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Status of Seawater Quality at Koh Rong Island, Sihanoukville, Cambodia

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Abstract: *Marine water quality can be good or bad depending on the presence or absence of different components. The delicate underwater ecosystem risks collapsing when the chemical run-off contaminates the ocean. Increased levels of chemicals can lead to toxic algal blooms, threatening the safety of marine life. Even minor damage to an ecosystem can have larger repercussions, as the harmonious balance becomes disturbed. Therefore, this study aimed to determine the physico-chemical parameters around Koh Rong Island in situ and understand the water conditions related to corals and marine biodiversity. In this study, 15 sampling points were chosen across the island to collect water sampling to retrieve some physio-chemical parameters such as temperature, EC, TDS, salinity, pH, DO, ORP, and Chl-a. As a result, the water quality parameters were in the acceptable range of marine water quality according to the water quality standard for coastal water by EPA. The temperature was around 31℃ for the dry season and 29.5℃ for the rainy season. While EC was about 53 mS/cm and TDS was 32.2 ppt for the dry season and 26.8 ppt for the rainy season. For Salinity, in the dry season, was about 32 psu, and in the rainy season, it decreased to 26.8 psu. The pH, DO, ORP, and Chl-a were 7.35, 8.07 mg/L, 257 mV, and 0.58 µg/L, respectively, in the dry season. While in the rainy season, pH was slightly increased to 7.83. The DO decreased to 7.96 mg/L, the ORP up to 294 mV, and Chl-a was 0.014 µg/L. Additionally, the Water pollution index (WPI) was also studied to clarify the condition of water around the study area. WPI of both seasons were in the good range with WPI = 0.72 and 0.71 respectively. with a good condition of water quality for marine biodiversity. It has shown that the coral damage or low number of fish and invertebrate abundance around the study areas has no sign related to the pollution of the water. However, basic marine water quality alone may not account for the complex and multifaceted causes of coral reef destruction, such as climate change, pollution, overfishing, and dynamite fishing. Therefore, further research is needed to investigate the specific factors and mechanisms that lead to coral bleaching and mortality.*

Keywords: Marine water quality, WPI, Koh Rong Island, Coral Reef

1. [1]INTRODUCTION

With the advent of the "Ocean Era", marine resource utilization and shipping development have become increasingly important for human socio-economic development. However, human activities frequently affect the relatively fragile ecological environment of coastal water. Marine environmental protection and sustainable development have received increasing global attention, especially in coastal waters, which are closely associated with human activities [1]. Ocean environmental monitoring is regarded as the only way of oceanic information acquirement, including meteorological and hydrological conditions, sediment, life, and ocean dynamics [2]. Like the east Gulf of Thailand, coastal water comprises extensive reefs, beaches, seagrass meadows, and mangrove communities that support coastal fisheries, tourism, and

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aquaculture activities. Environmental factors influencing the biodiversity, status, and health of coral reefs in the east Gulf of Thailand include oceanography, climate, and freshwater flows. These factors influence the estuarine and marine water circulation patterns, water quality, and ambient environmental parameters including salinity profiles, sea temperature, pH, turbidity, and dissolved oxygen [3]. Additionally, Human activities have already negatively influenced water quality and aquatic ecosystem functions which generate great pressure on these ecosystems, resulting in a decrease in water quality and biodiversity, loss of critical habitats, and an overall decrease in the quality of life of local inhabitants [4]. It is therefore essential to prevent and control marine water pollution and to implement regular monitoring programs, which help to understand the temporal and spatial variations in marine water quality. Moreover, poor water quality is linked to coral stress, which leads to coral bleaching, and eventually coral death. High concentrations of dissolved oxygen, high bacteria levels, salinity, and turbidity are just a few degraded water quality indicators that adversely impact coral reef distribution and overall ecosystem health [5]. Degraded water quality also affects corals' reduced recruitment, decreased calcification, shallower depth distribution limits, altered composition, more heterotopic fauna, and loss of biodiversity [6]. Besides, ocean temperatures also play an important role. About 14% of the world's coral reef in just under a decade according to the analysis from the Glo. According to the study in Koh Rong marine protected area (KRMNP) suggested that abandoned, lost, and discarded fishing gear is a significant component of marine litter in Cambodia. Despite growth in the tourism sector, the communities in The KRMNP still depend on fishing as an income source and to meet their daily needs [7] and [8].

