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Modelling Multiple Floating Materials, Using Temporal Resolution Remote Sensing Data

(A Case Study: Obhur Creek Area, Red Sea, Saudia Arabia)

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ABSTRACT

Surface water floating materials cause significant negative environmental impacts. This study investigates, floating materials, size, distribution and rate of change, using remote sensing satellite data and debris detection indices. Sentinel-2 images captured at different times in the years, 2016, 2020 and, 2024 were used. Obhur Creek, digital images processed, detection models applied, histogram-based thresholding values obtained, and results binarized to identify and map the floating materials. Results demonstrated a multiscale distribution with continuous variations in size and shape. The yearly, rate of increase of materials size was 3.12%. This highlights a significant, issue that may lead to serious environmental negative impacts in Obhur Creek area in particular and the Red Sea coast in general.

Keywords: NDTI, FDI, DSI1/2, Floating Material, Index, Obhur Creek, Red Sea.

1. INTRODUCTION.

Surface water various waste materials, including water debris, garbage, and plastics become a critical environmental issue. Large area of these floating materials causes significant negative impacts to marine environment. Different methods are available in the literature for assessing and monitoring mutli-type floating materials. These range from volunteer groups manual inspection activities and surveillance videos to modern technology-based methods (image processing, deep learning, etc.). The manual methods are time consuming, labor intensive, limited in coverage and demand substantial resources. However, large areal coverage, remote sensing-based detection methods play an important role in this issue, despite the significant challenges posed by the complex optical characteristics of the remote sensing imagery. This paper investigates the temporal spatial distribution of multiple debris in Obhur Creek area. The area is affected by multiple debris types, produced by humans' activities in the area and those driven by the red sea at the mouth of the Creek. Three debris detection methods were used in the study. These are based on the spectral reflectance characteristics of the multiple floating debris and the background water. The Normalized Difference Turbidity Index (NDTI), the Floating Debris Index (FDI), and the Debris Spectral Index (DSI1/DSI2) methods. Sentinel 2A images were processed and used in the study. SNAP, QGIS, PAINT and Microsoft Excel, were used for digital image processing, plotting/presentation and

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statistical analysis. “Surface water multi-type materials is an important environmental issue. Marine debris pollution has become a major global environmental issue that has garnered significant public attention” (Kurniawan et al., 2021; Zhou et al., 2022). In this study, we focus on the commonly occurring multi-types of floating materials. The three remote sensing debris detection models were successfully applied to Sentinel-2 imagery to identify floating materials distributions across the study area. The findings enhance the understanding of the distribution pattern of these materials and establish an operational satellite-based methodology for their rapid monitoring. This provides a significant support for environmental management and protection in the study area.

2. RESEARCH PROBLEMS.

Detection and mapping of multi-type floating materials, leading to negative environmental impacts in the study area.

3. RESEARCH OBJECTIVES.

Monitoring the phenomena of multi-floating materials distribution, using temporal resolution satellite images, from the European Space Agency's (ESA), Sentinel-2 Multi Spectral Imagery Satellites. This serves as a pilot project, and facilitates the design and implementation of the multi-type floating materials, general-purpose removal, preventive measures and combating operations in the Red Sea coast.

4. THE STUDY AREA.

The study area comprises Obhur Creek water surface area and, the Red Sea coast at the mouth of the creek. It is located around 30 kilometers north of Jeddah’s city Centre, on the eastern shore of the Red Sea in western Saudi Arabia. It extends for a length of ten kilometers and width of five hundred meters. This Obhur creek serves as a prominent sea tourism hub in the Jeddah region. It is an open year-round, entertainment area, beasy with a variety of activities. Figure 1, shows the location of the study area.

Figure 1, The study area, 1 (Red Sea), 2 (Red Sea coast and, 3 (Obhur creek.

5. **Data sets.**

Radiometrically and geometrically corrected (BoA) level 2A Sentinel-2 data products were obtained from the official Sentinel website (htt ps://sentinels.copernicus.eu/). Sentinel- 2 data have broad spectral coverage, particularly in the red-edge and near infrared (NIR) regions and high spatial resolution (10–20 m). These regions are important for floating materials detection (high reflectance). Three images collected at dates 2016, 2020 and 2024 were obtained. Various types of software were used for the data processing. The ESA Sentinel-2 SNAP, QGIS/Paint and Microsoft Excel sheets are used for image processing operations, creating and displaying plots/figures and statistical analysis, respectively.

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5.1 Bands Glint Correction.

The glint correction was applied to the satellite images to remove the direct reflectance from the top of the air-water interface from the images. The de-glint module available in Sentinel SNAP was applied. It is based on Hedley at al. (2005) and performs, glint correction, cloud masking and land water masking (ESA SENTINEL-2 User Handbook, 2015).

5.2 Bands Filtering.

The bands were filtered by applying the non-linear filters, (median) module available in Sentinel SNAP program, to enhance the image quality and remove noise and blur areas from the satellite images.

5.3 Bands Normalization.

All Sentinel-2 bands were normalized to ensure that the models results are not biased by differences in reflectance values across the image. Non-normalized bands may lead to inaccuracies in the model results (false positives/negatives). Normalization standardizes the range of brightness values across the bands, and ensures equal contributions of the bands to the model. Absent band normalization, may lead to model domination by some bands, and results over determination. The bands were normalized using the Min-Max Normalization Method (Sarah Lee, 2025; Xiaotong. Zhu H. al el., 2022).

$$I' = (I - I_{min}) / (I_{max} - I_{min}) \times (L_{max} - \mathrm{L}_{\mathrm{min}}) \qquad (1)$$

where I^' is the output pixel value, I is the input pixel value, I_min and I_max are the minimum and maximum pixel values in the input image, and Lmax and Lmin are the maximum and minimum values in the output image.

6. RESEARCH METHODOLOGY.

The Normalized Difference Turbidity Index (NDTI), the Floating debris Index (FDI), and the Debris Spectral Index (DSI1/DSI2) methods were adopted for the floating materials detection in the study area.

6.1.The Normalized Difference Turbidity Index (NDTI).

The NDTI is a band index defined by (Lacaux et al, 2007) as follows:

$$\mathrm{NDTI} = (\mathrm{Red} - \mathrm{Green})/(\mathrm{Red} + \mathrm{Green}) \qquad (2)$$

Where Red and Green represent the red and green bands reflectance values respectively.

The general interpretation of the Index values is that, Lower values (Negative or near zero) indicate higher turbity, while higher values indicate clear water.

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6.2 The Floating Debris Index (FDI).

