the NO_3 at Labuhan Haji beach, with similar content of 0.036 mg L^{-1}. Also, the nitrate (NO_3) at Labuhan Haji appears relatively high due to community activities on the coast/land, where unwanted materials are directly and inappropriately disposed into the sea. In addition, the existence of river water flowing into the beach also serves as a transportation medium for agricultural waste and other human activities related to the sea[11].

Phosphate: The phosphate content in Mantehage waters ranges from 0.008-0.019 mg L^{-1} at an average of 0.015 mg L^{-1} (Table 1). This value is under the specified quality standard for marine tourism at 0.015 mg L^{-1}, based on the Minister of Environment Decree No. 51 of 2004. However, the estimate varied from the measurement results in Moyo Hilir and Lape sub-districts, between 0.03-0.3 mg L^{-1}. Extensive land activities are believed to trigger the phosphate content beyond the quality standard, including livestock, agricultural operations and the landfill existence in the coastal areas. This research implies that the involvement of academics through

this study is very helpful for policymakers in developing strategies for developing Mantehage island tourism areas. The data of this study can be applied in determining the best location for snorkelling and diving areas, Mantehage Island is very feasible to be developed as a marine tourism location because it is supported by very good water conditions and follows environmental quality standards. This study has limitations in research time, where the sample is only taken in one season, does not represent another season, besides that this study has not studied the overall condition of the oceanographic parameters.

CONCLUSION

Based on the values of salinity, temperature, turbidity, pH, total suspended solids, dissolved oxygen, NO_3-N and PO_4-P, the condition of Mantehage water quality obtained a suitable category within the specified standards of the minister of the Environment Republic of Indonesia. Several parameters known to exceed these provisions, including nitrate and phosphate content, indicate the instantaneous value during measurement. Therefore, an in-depth study, sufficient interval and sampling location to represent the spatial and temporal conditions of the entire island are greatly required. This outermost island generally appears suitable as a marine tourism attraction, particularly snorkelling and diving. Furthermore, the beauty of coral reefs is believed to be a major tourist object with the need for further encouragement. Mantehage Island is very feasible to be developed as a marine tourism area, especially for snorkelling and diving activities, underwater beauty, high biodiversity and supported by good water conditions make this island attractive to tourists.

SIGNIFICANCE STATEMENT

This study discovered the condition of the seawater quality of Mantehage Island which can be developed as an underwater tourism location, the good status of coral reefs supported by underwater beauty makes Mantehage Island worthy of development, that can be beneficial for the government, researchers and the people of Mantehage Island in developing tourism. This study will help the researchers to uncover the critical areas of the outermost small island of Indonesia that many researchers were not able to explore. Thus a new theory on the condition of seawater quality for the development of marine tourism may be arrived at.

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REFERENCES

1. Tangian, D., D. Djokosetiyanto, K. Kholil and A. Munandar, 2015. Model of ecotourism management in small islands of Bunaken National Park, North Sulawesi. J. Indonesian Tourism Dev. Stud., 3: 75-84.
2. Djamaluddin, R., 2018. The mangrove flora and their physical habitat characteristics in Bunaken National Park, North Sulawesi, Indonesia. Biodiversitas J. Biol. Diversity, 19: 1303-1312.
3. Opa, E.T., J.D. Kusen, R.C. Kepel, A. Jusuf and L.J.L. Lumingas, 2019. Community structure of mangrove in Mantehage Island and Paniki Island, North Sulawesi, Indonesia. AACL Bioflux, 12: 1388-1403.
4. Kase, A., I. Manembu and J. Schaduw, 2019. The condition of Mantehage Island coral reefs of North Minahasa district, North Sulawesi province. J. Coastal Trop. Seas, 7: 208-212.
5. Schaduw, J.N.W., K.I.F. Kondoy, V.E.N. Manoppo, A. Luasunaung and J. Mudeng *et al.*, 2020. Data on percentage coral reef cover in small islands Bunaken National Park. Data Brief, Vol. 31. 10.1016/j.dib.2020.105713.
6. Schaduw, J.N.W., K.F.I. Kondoy, 2020. Seagrass percent cover in small islands of Bunaken National Park, North Sulawesi Province, Indonesia. AACL Bioflux, 13: 951-957.
7. Kalalo, F.P., 2017. Law enforcement and conservation at Bunaken National Park, North Sulawesi, Indonesia as perceived by the local coastal communities. AACL Bioflux, 10: 1413-1420.
8. Wagey, B.T., F.B. Boneka and R. Mantiri, 2020. Status of marine biodiversity and community perception on marine conservation in Mantehage Island, Bunaken National Park, North Sulawesi, Indonesia. AACL Bioflux, 13: 3830-3839.

9. Schaduw, J.N., 2018. Distribusi dan karakteristik kualitas perairan ekosistem mangrove pulau kecil taman nasional bunaken. Majalah Geografi Indonesia, 32: 40-49.
10. Kurniadi, B., S. Hariyadi and E.M. Adiwilaga, 2015. The waters quality of the Buaya river in Bunyu Island, North Kalimantan in tidal conditions. Indonesian J. Agric. Sci., 20: 53-58.
11. Haerudin, H. and A.M. Putra, 2019. Analisis baku mutu air laut untuk pengembangan wisata bahari di perairan pantai labuhan haji kabupaten Lombok Timur. Geodika: J. Kajian Ilmu dan Pendidikan Geografi, 3: 13-18.
12. Tomczak, M. and J.S. Godfrey, 1994. Regional Oceanography: An Introduction. 1st Edn., Pergamon, Oxford, ISBN-13: 9781483287614, Pages: 422.
13. Simanjuntak, M., 2012. Sea water quality observed from nutrient aspect, dissolved oxygen and pH in the Banggai waters, Central Sulawesi. J. Ilmu Teknologi Kelautan Tropis, 4: 290-303.
14. Putra, A., T.A. Tanto, W.S. Pranowo, I. Ilham, H. Damanhuri, Y. Suasti and T. Triyatno, 2018. The suitability ecotourism beach based geospatial in Padang city-Indonesia : Case study of category recreation beach and mangrove. J. Segara, 14: 87-94.
15. Wisha, U.J., T.A. Tanto and I. Ilham, 2016. Physical and chemical conditions of Bayur Bay waters on the East and West season. Indonesian J. Mar. Sci., 22: 15-24.