Monitoring of physicochemical parameters is necessary for ecosystem conservation because the divergence of given ranges of these parameters may affect the marine organisms such as hindering growth, mortality, and an overall reduction in ecosystem services. It is therefore essential to prevent and control marine water pollution and to implement regular monitoring programs, which help us to understand the temporal and spatial variation in marine water quality conditions. Poor water quality also decreases the resilience of these systems and can lead to stronger impacts from climate change, the threats to which atoll communities are particularly vulnerable. Cambodia has a 435 km long coastline which includes 69 islands within the Gulf of Thailand. Many of these islands have coral reefs and associated seagrass beds and/or mangrove habitats in their periphery, providing crucial habitats for a great diversity of marine species that provide significant economic goods and services that are critical to well-being [9].

This study aims to evaluate the water quality of seawater through field studies performed in the dry season and rainy season in other to understand the water conditions around Koh Rong Island.

2. METHODOLOGY

2.1 Study Area

Koh Rong is a 78 km^2 large island approximately 25 km off the Cambodian coastal city of Sihanoukville at 10°43'44.7" N latitude and 103°13'54.2" E longitude. It is one of the two major islands of the Koh Rong Archipelago. There are four village communities on Koh Rong: Koh Touch (south-east), Prek Svay (northeast), Daem Thkov (east), and Sok San (west) while most locals live from fishing (70%) and small-scale crop cultivation (30%). For this study, 15 sampling sites were around Koh Rong Island during the dry season (April 23rd, 2022), as well as the rainy season (June 12th, 2022) as shown in Fig. 1. The specific sampling location and coordinate are shown in Table 1.

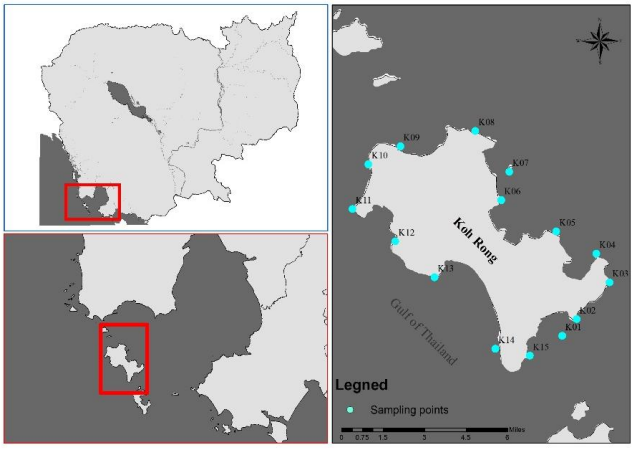

Fig.1. The location of Koh Rong Island

Table 1. The sampling site and coordination

Sampling Site	Longitude	Latitude
K1	103.2912N	10.6704E
K2	103.2987N	10.6791E
K3	103.3159N	10.6983E
K4	103.3090N	10.7133E
K5	103.2880N	10.7249E
K6	103.2593N	10.7413E
K7	103.2635N	10.7561E
K8	103.2458N	10.7775E
K9	103.2065N	10.7694E
K10	103.1897N	10.7601E
K11	103.1815N	10.7367E
K12	103.2039N	10.7197E
K13	103.2244N	10.7010E
K14	103.2562N	10.6637E
K15	103.2742N	10.6600E

2.2 Field campaign and laboratory data collection

The field campaign consisted of the collection of water samples as well as the performing of tests to retrieve some physicochemical parameters and conditions in the field. Field sampling was collected around Koh Rong Island as seen in Fig. 1. Water quality parameters like temperature, EC, salinity, pH, ORP, TDS, and DO, were measured by using Multi-Exo (YSI Incorporated, USA). The Multi-Exo Sonde was set to 5 minutes for every measurement and it was washed with sampled water before running to prevent contamination from one sample to another. Additionally, at each sampling point, duplicated samples were taken just below the water surface using 500 ml plastic bottles. These bottles were uncapped once completely and allowed to fill with water. Once all air pocket was eliminated and the bottle was full, it was again capped whilst underwater. The bottles were taken out of the water and immediately stored in a cooler box to keep them cool and away from sunlight. All sampling took place on 23rd April 2022 and 12th June 2022.

2.3. Water Pollution Index (WPI)

The pollution index is a useful tool to provide information about the water quality. It was determined using the following formula [10]. For this study, a total of 8 water quality parameters were selected to estimate the pollution load of seawater by applying WPI, based on their standard permissible limits as defined by WHO. However, WPI can accommodate a greater number of variables as it is flexible for n number of parameters.