The floating Debris Index can be used to identify floating materials by enhancing their contrast with the background water. It is calculated by defining the difference between the observed NIR reflectance and a calculated baseline. Developed by Biermann at el., (2020).

$$FDI = R_{rs,}NIR - (R_{rs,}RED2 + (R_{rs}SWIR - R_{,rs,}RED2) * ((\lambda_{NIR} - \lambda_{RED}) / (\lambda_{swir} - \lambda_{RED})) * 10 \quad (3)$$

Where $R_{rs,}NIR$, $R_{rs,}RED2$ and $R_{rs}SWIR$ are the reflectance values in the near infra-red, red edge 2 and short- wave infrared bands, respectively. Wave length values are the central wave lengths.

6.3 The Debris Spectral Index (*DSI1/DSI2*).

The *DSI1/DSI2* are described by Shengqiang Wang, al el. (2025) as follows:

$$DSI1 = R_{rs}{}^{d}(AVE) - R'_{rs}{}^{w}(AVE) \quad (4)$$

where R^d (AVE) is the R (AVE) value of pixels containing floating debris in the MSI sensor image, and R'^w(AVE) stands for the R (AVE) value of background water pixels without floating debris.

$$DSI2 = (R'_{rs}(\lambda_{RED}))/(Rrs(\lambda RED)) \quad (5)$$

where $R_{rs}(\lambda_{RED})$ is the $R_{rs}(\lambda)$ in the red band, and $R'_{rs}(\lambda_{RED})$ represents the baseline reflectance at the red band, estimated by linear interpolation between the green and red-edge 2 bands, and is calculated as:

$$R_{rs}'(\lambda_{RED}) = R_{rs}(\lambda_{GREEN}) + (R_{rs}(\lambda_{RE2}) - R_{rs}(\lambda_{GREEN}))\,(\lambda_{RE2} - \lambda_{GREEN})\,(\lambda_{RED} - \lambda_{GREEN}) \quad (6)$$

where $R_{rs}(\lambda_{Green})$, $R_{rs}(\lambda_{RED})$ and $R_{rs}(\lambda_{RE2})$ signifies the $R_{rs}(\lambda)$ in the green, red, and red edge 2 bands of the MSI sensor, with wavelengths of 559 nm, 665 nm, and 740 nm, respectively.

6.4 Workflow.

Three atmospherically and radiometrically corrected, Sentinel 2 images were processed to remove glint reflections, bands were filtered to enhance their quality, normalized to standardize their range of intensity values and ensure their equal contribution to the detection models. The three floating materials detection methods were applied and results are presented in the following section. Figure 2, is a workflow diagram showing the steps followed in the conducted research.

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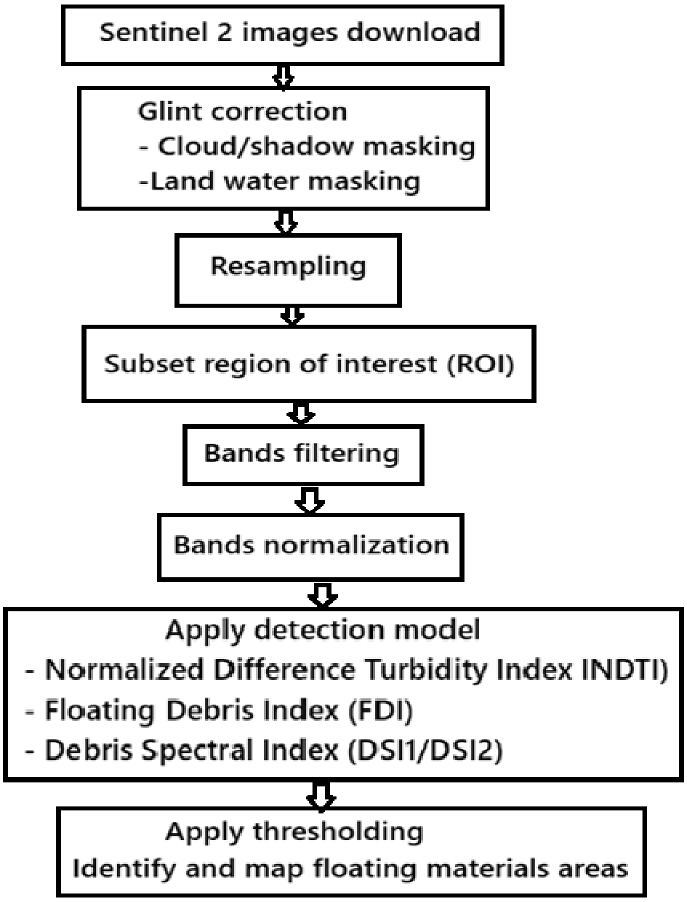

Figure 2, Workflow showing the steps followed in conducting the study.

7. RESULTS AND DISCUSSIONS.

Sentinel 2 images processed, detection models applied, histogram-based thresholding values obtained, and results binarized to identify and map the floating materials, using Sentinel SNAP program, for the years 2016, 2020 and, 2024. Floating materials distribution, mapping and analysis were obtained using QGIS program. Results are presented in the Tables and Figures below.

Table 1: Floating materials for the years 2016, 2020 and, 2024 using the three detection methods.

Method	Threshold value	No. of pixels tested	Debris pixels	Area (m^2)	Percentage	Year
NDTI	- 0.15	186182	16756	1.676	9 %	2016
FDI	-29.3	186478	9324	0.932	5 %	2016
DSI12	00/0.65	186482	13054	1.305	7 %	2016
NDTI	+0.0167	193113	30898	1.931	16%	2020
FDI	-0.237	191113	19111	1.911	10%	2020
DSI12	-0.3/00	186482	26107	2.611	14 %	2020
NDTI	-0.29	185324	25445	2.594	14%	2024
FDI	-0.18	186481	37296	3.729	20%	2024
DSI12	17/0.8	186481	31701	3.170	17 %	2024

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Table 2, The rate of increase of floating materials in the years 2016, 2020 and, 2024.

Year / Method	2016	2020	2024	Average %
NDTI	9%	16%	14%	13.0%
FDI	5%	10%	20%	11.7%
DSI1/2	7%	14%	17%	12.7%
	Overall average rate of increase (37.4/3)			12.47%
	Rate of increase per year (12.47%/4)			3.12%

A clustered column chart (Figure 3) summarizes Table 1. This Figure clearly, revealed the increase of the floating materials with time, for the years 2016, 2020 and, 2024. Table 2, demonstrated an average rate of increase, 13.0%, 11.7% and 12.7% for the years 2016, 2020 and 2024, respectively, with an overall average rate of 12.47%. Thus, the approximate of floating materials increase per year is 3.12%. This is a significant increase that needs an attention from concerned authorities and requires an urgent consideration.

