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THE CORRELATION BETWEEN SEA SURFACE TEMPERATURES AND CHLOROPHYLL-A CONCENTRATION

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ABSTRACT

The examination of the correlation between sea surface temperature and chlorophyll-a concentration is essential for facilitating the surveillance and evaluation of marine ecosystems. Chlorophyll-a functions as a gauge of the prevalence of plant plankton and biomass in coastal waters, whereas sea surface temperature is a determinant that impacts the proliferation of plant plankton. This study aims to investigate the relationship between sea surface temperature and chlorophyll-a concentration on the surface of the sea. The case study was conducted in the upper Gulf of Thailand, Chonburi Province, in the year 2566 using data from the Aqua/MODIS satellite. Study results indicate that the amount of chlorophyll-a produced in 2022 ranged from 0.369 µg/L to 5.714 µg/L. When the amount of chlorophyll-a was correlated with the sea surface temperature, a high level of correlation was observed, with a regression coefficient of 0.859.

Keywords: remote sensing, thermal infrared, land surface temperature, **s**entinel data.

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INTRODUCTION

The coastal area of the Gulf of Thailand's upper region is adjacent to the provinces of Chonburi, Chachoengsao, Samut Prakan, Bangkok, Samut Sakhon, Samut Songkhram, and Phetchaburi, with a territorial sea boundary extending 12 nautical miles or approximately 22.2 kilometers from the baseline defined by the United Nations Convention on the Law of the Sea as the furthest seaward measurement from the coastline [1]. The physical characteristics of the upper Gulf of Thailand, being a semi-enclosed gulf, are influenced by the prevailing winds, resulting in the circulation of water from the deep sea to the sea surface, known as upwelling. This phenomenon enriches the sea surface with essential nutrients for the growth of phytoplankton, which is an indicator of marine fertility [2].

Furthermore, the upper part of the Gulf of Thailand is also a particularly rich resource area, both in terms of living and non-living resources. The growth of chlorophyll is affected by the fluctuation of sea surface temperature, such as during the El Nino event, which causes abnormal increases in sea surface temperature. This has an impact on the density of chlorophyll. Therefore, monitoring the relationship between sea surface temperature and chlorophyll density provides insight into the growth of chlorophyll influenced by sea surface temperature. This understanding is crucial for comprehending the marine ecosystem when facing changes in meteorological conditions [3].

The sea surface temperature is one of the important factors in the ocean due to its significance in studying the processes of physics, chemistry, and marine biology in the sea, which affects the increase or decrease in the growth of phytoplankton. In addition, the temperature of the sea surface also affects the distribution of phytoplankton according to geographical characteristics as well [4]. Chlorophyll-a is a pigment or substance used in the synthesis of light within the cells of plant plankton, which are single-celled algae that are small and float in the water mass, carried by wind waves and water currents. Therefore, plant plankton is important for the aquatic ecosystem because it is the primary producer and indicates the fertility of the water source [5].

From the research study on chlorophyll-a, it is currently found that various methods and technologies are being applied, especially Remote Sensing Technology [6-10], which is now widely used as a primary tool in studying various spatial phenomena. This technology relies on satellite data as a tool for continuously recording spatial data efficiently in surveying natural resources both on land surfaces, sea surfaces, and underwater. It covers a wide area, and the data obtained is always up-to-date [11-22]. For Thailand, the application of Remote Sensing Technology in the research of chlorophyll-a is still very limited. Due to the importance mentioned above, this study aims to investigate the relationship between chlorophyll concentration and sea surface temperature. The coastal area of Chonburi province was chosen as the representative study area for this research.

MATERIALS AND METHODS

Study Area

The coastal area of the Gulf of Thailand's upper region is adjacent to the provinces of Chonburi, Chachoengsao, Samut Prakan, Bangkok, Samut Sakhon, Samut Songkhram, and Phetchaburi. The coastal area of

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Chonburi province (Figure-1) was chosen as the representative study area for this research.