In the first step, the pollution load (PL_i) of the i^{th} parameter was calculated using the following formula:

$$PL_i = 1 + \left(\frac{C_i - S_i}{S_i}\right) \qquad (Eq\ 1.)$$

Where C_i indicates the observed concentration of the i^{th} parameter, S_i is the standard or highest permissible limit for the respective parameter. The difference between Ci and Si is divided by the respective Si for recognizing the decrease or increase in the standardized value (PLi) of a particular parameter about its standard permissible limit (Si). In the case of pH, a value of 7 is considered neutral, but <7 or >7 is detrimental, with this view following equations are recommended for different pH ranges.

If the pH is <7, then the equation is recommended. Where, Si_a is the minimum acceptable pH value i.e., 6.5

$$PL_i = \frac{C_i - 7}{S_{i_a} - 7} \qquad (Eq\ 2.)$$

If pH is >7, then Si_b would be the maximum acceptable pH value i.e., 8.5 and the suggested equation is mentioned below

$$PL_i = \frac{C_i - 7}{S_{i_b} - 7} \qquad (Eq\ 3.)$$

Finally, the pollution status of a sample or water pollution index (WPI) with n number of variables (parameters) can be evaluated by aggregating all the pollution load and finally dividing with n, as mentioned in the following equation. It can be expressed as:

$$WPI = \frac{1}{n}\sum_{i=1}^{n} PL_i \qquad (Eq\ 4.)$$

The WPI values may be classified based on n number of parameters into four categories (Table 2)

Table 2. Marine water quality index classification [10]

Category	WPI value
Excellent	<0.5
Good	0.5-0.75
Moderately polluted	0.75-1
Highly polluted	>1

WPI may be considered as an integrated approach as it converts all the input parameters to a single value index to classify the water quality, where any little change in the concentration of any input variable can change the WPI class of water quality. Moreover, WPI is free from the use of any theoretical ideal value or dissimilar weights of any variables which is a practice in some conventional indexing approaches. Additionally, WPI can be applied to a wide range of data sets (even when the variables are not normally distributed and skewed). Besides, the use of different indices for different purposes may be lengthy and time-consuming for a single study, where WPI can deliver a general idea of water quality status in context with any input parameters, and can be applicable for any designed purpose by just applying the standard guideline values for that particular use.

3. RESULTS AND DISCUSSION

3.1. Water quality parameters along the Koh Rong Island

The values of water quality parameters obtained from all the sampling points are presented in Table 2. Temperature is an important factor to consider when assessing water quality due to its influence on other parameters such as DO, EC, Salinity, ORD, pH, and water density [11]. Especially in seawater, Sea surface temperature has a significant societal impact, though, e.g., large ocean gyres and atmospheric circulation cells influencing weather and climate, weather systems and serve storms and local scale phenomena, such as the generation of sea breezes and

convective clouds [12]. In this study, the temperature of surface water temperature ranged between 30.5℃ to 32.1℃ in the Dry season. In the rainy season, the temperature decreased to 28.4℃ at the lowest and 30.1℃ for the highest temperature compared to the highest seawater temperature recorded in Ko Khang Khao Island which was 33℃. While for EC, it is commonly used to examine the mixing of freshwater in seawater. EC can be easily measured by a conductivity meter and the changes in conductivity may indicate that discharge on some other source of disturbance has decreased the relative condition or health of the water body and its associated biota [13]. Whereas, in this study, the average value of EC for both dry and rainy seasons were similar with the values of 53.03 mS/cm and 53.02 mS/cm, respectively. The average TDS value of this study was around 32217.34 mg/L out of 15 sampling points where the highest value was 32428.74 mg/L and the lowest one was 31516.27 mg/L. Ocean salinity is generally defined as the salt concentration (e.g., Sodium and Chloride) in seawater. It is measured in units of PSU (Practical Salinity Unit), which is a unit based on the properties of seawater conductivity. it is a strong contributor to conductivity and helps determine many aspects of the chemistry of natural waters and their biological process. It can be a chemical stressor in the aquatic environment as fluctuating levels of salinity can affect aquatic biological organisms that are adapted to prevailing salinity concentrations. A sudden change in salinity can destroy the coral reefs, which is caused by climate change. Moreover, the salinity profile of the ocean helps understand the fluctuation in the seawater cycle [14]. The average value of Salinity in this study was about 32.44 PSU in the dry season but it decreased to 31.9 PSU in the rainy season compared to the low salinity caused by severe runoff during the rainy season in Ko Khang Khao Island with a salinity of 11.18 psu at the lowest which cause the coral to bleach in 2011 [15].

