



Identifying Hydrocarbon Wastes in the Vicinity of Oil Transmission Lines Based on Remote Sensing

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ABSTRACT

Hydrocarbon index is a significant spectral index in the direct detection of hydrocarbon materials. In this study, it has been tried to identify hydrocarbons resulted from the leakage of oil lines that have accumulated in the adjacent lands through using aster images. In order to identify hydrocarbons, the aster image was first taken in 2005, that is, the time after the hydrocarbon leakage in the vicinity of Shadegan Wetland. After editing and pre-processing the images, a hydrocarbon index was applied to the ester image. The upper edge of this index displays the areas with high pollution of hydrocarbons, and the lower edge of this index represents the clean areas without hydrocarbon materials. In order to evaluate and validate the presence of hydrocarbons, two spatial statistical analysis methods of Moran insulin and hot spots were applied, that the results of hot spots analysis showed that the areas that were identified as sensitive and with hydrocarbon pollution can be confirmed with about 99% accuracy.

Keywords: *Hydrocarbon wastes, Spectral index, Remote sensing, Aster images*

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1. INTRODUCTION

Iran is a country with valuable wealth such as oil, and the existence of many oil transmission lines in Iran provides the ground for hydrocarbon pollution. Due to the fact that the presence of hydrocarbons is detrimental to the environment, and the occurrence of such leakages incurs huge costs, ground and field methods should be used to monitor and control these oil pollutants. In addition to being expensive, ground methods are very time consuming and are only used for leakages from oil pipelines. But there is no way other than using satellite images to identify the areas affected by hydrocarbon waste from oil pipelines on a large scale at a lower cost and time. Remote sensing plays a significant role in oil monitoring (Fingas and Brown, 1997). Remote sensing is an appropriate tool for direct and indirect detection of hydrocarbons (Schumacher, 1996). One of the available methods that can fulfill our needs on a large scale is the use of remote sensing science and image processing tools that can be used to identify and monitor oil transmission lines and adjacent lands. Therefore, in this study, using ester

images and remote sensing analyzes, it has been tried to detect hydrocarbon-contaminated lands from healthy lands adjacent to pipelines. To identify hydrocarbons in this study, ester images from 2004 were used. So far, various methods have been investigated to detect hydrocarbons in the form of leakages or oil stains (Polychronis and Vassilia, 2013).

2. METHODOLOGY

Various methods have been examined to detect hydrocarbon wastes through satellite images. In this study, in order to detect hydrocarbon materials, hydrocarbon index (HI) has been used. This index affects the reflection of pixels related to bands located in the near-infrared range (Guifang et al., 2013). In order to apply the HI hydrocarbon index, the ester image of the study area was obtained from the USGS site, and to produce an integrated image of the target area, first, three ester images were matched in terms of the histogram and then mosaiced. QGIS and ArcGIS software have also been used to process images and generate maps related to hydrocarbon pollution. The information about the data used has shown in table 1.