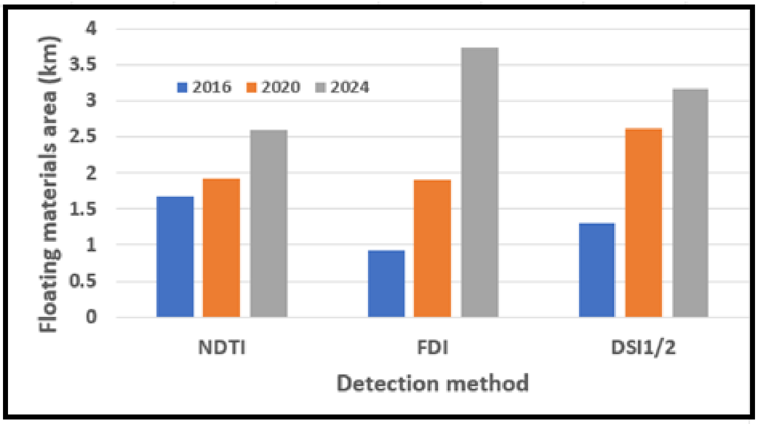

Figure 3, A clustered column chart showing, the floating materials areas (km), for the three detection methods, in the years 2016, 2020 and, 2024.

7.1 Spatial Distribution of Floating Materials.

The floating materials distribution patterns, produced by the three detection methods for the years, 2016, 2020 and, 2024 are presented in Figures 4- 6, 7-9 and 10-12, respectively. However, due to the dynamic environment of the floating materials, floating materials exhibit a multiscale distribution with continuous variations in size and shape. The common general spatial pattern shared by the three detection methods is that, floating materials are located along the Red Sea coast and Obhur Creek north and south coasts, with noticeable concentrations along the north coast. Needless to say, that, field survey data is more significant for reliable output evaluation. Such data is not available for the study area. However, the *DSI1/2* detection method was applied through controlled experiments and spectral simulations, using Sentinel-2 data, results were tested by the confusion matrix and,

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acceptable results are reported (Shengqiang Wang, al el.,2025).

In the year 2016, the NDTI method demonstrated noticeable concentrations of floating materials, in Obhur Creek central area and far north tongues (Figure 4). This phenomenon is not demonstrated by the other detection methods. This may be attributed to the holistic nature of this detection method. For the year2020, similar materials distribution patterns, are demonstrated, with some variations. Concentrations of floating materials, in Obhur Creek central area and far north tongues, are demonstrated by the NDTI and DSI1/2 methods (Figures 7 and 9). For the year 2024, the FDI and *DSI1/2* detection methods demonstrated, similar distribution patterns (Figures 11 and 12), and material concentrations in Obhur Creek central area and tongues are obtained for the NDTI method (Figure 10).

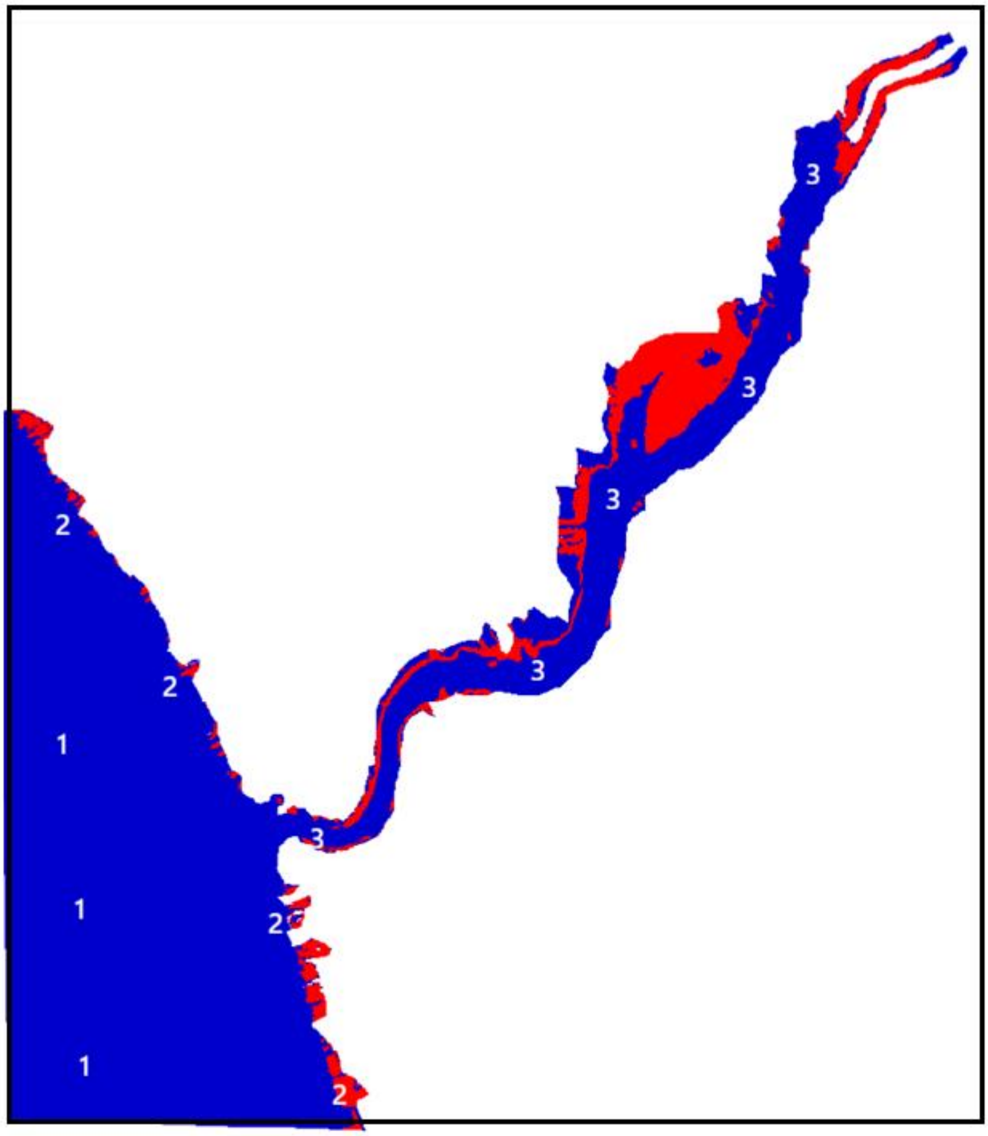

Figure 4, NDTI (2016), floating materials distribution pattern, Red Sea (1), Red Sea coast (2) and, Obhur creek (3).

