Article

Assessment and Impact of Oil Spills in Northern Coastline of Oman

Tamadhar Al-Hashmi [1] and Mohammed M. Bait-Suwailam [1,2,*]

[1] Dept. of ECE, Sultan Qaboos University, Muscat, Oman; s69441@student.squ.edu.om
[2] Communication and Information Research Center, Sultan Qaboos University, Muscat, Oman; msuwailem@squ.edu.om
* Correspondence: msuwailem@squ.edu.om

Abstract: The northern coastal of Oman, Gulf of Oman is an incredibly important coastal shipping route for oil and gas around the world. Due to its important geographical location, any oil spills in this area might have negative consequences on the world economy and energy markets in addition to the marine habitat. Considering how crucial it is to actively monitor and respond to oil leak accidents, this research study aims to investigate the significance of oil spill accident that happened between April and May 2020. The work investigated such oil spills using the Sentinel Application Platform, known as SNAP. Furthermore, satellite imagery data were made available through the Copernicus Open Access Hub, a freely accessed platform that runs by the European Space Agency (ESA). This study specifically made use of the Sentinel-1 satellite's radar imagery data, which are a great assess for the detection and estimation of oil spills.

Keywords: Oil spill; sea of Oman; sentinel mission; snap.

1. Introduction

All-weather, day-and-night imagery data are continuously provided at C-band by the satellite imaging radar mission of Sentinel-1. The Sentinel-1 constellation offers high reliability, enhanced revisit time, geographic coverage, and quick data distribution to support operational applications in the priority fields of emergency services, land monitoring, and maritime monitoring [1]. It is the first satellite in the constellation of the Copernicus Program run by the European Space Agency. Sentinel-1A and Sentinel-1B, a constellation of two satellites that originally made up this mission, shared the same orbital plane while, Sentinel-1C and Sentinel-1D, two more satellites, are now being developed and due to the retirement of Sentinel-1B, the constellation is now down to just Sentinel-1A [2].In addition, Sentinel-1 is a dual polarization Synthetic Aperture Radar (SAR) system that maintains phase information. It can transmit signals in either horizontal (H) or vertical (V) polarization and receive signals in both polarizations. One of its main objectives is to monitor ocean, and sea activities, including sea-ice, oil spills, maritime surveillance services, and waves using a 12-day revisit interval. Meanwhile,in some circumstances, Sentinel-1 data can be accessible for free in less than 10 minutes or almost immediately [2]-[3].

The synthetic-aperture radar (SAR) instrument is carried by the Sentinel-1 satellite which utilizes wavelengths that are unaffected by cloud cover or poor lighting. It achieves this by sending out a microwave signal of its own source to sense and inspect Earth's surface features via recording of backscattered energy. SAR is mostly used for emergency management, land monitoring, and maritime monitoring, including but not limited to oil spill, sea-ice level, ship activity and marine wind [2].

Regarding oil spill, accidents involving oil tankers and offshore industries, as well as intentional discharges of oil products from ships are the main causes of oil spills. Such maritime illegal activities pose serious threats to the ocean's ecosystem and marine environment, which makes it crucial to have a competent surveillance system for monitoring the

Citation: Al-Hashmi, T.; Bait-Suwailam, M. Assessment and Impact of Oil Spills in Northern Coastline of Oman. *Journal Not Specified* **2023**, *1*, 0. https://doi.org/

Received:
Revised:
Accepted:
Published:

sea surface, including as vast area coverage and the ability to monitor ocean surface day and night in all weather situations. In order to ensure reliable monitoring, spaceborne SAR systems are increasingly utilized as a supplement to existing ground-based monitoring systems, ship and aircraft observation [4]. The advantage of the deployment of SAR-based solutions is the ease of identification of oil spills, which can be seen as dark spots as a result of the changes they make to Bragg backscatter by dampening of the resonant sea surface capillary waves and altering surface roughness. Meanwile, the difference in wavelength between marine background and oil spills affects radar system detection while best contrast is provided by X-band radars, followed by C-band and L-band. Moreover, better radar's image quality is also affected by radio wave polarization and VV polarization yields the best results. The oil spill detection method based on Synthetic Aperture Radar (SAR) yielded accurate results for all incidents at wind speeds ranging from 3 to 9 m/s [5].