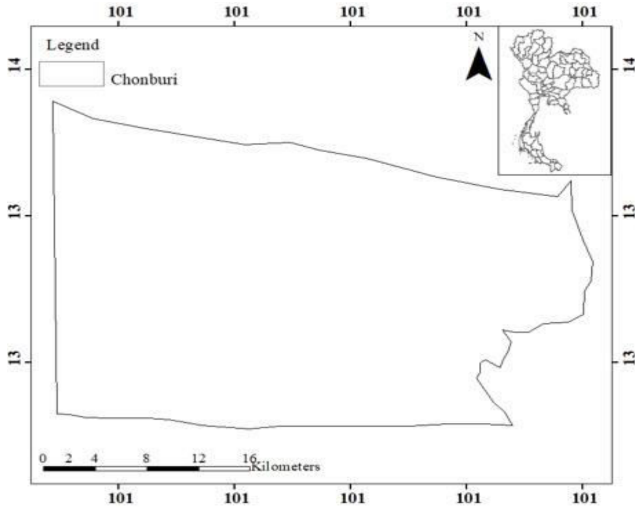

Figure-1. The study area.

Satellite Data

The information gathered from the Sentinel-2 satellite using the Multi-Spectral Imager (MSI) system comprised 13 bands (Table-1) that span from the visible band to the shortwave infrared band, with spatial resolution at 10, 20, and 60 meters based on wavelengths. The data recording cycle was consistently repeated at the same position every 5 days. For this study, data were acquired from the Sentinel-2 satellite in 2022. The selected data were those with cloudy conditions not exceeding 10%.

Table-1. 1. Sentinel-2 spectral band.

Bands	Central wavelength (nm)	Bandwidth (nm)	Spatial resolution (m)
Band 1 - Coastal Aerosol	443	20	60
Band 2 - Blue	490	65	10
Band 3 - Green	560	35	10
Band 4 - Red	665	30	10
Band 5 - Vegetation Red Edge	705	15	20
Band 6 - Vegetation Red Edge	740	15	20
Band 7 - Vegetation Red Edge	783	20	20
Band 8 - NIR	842	115	10
Band 8A - Vegetation Red Edge	865	20	20
Band 9 - Water Vapor	945	20	60
Band 10 - SWIR - Cirrus	1380	30	60
Band 11 - SWIR	1610	90	20
Band 12 - SWIR	2190	180	20

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Sea Surface Temperature

The collection of Surface Sea Temperature data was conducted in the province of Chonburi from the website https://seatemperature.info/.

METHODOLOGY

The study methodology is segmented into the subsequent stages:

In the study "The examination of the correlation between sea surface temperature and chlorophyll-a concentration", the chlorophyll-a concentration was analyzed using data from the Sentinel-2 satellite with Equation 1 [23-25].

$$\text{CHLA } (\mu g/L) = (\text{Band1}+\text{Band2})/(\text{Band3}) \quad (1)$$

Data collection of sea surface temperature in the Gulf of Thailand from January to December 2022 was conducted by extracting information from the website sea temperature (https://seatemperature.info) resulting in temperature values in degrees Celsius.

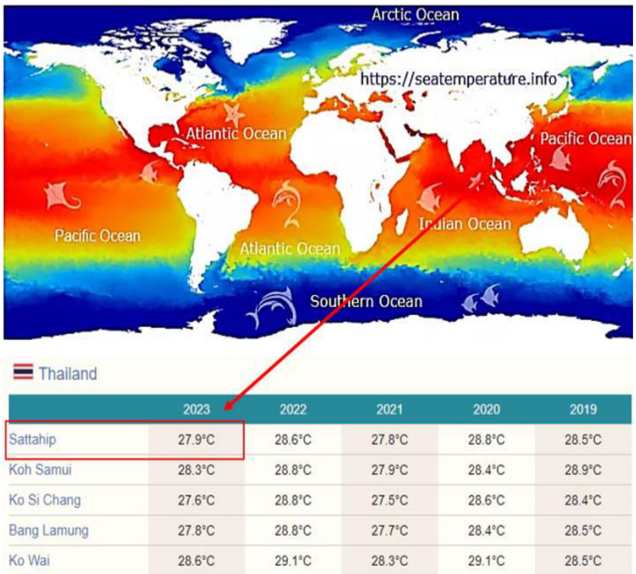


Figure-2. Surface sea temperature in 2022.