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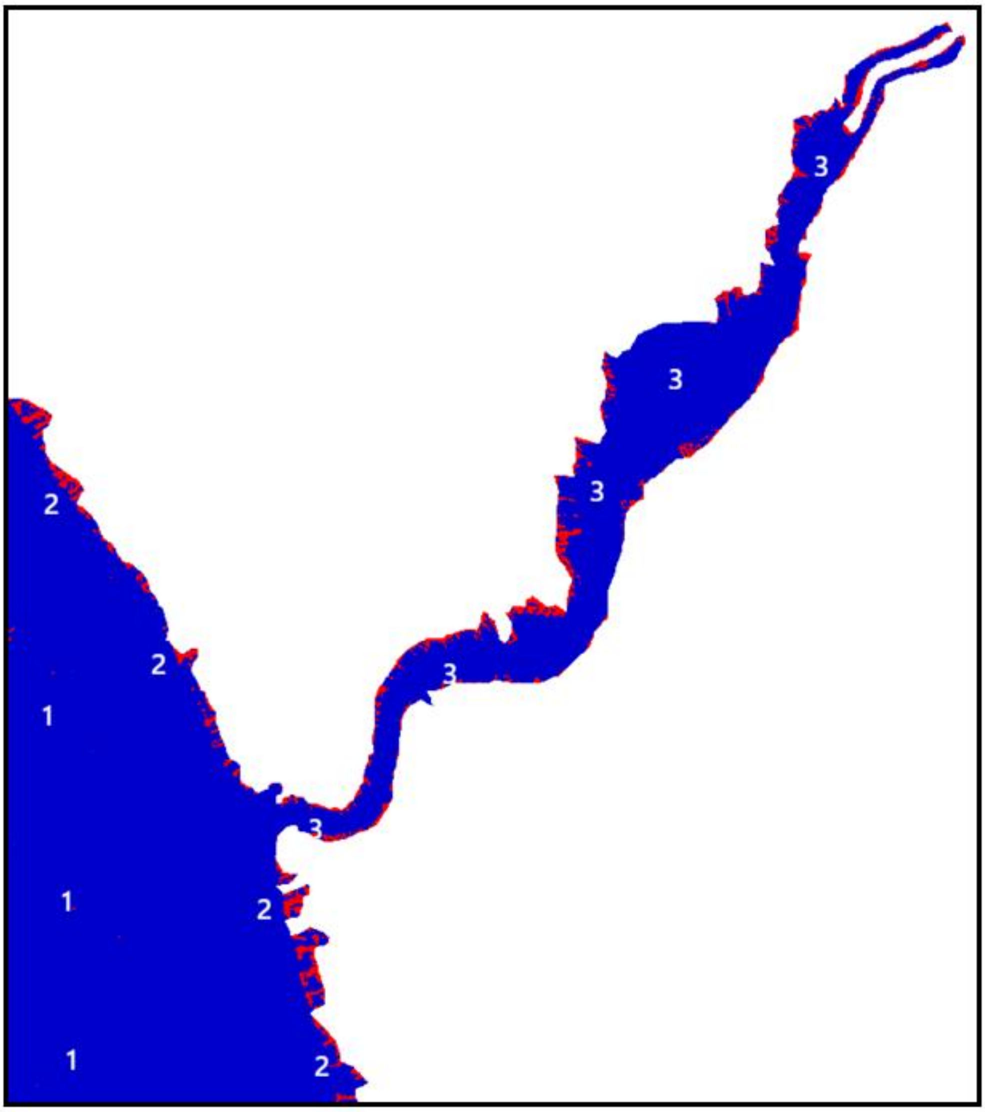

Figure 5, FDI (2016), floating materials distribution pattern, Red Sea (1), Red Sea coast (2) and, Obhur creek (3).

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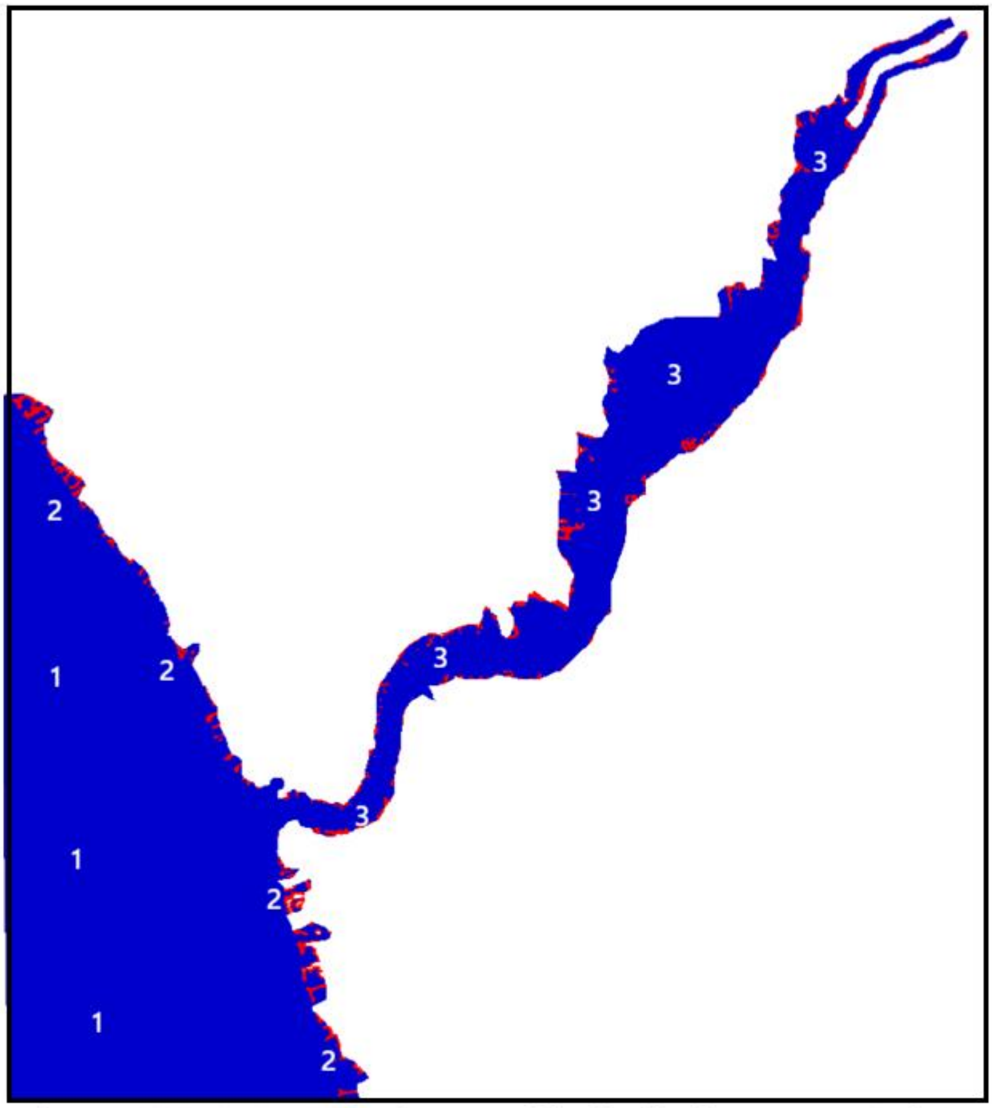