Table 3. Seasonal mean value, range, and statistical variation of water quality parameters of Koh Rong Island

Parameter	Dry season n =15		Rainy season n = 15	
	Range	Mean± SD	Range	Mean± SD
Temp.	30.5-32.1	31.26±0.4	28.4-30.1	29.5±0.46
EC	52.4-53.6	53.03±0.3	50.1-56.6	53.02±1.3
TDS	31.5-32.5	32.2±0.26	25-32.9	26.8±1.7
Salinity	31.6-32.7	32.44±0.3	27-33.1	31.9±1.45
pH	7.27-7.46	7.35±0.05	7.56-7.96	7.83±0.09
DO	7.74-8.49	8.07±0.2	6.9-9.4	7.96±0.7
ORP	154-244	210±23	257-358	294±23
Chl-a	0.09-15.6	0.58±0.5	0.001-0.1	0.014+0.03

For pH, It is a very valuable oceanographic parameter due to it reflects the thermodynamic state of all various acid-based systems in seawater [16]. In this study, the range of pH is between 7 where the highest value was 7.46 while the lowest was 7.27 and the average value of pH was 7.36. Whereas, DO is an important parameter in assessing water quality due to the influence on the living organisms within the water body. DO of seawater surrounding Koh Rong was about 8.09 mg/L. The range of DO is an important parameter in assessing water quality due to its influence on the living organisms within the water body. The DO of seawater around Koh Rong was about 8.09 mg/L. The range of DO should not be less than 7. On the other hand, ORP is a measure of the relative oxidizing power of the water. According to Prasad *et al.*, (2016), the value of ORP around 100-200 mV indicated as good for aquatic life. The average value of ORP in Koh Rong was 207.38 mV. While Chlorophyll-A, it plays an important role in converting water and carbon dioxide into organisms and oxygen [18]. Around Koh Rong, Chl-a value ranges between 0.05-1.31 µg/L with an average value of 0.43 µg/L.

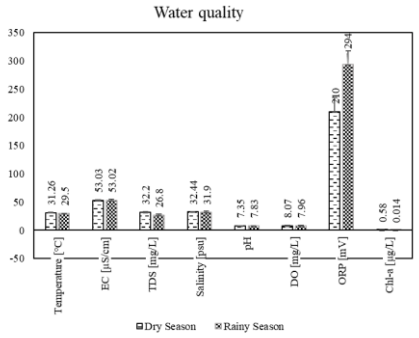

Fig.2. Value of each water quality parameter in both Dry and Rainy seasons

3.2. Marine water pollution index

The proposed index, WPI is based on the standard permissible limits of seawater and freshwater parameters recommended by the WHO. In this study, WPI for each sample was calculated to evaluate the degree of pollution in seawater for marine biodiversity using 8 water quality parameters (n=8). According to WHO, The WPI classified water quality status into four different categories such as excellent when WPI <0.5; good water quality if WPI ranges between 0.5 to 0.75; moderately polluted water, if it ranges from 0.75 to 1; and high polluted water, if WPI is higher than 1 (Table 1). Following The Water Quality Index for the Protection of Aquatic Life according to MRC, with a rating score 9.5 ≤ WQI ≤ 10 considered as high quality while rating score between 9.5 and 8 was classified as good quality and between 8 and 6.5 was classified as moderate. Following

the rating score between 6.5 and 4.5 was considered as poor quality. And the rating score below 4.5 is considered as very poor water quality [19].

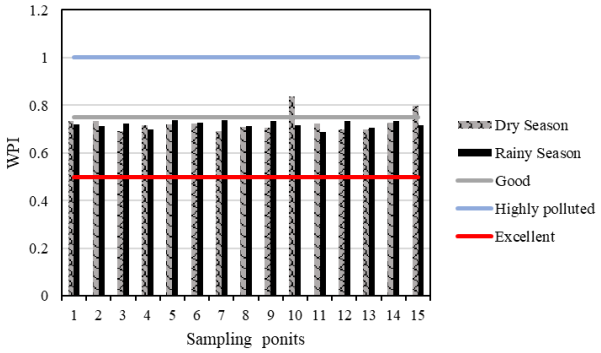

Figure 3. Water pollution index (WPI) of seawater around Koh Rong Island

According to the results of the pollution index calculation in Figure 2, it can be seen that most of the observation points are characterized as good water quality, whereas only points 10 and 15 during the dry season are categorized as moderately polluted with index values of 0.83 and 0.79. However, for on overall water pollution index, both the dry season and rainy season are considered to a good water quality with WPI of 0.72 and 0.71 respectively.

4. CONCLUSIONS

The parameters of the water environment consisting of Temperature, EC, TDS, Salinity, pH, DO, ORP, and Chl-a are within the standard quality of marine biota in most of the observation points with the acceptable value of water pollution index of 0.72 and 0.71 in overall. In general, with a good condition of water quality for marine biodiversity. It has shown that the coral damage or low number of fish and invertebrate abundance around the study areas has no sign related to the pollution of the water. Overfishing and Anchor damage around the area could potentially be factors affecting of condition of corals and marine biodiversity around Koh Rong Island.