Analyzing the chlorophyll-a concentration obtained from Sentinel-2 satellite imagery to investigate the statistical relationship with sea surface temperature data using the Linear Regression method.

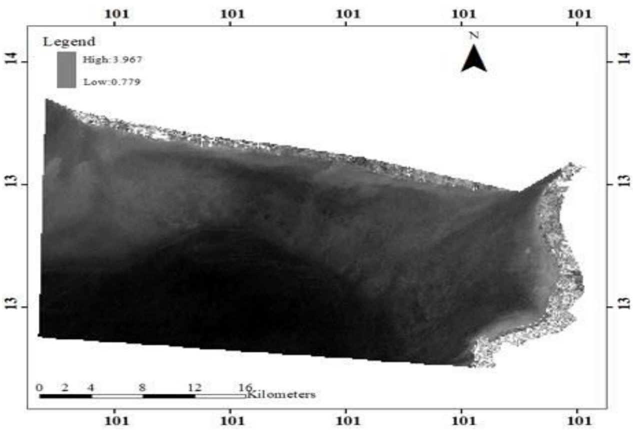
RESULTS AND DISCUSSIONS

In 2022, data from the Sentinel-2 satellite over the Gulf of Thailand, particularly in the study area of Chonburi province, revealed comprehensive information that could be analyzed for 4 months, namely January, March, June, and December. The results of the analysis of chlorophyll-a quantities in 2022 are illustrated in Table-2.

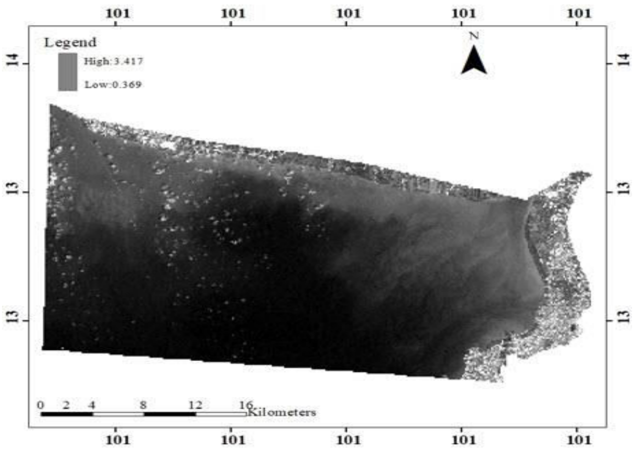
Table-2. Chlorophyll-a concentration in 2022.

chlorophyll-a					
Day	Month	Min (µg/L)	Max (µg/L)	Mean (µg/L)	Sea Surface Temperature (°C)
1	Jan	0.779	3.967	2.373	28.300
12	Mar	0.369	3.417	1.893	27.500
10	Jun	0.553	5.714	3.133	30.200
27	Dec	1.024	3.522	2.273	28.300

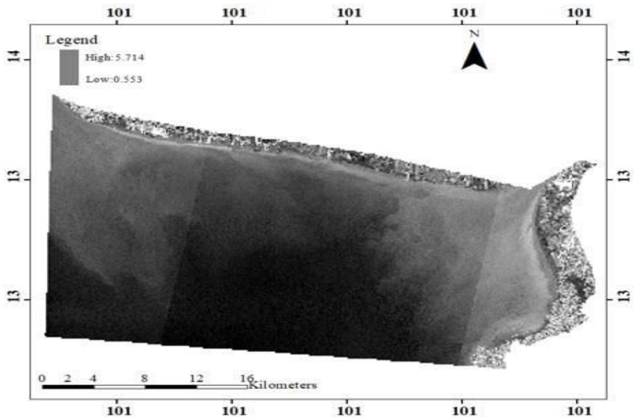
The analysis of the chlorophyll-a quantity in the study area (refer to Figure-3) processed from Sentinel-2 image indicates that the chlorophyll-a quantity on January 1, 2022, ranged from 0.779 micrograms per liter to 3.967 micrograms per liter with a sea surface temperature of 28.300 degrees Celsius. On March 12, 2022, the chlorophyll-a quantity ranged from 0.369 micrograms per liter to 3.417 micrograms per liter with a sea surface temperature of 27.500 degrees Celsius. By June 10, 2022, the chlorophyll-a quantity ranged from 0.553 micrograms per liter to 5.714 micrograms per liter with a sea surface temperature of 30.200 degrees Celsius. On December 27, 2022, the chlorophyll-a quantity ranged from 1.024 micrograms per liter to 3.522 micrograms per liter with a sea surface temperature of 28.300 degrees Celsius.