Figure 6, DSI1/2 (2016), floating materials distribution pattern, Red Sea (1), Red Sea coast (2) and, Obhur creek (3).

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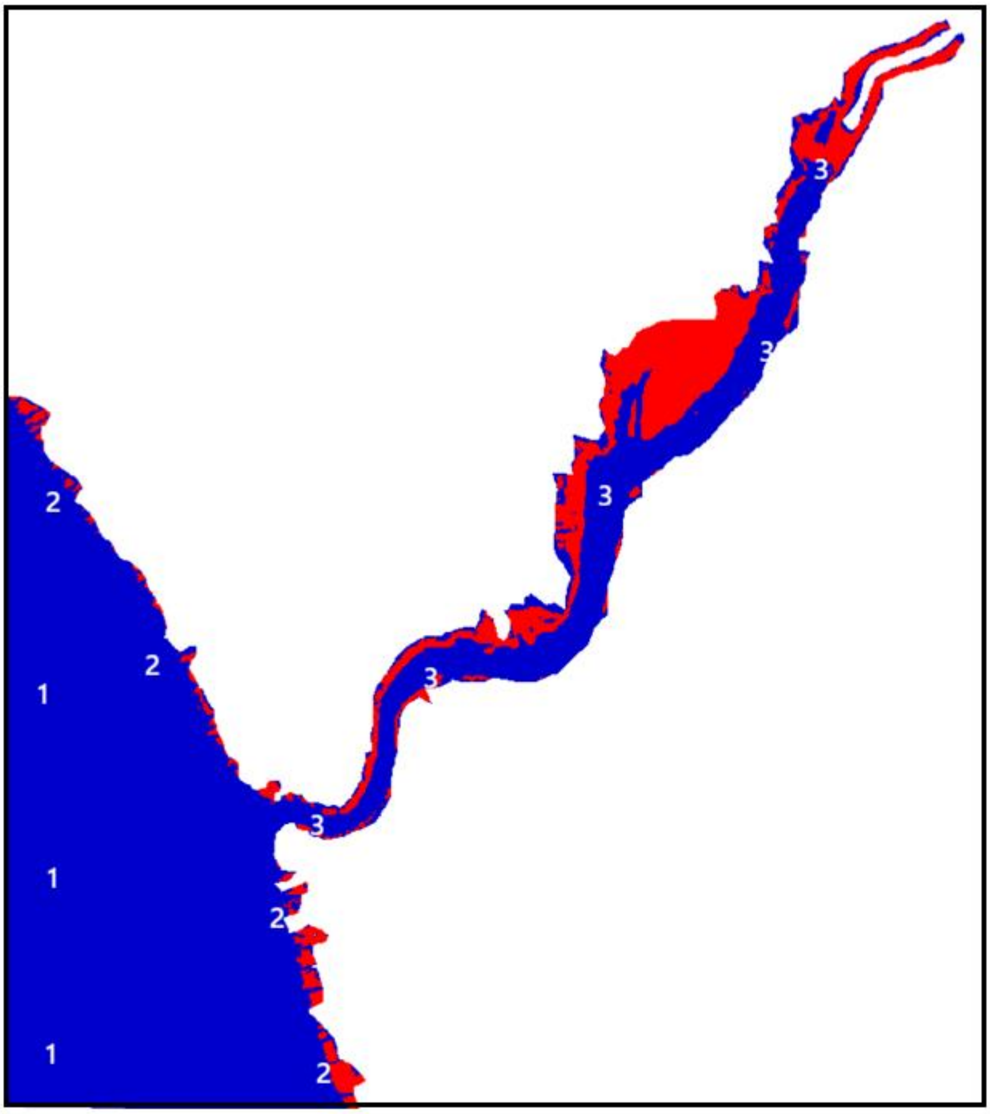

Figure 7, NDTI (2020), floating materials distribution pattern, Red Sea (1), Red Sea coast (2) and, Obhur creek (3).