Several research studies have investigated possibility to track oil spills in the Arabian Gulf area, including Bahrain, Saudi Arabia and UAE [6]-[7]. In Oman, the Environment Authority is the governmental body responsible for monitoring and controlling any potential hazardous related to oil spills along the Sultanate's coastal areas in cooperation with other governmental bodies. The Authority keeps reminding fishermen to report any oil spills that could be spotted. Unfortunately, Oman has reported several oil spills that took place in many coastal areas, including Muscat (December 2014), Sohar (July 2021), Salalah (April 2023) and Sea of Oman (March-May 2020). Strait of Hurmoz connects the northern part of Oman via Gulf of Oman with the Arabian Gulf with 35 to 60 miles (55 to 95 km) wide. Furthermore, it is of significant strategic and economic importance, particularly given that more than 5000 oil tankers bringing in shipment from several ports on the Arabian Gulf must cross the strait [8]. As a consequence of this, we expect high rise of negative consequences from the threat of oil spill and its pollution.

In this research work, we investigate the impact of oil spill in Sea of Oman during the period from April to May 2020. The study focuses on the use of satellite Sentinel-1 imagery data for the images processing and analysis using SNAP tool.

2. Materials and Methods

The study looks into if there will be an oil spill in the Strait of Hurmoz between April and May 2020. In Figure. 1, the study area is highlighted. The radar's images then obtain from Copernicus Open Access Hub which an online platform provided by the European Space Agency (ESA). Furthermore, it acts as a single archive for the enormous amount of Earth observation data gathered by the Sentinel satellite mission and other satellite missions under the Copernicus program. Access to a variety of satellite data and products, such as imaging, radar data, and other remote sensing data, is free and accessible through the hub. Next, Sentinel-1 was selected with ground range detected product (GRD) and two images from the Copernicus program at the dates of 24 April and 30 May in 2020 were downloaded. Following that, the imagery data from 30th May 2023 is imported into the SNAP software, after which it was processed.

Figure 1. The study area of interest affected by the oil spills.

The steps to determine a spill of oil using SNAP tools are as follows, as displayed in Figure 2:

1. Single Product Speckle Filtering: This is done to reduce speckle effect caused by interference in radar imagery and enhance the quality of image.
2. Land-sea-Mask:It is used to limit the analysis to the water regions of the image, obviating the requirement to process or examine land areas that are unimportant for oil spill detection.This leads to improve the efficiency, accuracy, and interpretation of the analysis by focusing on the relevant water areas where oil spills are expected to occur.
3. Calibration: It guarantees data validation, radiometric correctness, consistency, cross-sensor compatibility, and accuracy of derived parameters. These advantages help improve the identification and monitoring of oil spills for efficient response and environmental management, as well as the trustworthy and accurate analysis of satellite photos.
4. Oil-Spill-Detection: It is applied to take advantage of automatic detection, effective processing, parameter customization, visualization, and workflow integration.
5. Oil-Spill-Clustering: Through doing this, the detected oil spill pixels are analyzed and categorized according to their properties and spatial distribution. Clustering techniques aid in locating spatially continuous areas of oil spills and can offer important details about the size, pattern, and form of the spills.

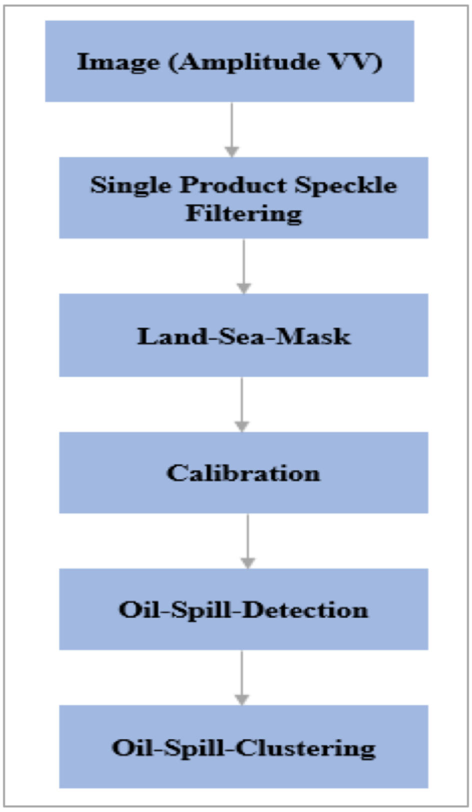

Figure 2. Flow chart illustrating the needed processing steps to analyze the oil spills using SNAP tool.