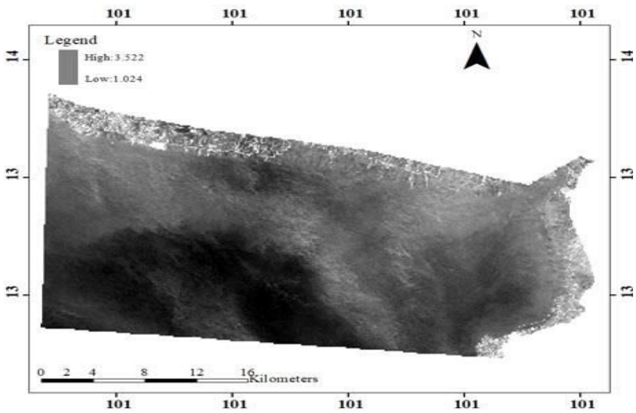
(a)



(b)



(c)



(d)

Figure-3. Illustration of the average concentration of chlorophyll-a in the sea surface area (a) January, (b) March, (c) June, and (d) December.

For the analysis of the relationship between the chlorophyll-a quantity obtained from the Sentinel-2 satellite and the sea surface temperature data refer to Figure-4. The results of the simple linear regression equation calculation, with Y representing the average quantity of chlorophyll-a and X representing the average sea surface temperature, revealed an R^2 value of 0.989. This R^2 value, which is close to 1, indicates a high level of correlation.

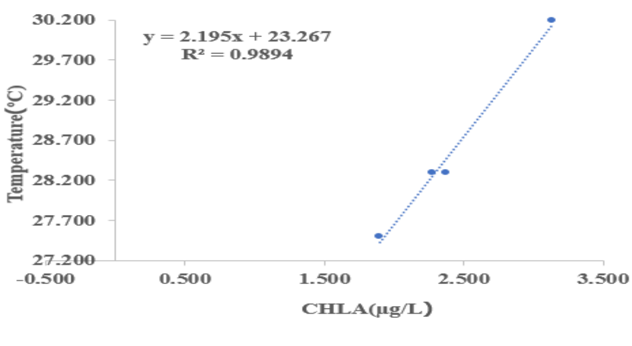


Figure-4. Relationship between the chlorophyll-a quantity obtained from the Sentinel-2 satellite and the sea surface temperature data.

CONCLUSIONS

In this study, chlorophyll-a quantities were determined using remote sensing technology in the Chonburi province by analyzing satellite images from Sentinel-2. The aim was to calculate the chlorophyll-a concentrations and establish the relationship between chlorophyll-a quantities and sea surface temperature through a simple linear regression analysis to create maps showing chlorophyll-a concentrations in Chonburi province. The results obtained in the year 2022 revealed that the minimum chlorophyll-a concentration was approximately 0.369 micrograms per liter with a sea surface temperature of 27.500 degrees Celsius, while the maximum chlorophyll-a concentration was around 5.714 micrograms per liter with a sea surface temperature of 30.200 degrees Celsius. Furthermore, the analysis of the relationship between the quantity of chlorophyll-a and sea surface temperature reveals a significant correlation. The relationship between sea surface temperature and changes in the density of chlorophyll-a is evident. However, factors causing the occurrence of chlorophyll-a on the sea surface in the upper Gulf of Thailand, particularly in Chonburi Province, are unlikely to be solely due to sea surface temperature. Other unexplored factors such as wind currents, light intensity, water quality, salinity, and nutrients should also be considered. This study demonstrates that modern satellite data processing techniques can provide valuable information for monitoring changes in chlorophyll-a on the sea surface in the upper Gulf of Thailand, particularly in Chonburi Province.

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