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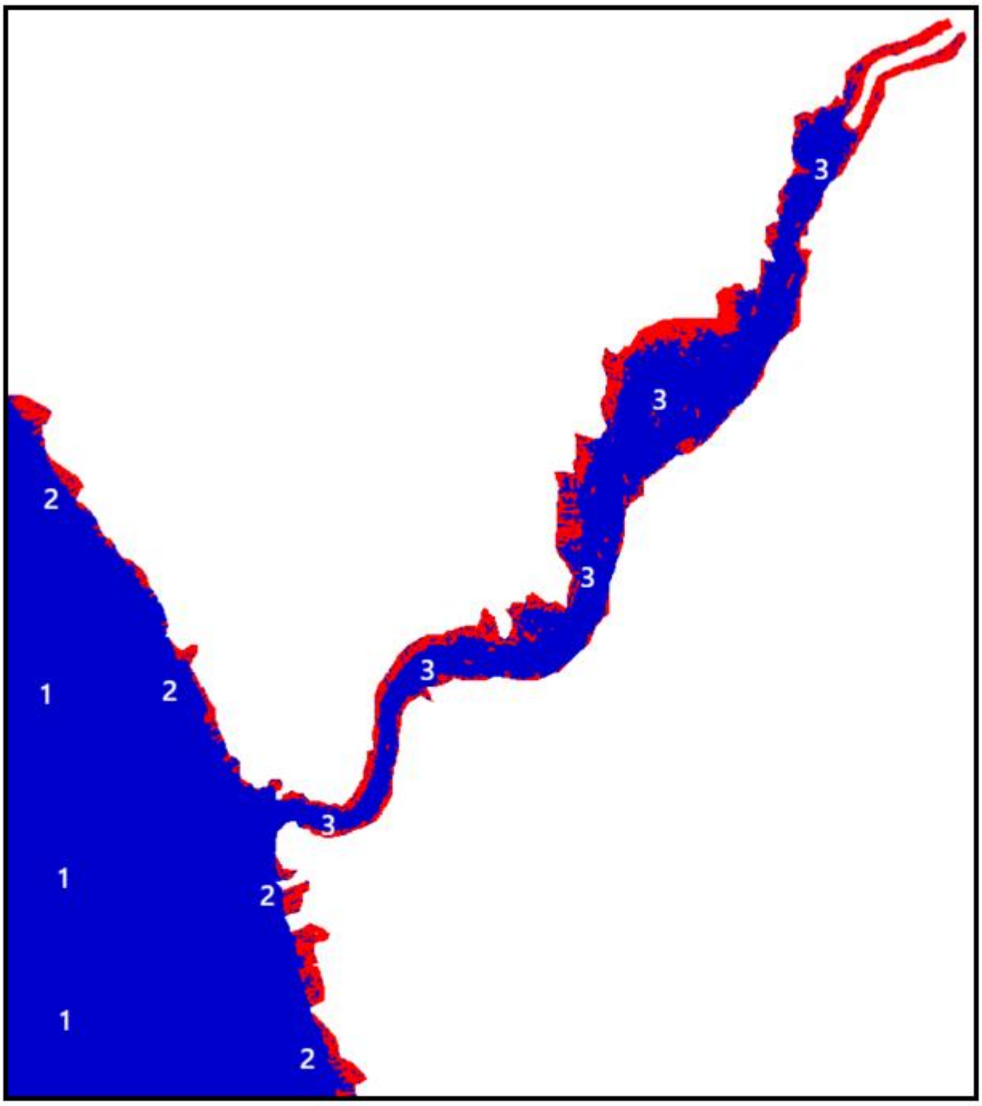

Figure 8, FDI (2020), floating materials distribution pattern, Red Sea (1), Red Sea coast (2) and, Obhur creek (3).

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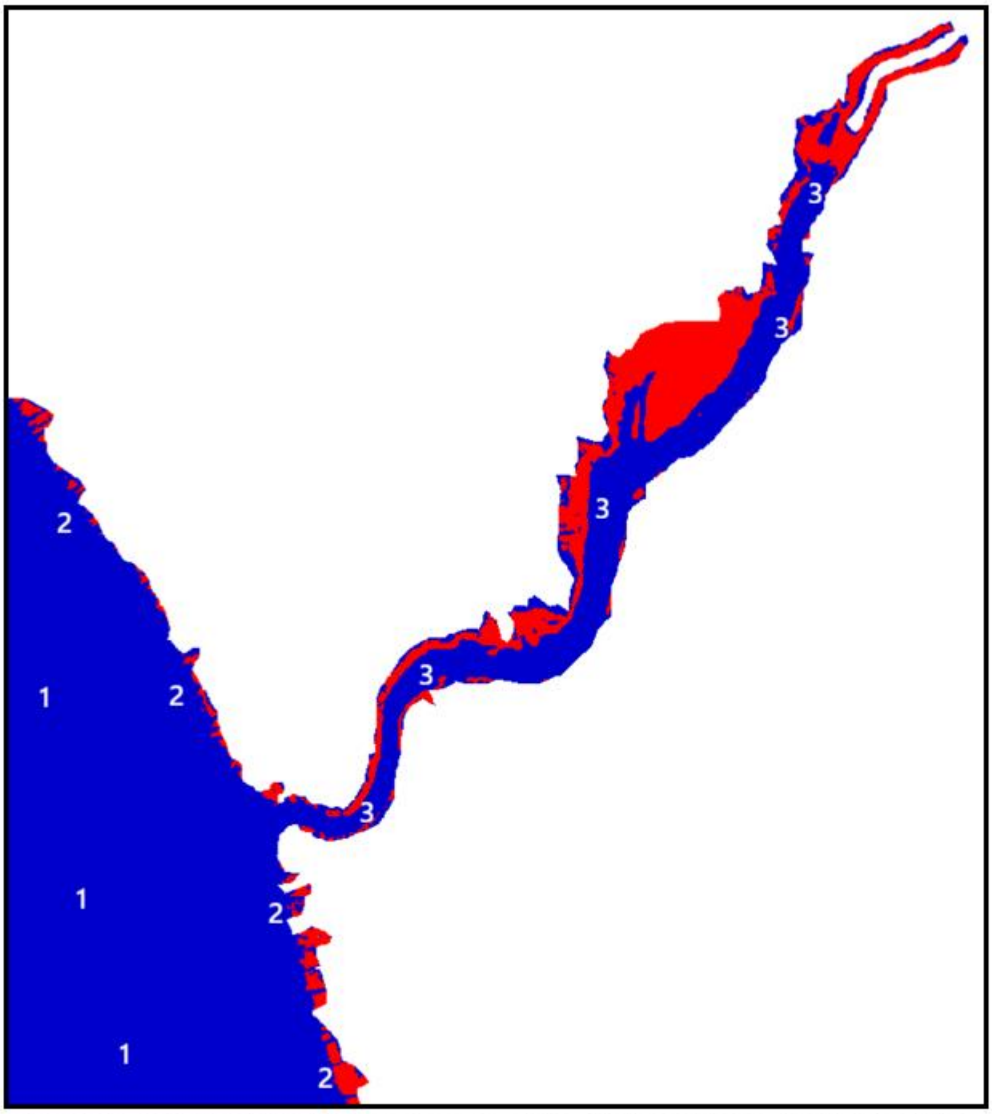

Figure 9, DSI1/2 (2020), floating materials distribution pattern, Red Sea (1), Red Sea coast (2) and, Obhur creek (3).