3. Results

Before applying the oil spill detection method depicted in Figure 2, the imported image with VV-polarization, as illustrated in Figure 3, is zoomed in to identify any potential oil slick and to facilitate a more detailed examination. Upon closer examination, it becomes evident that the image is inverted. As a result of this analysis, Figure 4 is generated, wherein the oil spill region is represented as a dark spot because oil spill areas are defined by SNAP as dark spots with backscatter levels that are lower than average in non-oil spill areas [7]. Moreover, it is important to note here that the Hurmoz Strait is experiencing numerous occurrences of oil spillage. The oil slicks are observed in various locations within the strait, posing significant environmental risks and challenges for the surrounding ecosystems and communities.

Figure 3. An imported Sentinel-1 imagery data in SNAP showing the backscattered amplitude VV.

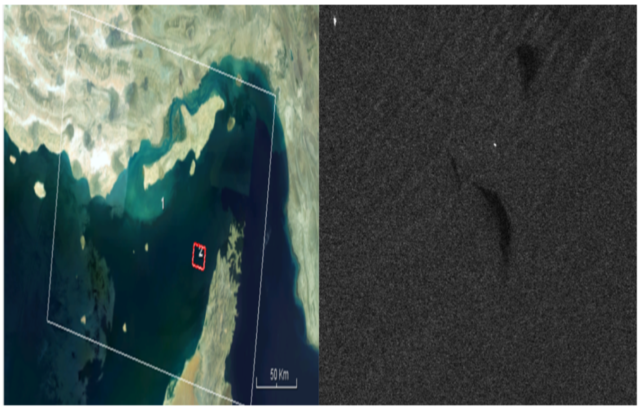

Figure 4. Sentinel-1 imagery data showing the area of interest at the left and oil spill detected on 30 May 2020 at the right.

In SNAP software, oil spill detection and mapping is a powerful automatic processing tool suitable for SAR sea applications. The automatic SNAP (Sentinel Application Platform) flowchart, as shown in Figure 2 can identify and assess oil spills. Two radar imagery data have been acquired from the Copernicus Open Access Hub; the first was taken on 24th April, 2020, and the second was taken on the 30th May, 2020 and then applied to the automatic SNAP tools for oil spill processing and detection . The results of this process are presented in Figure 5, which provides compelling evidence of an increase in oil slicks between April and May 2020. It is abundantly clear from Figure 5 that the frequency of oil spills has increased over time.In addition, the image reveals a visual representation of the oil slicks, clearly demonstrating a larger presence in May compared to April 2020.

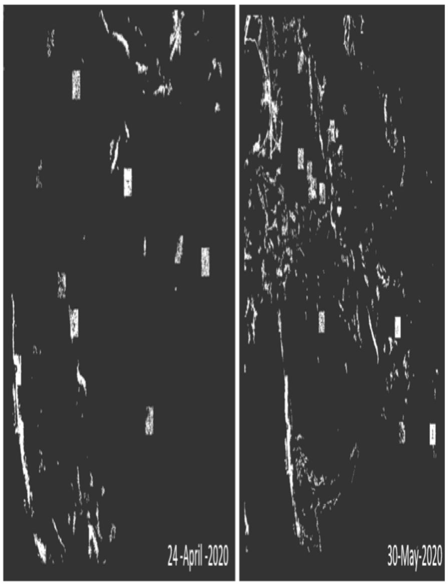

Figure 5. Sentinel-1 processed imagery data showing the increase in oil spills from April 2020 to May 2020, in the area as shown in Figure 4.

To further investigate the magnitude of the oil spill, profile plots were generated for both May and April as shown in Figure 6, focusing on a specific location within the area of interest. These profile plots depict the reflectance values for each pixel along the chosen line graphically. While the reflectance values for oil register at a lower level, at 15 dB, the reflectance values for water in May 2020 are remarkable for being around 20 dB.Additionally, the profile plot comparison offers quantitative proof of the rise in oil spills in May 2020. The difference between the reflectance values for the oil slick and the water shows how unique the oil spill is and how its magnitude significantly increased during that particular month.