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REFERENCES

[1] Z. Wang, C. Bu, H. Li, and W. Wei, "Seawater environmental Kuznets curve: Evidence from seawater quality in China's coastal waters," *J. Clean. Prod.*, vol. 219, pp. 925–935, 2019, doi: 10.1016/j.jclepro.2019.02.012.

[2] X. Sun, X. Wang, D. Cai, Z. Li, Y. Gao, and X. Wang, "Multivariate Seawater Quality Prediction Based on PCA-RVM Supported by Edge Computing towards Smart Ocean," *IEEE Access*, vol. 8, pp. 54506–54513, 2020, doi: 10.1109/ACCESS.2020.2981528.

[3] B. Carter *et al.*, "Coral reef, water quality status and community understanding of threats in the eastern gulf of Thailand," 2014.

[4] M. L. Wu *et al.*, "Identification of coastal water quality by statistical analysis methods in Daya Bay, South China Sea," *Mar. Pollut. Bull.*, vol. 60, no. 6, pp. 852–860, 2010, doi: 10.1016/j.marpolbul.2010.01.007.

[5] NOAA, "What is water quality_." 2022.

[6] ISRS, "The effects of terrestrial runoff of sediments, nutrients and other pollutants on coral reefs," *Int. Soc. Reef Stud.*, no. Briefing Paper 3, pp. 1–18, 2004.

[7] Fauna & Flora International, "Solid Waste Management and Marine Litter in the Koh Rong Archipelago: Findings & recommendations from an assessment of Solid Waste Management systems," 2021.

[8] B. Krell, M. Skopal, and P. Ferber, *Koh Rong Samloem and Koh Kon Marine Environmental Assessment Preah Sihanouk Province Report on Marine Resources and Habitats*. 2011.

[9] K. Sour, C. L. Ming, and K. TUN, "STATUS OF CORAL REEFS: IN SOUTHEAST ASIAN COUNTRIES," 2004.

[10] M. Hossain and P. K. Patra, "Water pollution index – A new integrated approach to rank water quality," *Ecol. Indic.*, vol. 117, no. May, p. 106668, 2020, doi: 10.1016/j.ecolind.2020.106668.

[11] I. Fondriest Environmental, "Water Temperature," *Monthly Weather Review*, 2014. https://www.fondriest.com/environmental-measurements/parameters/water-quality/water-temperature/#watertemp1

[12] A. G. O. Carroll *et al.*, "Observational Needs of Sea Surface Temperature," vol. 6, no. 420, pp. 1–27, 2019, doi: 10.3389/fmars.2019.00420.

[13] M. Hayashi, "Temperature-electrical conductivity relation of water for environmental monitoring and geophysical data inversion," *Environ. Monit. Assess.*, vol. 96, no. 1–3, pp. 119–128, 2004, doi: 10.1023/B:EMAS.0000031719.83065.68.

[14] W. U. Sheng *et al.*, "Investigation of the Performance of an Inductive Seawater Conductivity Sensor," *Sensors & Transducers*, vol. 186, no. 3, pp. 43–48, 2015, [Online]. Available: http://www.sensorsportal.com

[15] S. Pengsakun, T. Yeemin, M. Sutthacheep, W. Samsuvan, W. Klinthong, and C. Chamchoy, "Monitoring of coral communities in the inner Gulf of Thailand influenced by the elevated seawater temperature and flooding," *Acta Oceanol. Sin.*, vol. 38, no. 1, pp. 102–111, 2019, doi: 10.1007/s13131-019-1376-8.

[16] A. G. Dickson, "The measurement of sea water pH," *Mar. Chem.*, vol. 44, no. 2–4, pp. 131–142, 1993, doi: 10.1016/0304-4203(93)90198-W.

[17] A. N. Prasad, K. A. Mamun, F. R. Islam, and H. Haqva, "Smart water quality monitoring system," *2015 2nd Asia-Pacific World Congr. Comput. Sci. Eng. APWC CSE 2015*, no. December 2016, 2016, doi: 10.1109/APWCCSE.2015.7476234.

[18] M. I. Abu Daya, T. Hobma, and Z. Vekerdy, "Coastal water quality monitoring with remote sensing in (East Kalimantan) Makassal Strait, Indonesia," *Esa*, vol. MSc, no. February, p. 98, 2004.

[19] Mekong River Commission, "2019 Lower Mekong water quality report," 2022.