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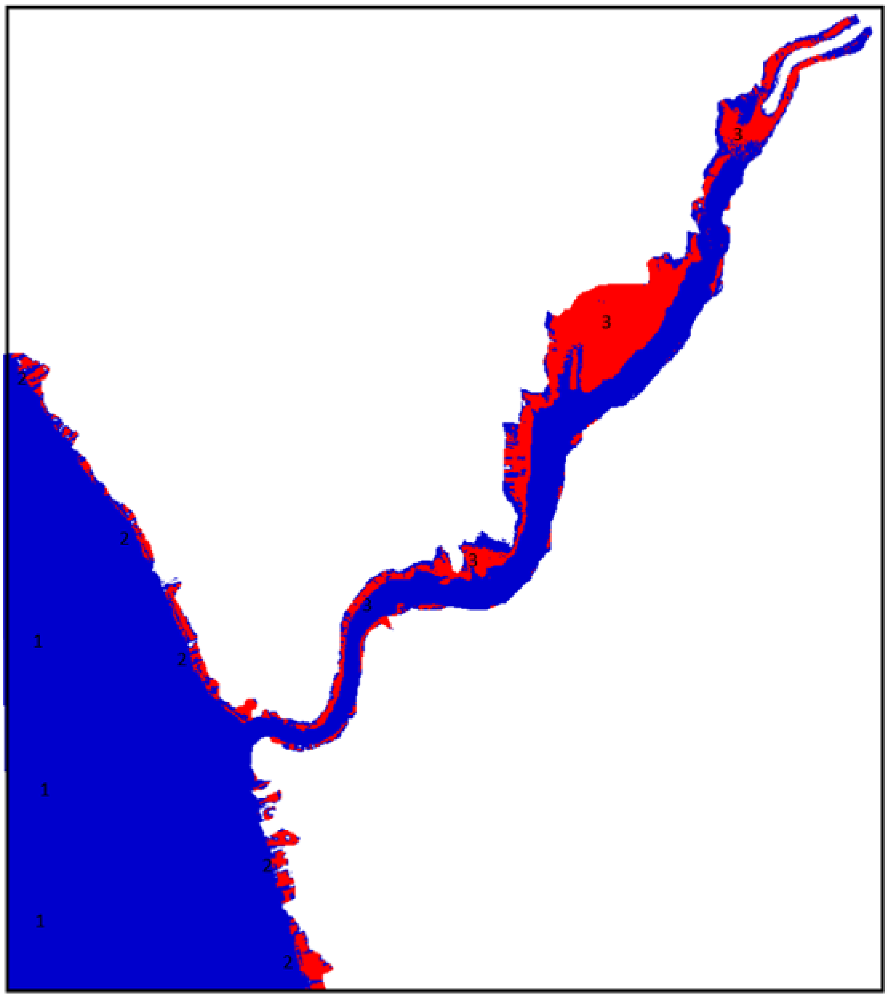

Figure 10, NDTI (2024), floating materials distribution pattern, Red Sea (1), Red Sea coast (2) and Obhur creek (3).

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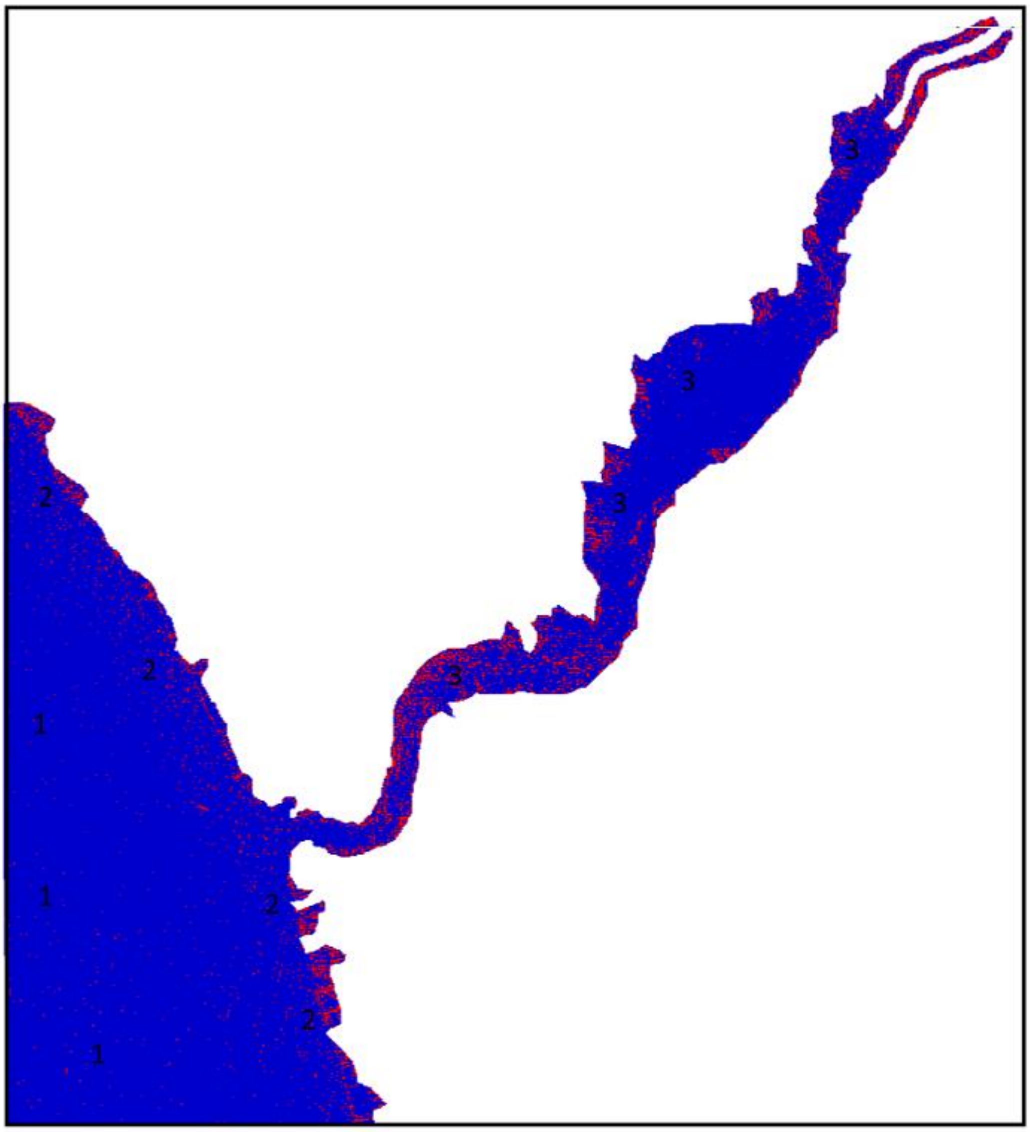

Figure 11, FDI (2024), floating materials distribution pattern, Red Sea (1), Red Sea coast (2) and Obhur creek (3).