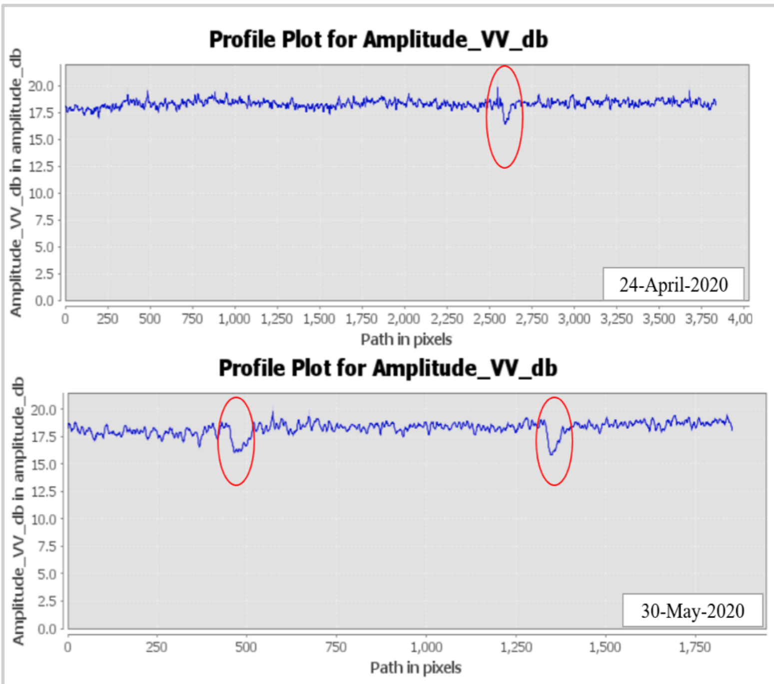

Figure 6. Sentinel-1 processed imagery data showing the increase in oil spills from April 2020 to May 2020.

4. Conclusions

In this research study, oil leaks in the Strait of Hormuz nearby northern coastal of Oman occur over two specified months in 2020, and their frequency is examined and analyzed. Satellite imagery data were obtained from the Copernicus Open Access Hub. The next step involved processing and identifying oil spills within the obtained photos using SNAP tool.
Based on the findings of this study, a considerable rise in the frequency of oil spills was realized from April to May. This study shows that the volume of oil in the Strait of Hormuz increased significantly over that time period. Furthermore, the results of the study highlight the significance of ongoing monitoring and quick response to lessen the effects of oil spills in this vital oil shipping route.

Author Contributions: "Conceptualization, M. Bait-Suwailam and T. Al-Hashmi; methodology, T. Al-Hashmi; software, T. Al-Hashmi; validation, T. Al-Hashmi; formal analysis, T. Al-Hashmi; investigation, T. Al-Hashmi; resources, T. Al-Hashmi and M. Bait-Suwailam; data curation, T. Al-Hashmi; writing—original draft preparation, T. Al-Hashmi; writing—review and editing, M. Bait-Suwailam; visualization, T. Al-Hashmi; supervision, M. Bait-Suwailam; project administration, M. Bait-Suwailam. All authors have read and agreed to the published version of the manuscript.

Funding: "This research received no external funding."

Conflicts of Interest: "The authors declare no conflict of interest."

References

1. Overview Of Sentinel-1. Available online: https://sentinels.copernicus.eu/web/sentinel/home (accessed on 30 May 2023).
2. Potin, P.; et al. Copernicus sentinel-1 constellation mission operations status.*2019 IEEE International Geoscience and Remote Sensing Symposium* **2019**.
3. Prastyanim R.; Basith, A. Utilisation of Sentinel-1 SAR imagery for oil spill mapping: a case study of Balikpapan Bay oil spill. *JGISE Journal of Geospatial Information Science and Engineering* **2018**.
4. Alexandrov, C; Kolev, N.; Sivkov, Y.; Hristov, A.; Tsvetkov, M. Oil spills detection on sea surface by using Sentinel-1 SAR images. In Proceedings of the 21st International Symposium on Electrical Apparatus and Technologies, Bourgas, Bulgaria, 3-6 June 2020.
5. Naz, S.; Iqbal, M.; Mahmood, I.; Allam, M. Marine oil spill detection using synthetic aperture radar over indian ocean. *Marine Pollution Bulletin* **2021,**162: 111921.
6. Marzooq, H.; Naser, H.; Elkanzi, E. Quantifying exposure levels of coastal facilities to oil spills in Bahrain, Arabian Gulf. *Environmental Monitoring Assessment* **2019,** pp. 191-160.
7. Issa, S. Monitoring oil spills offshore the United Arab Emirates using multi satellite data. *International Journal of Geographical Information system applications and remote sensing* **2010,** pp. 1-20.
8. Strait of Hormuz. Available online: https://www.britannica.com/place/Strait-of-Hormuz (accessed on 30 May 2023).