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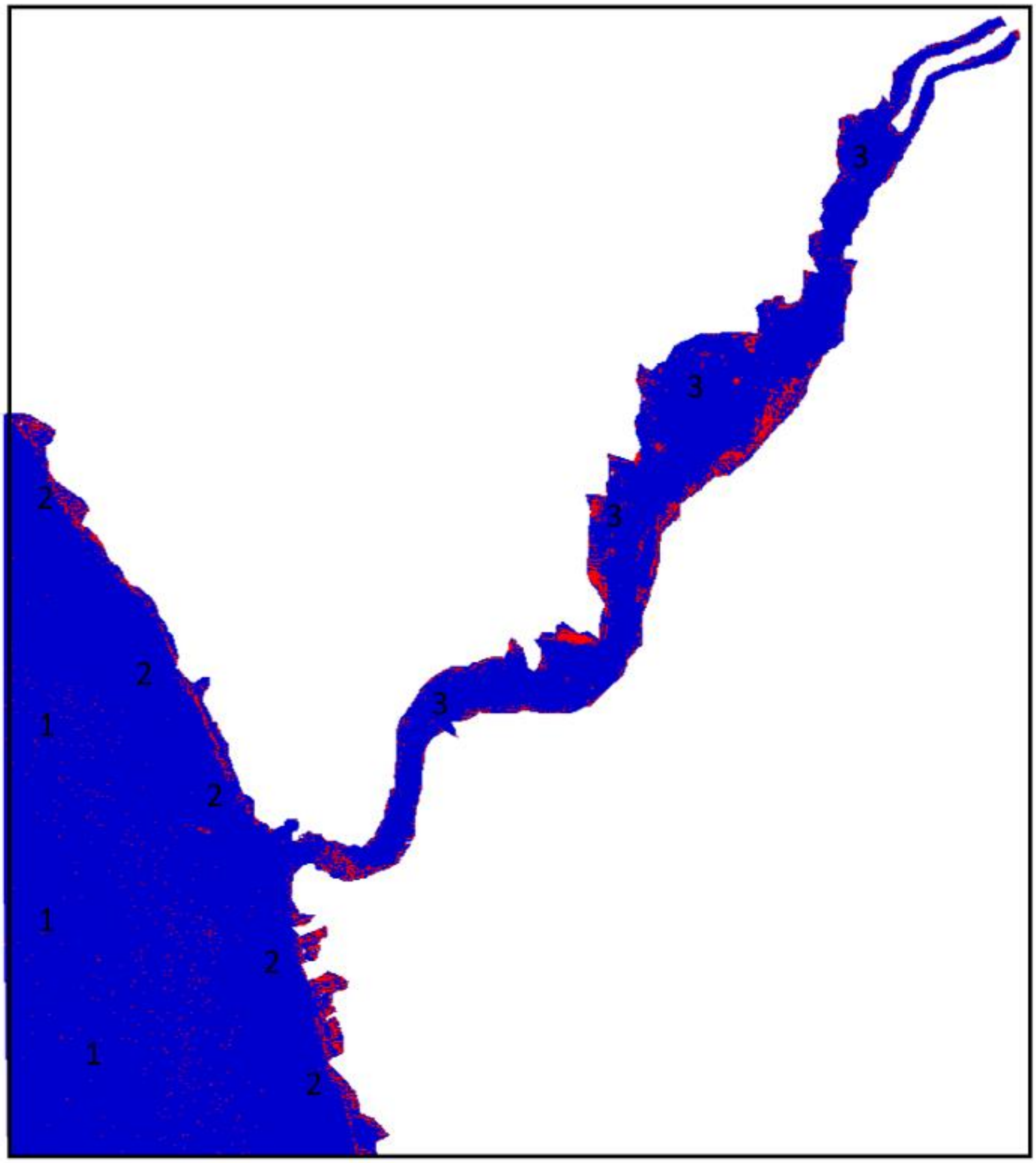

Figure 12, DSI1/2 (2024), floating materials distribution pattern, Red Sea (1), Red Sea coast (2) and Obhur creek (3).

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8. CONCLUSIONS.

The study demonstrated that remote sensing data and detection indices are effective tools for detecting, modelling, and monitoring water surface floating materials. The findings showed variations in materials spatial distribution and a significant increase in size. The rate of increase is 3.12% per year. This highlights the importance of planning, preventive measures and continuous monitoring to combat the environmental negative impacts in the study area, in particular and the Red Sea coast in general.

Author Contributions.

All authors contributed to the study conception and design. Data collection and analysis were performed by [Gar Al-nabi Ibrahim Mohamed] and [Faisal Alsaaq]. The first draft of the manuscript was written by [Gar Al-nabi Ibrahim Mohamed] and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Disclosures and Declarations:

- The authors have no relevant financial or non-financial interests to disclose.
- The authors have no competing interests to declare that are relevant to the content of this article.

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Data Availability.

Data will be made available on request.

REFERENCES.

1. ESA 2015 SENTINEL-2 User Handbook *Sentin. User Handb.*
2. htt ps://sentinels.copernicus.eu/
3. J. D, Hedely, al el. (2005). Simple and robust removal of sun glint for mapping shallow-water benthos. International journal of remote sensing, Vol 26, No 10. DOI:10.1080/01431160500034086.
4. J. P, Lacaux et al, (2007). Classification of Ponds from High-Spatial Resolution Remote Sensing: Application to Rift Valley Fever Epidemics in Senegal. Remote Sensing of Environment 106(1):66-74. DOI:10.1016/j.rse.2006.07.012
5. Kurniawan, S.B., al el. (2021). Current state of marine plastic pollution and its technology for more eminent evidence: a review. J. Clean. Prod. 278, 123537

6. Sarah Lee (2025). Mastering Contrast Stretching in Image Processing.https://www.numberanalytics.com/blog/ultimate-guide-contrast-stretching-image-processing
7. Shengqiang Wang, al el. (2025). Detecting multiple types of marine floating debris via satellite remote sensing informed by hyperspectral features. Ecological Indicators. doi.org/10.1016/j.ecolind.2025.114529
8. Xiaotong. Zhu, H. al el. (2022). « An ensemble machine learning model for water quality estimation in coastal area based on remote sensing imagery », *J. Environ. Manage.*, vol. 323, p. 116187, déc. 2022, doi: 10.1016/j.jenvman.2022.116187.
9. Zhou et al., (2022). Structural basis for potent antibody neutralization of SARS-CoV-2 variants including B.1.1.529. *Science, Vol* 376, Issue 6591. DOI:10.1126/science. abn8897