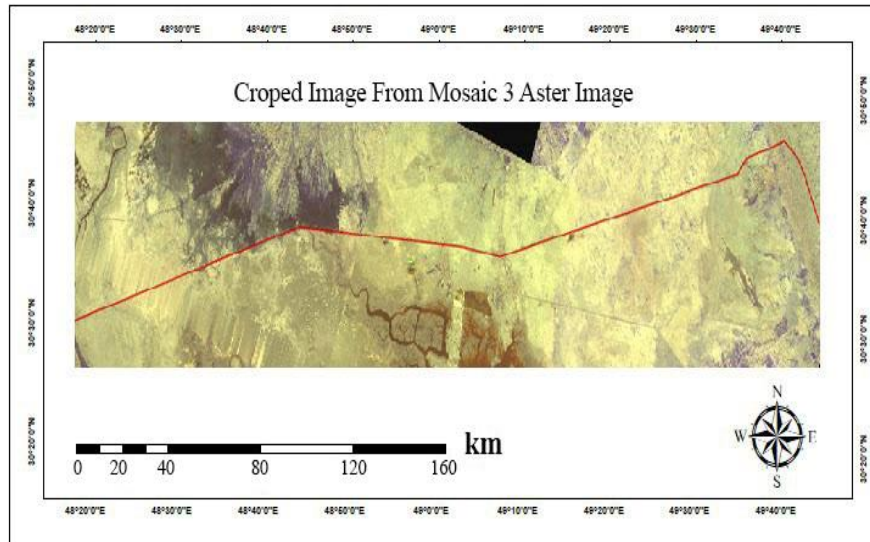


Figure 1. Improved and cropped image from mosaic 3 aster images

Table 1. Information about the data used in the research

Row	Spatial separation capability	Date (AD)	Number of bands
1	15	2004.10.08	14

2.1. Study Area

In this research, Aghajari-Abadan pipeline has been considered as the study area. As can be seen in Figure 2, the main purpose of the research is to monitor and examine the pipeline from Aghajari to Abadan discontinuously, which has been displayed in green on the image. This route starts from Aghajari starting

point with the coordination of 386819.92 (E) and 3399044.29 (N) and ends at Abadan refinery with the coordination of 239373.52 (E) and 3363812.34 (N). The focus area of this research is from Mahshar to Abadan. Figure 1 indicates the image of the study area on the mosaic image of ester. The reason for the significance of this part of the study area is the occurrence of a large hydrocarbon leakage in the vicinity of Shadegan wetland and contamination of lands and the environment with hydrocarbons.

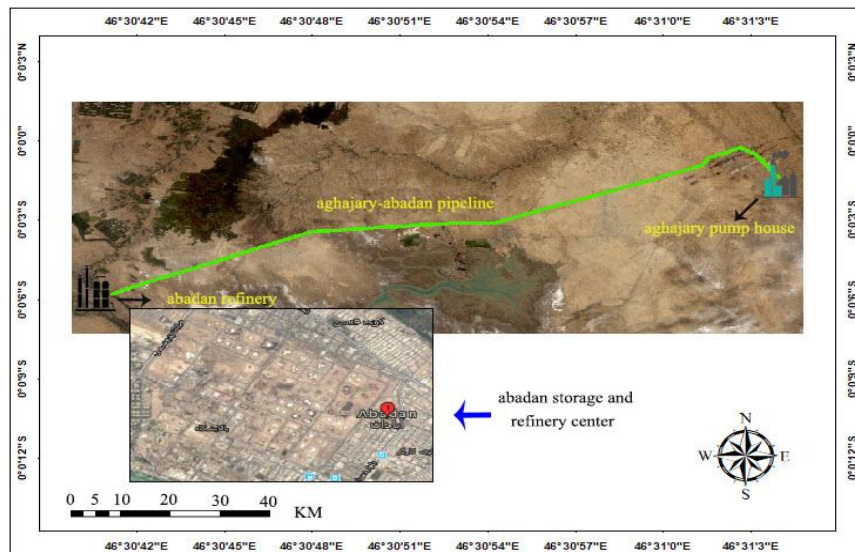


Figure 2. The area studied on the Landsat image 8

3. HYDROCARBON INDEX

The hydrocarbon index was introduced in 2001 by Cohen et al. to detect and interpret hydrocarbon materials in HyMap

hyperspectral images (Kühn et al., 2004). Based on this index, numerical values higher than zero in the output image show hydrocarbons, and as the concentration of hydrocarbons increases, these numbers become larger. The hydrocarbon

index at a wavelength of 1.73 mm is very close to the maximum water absorption. In the studies conducted previously, the spectral behavior curves of hydrocarbon materials were identified at wavelengths of 1.73 and 2.31 mm (Smejkalová and Bujok, 2012). The HI values of the hydrocarbon index can be easily calculated from the radiance and reflectance data and recorded by the signal-to-noise ratio. Complications have low energy at 1.73 mm. The HI index can be easily used like mathematical algorithms. In fact, the hydrocarbon index

converts multi-band data into single bands and determines the presence of hydrocarbon materials in that range. Detection and differentiation of hydrocarbons can be made by images with an RGB color combination, which can be made using hydrocarbon adsorption properties at a wavelength of 1.73 mm. In the soil spectral diagram, calcite adsorption occurs in the range of 2100 nm. This issue can affect the hydrocarbon uptake in the area of 2310 due to its proximity to the calcite uptake range (Mojtaba, et al., 2016).

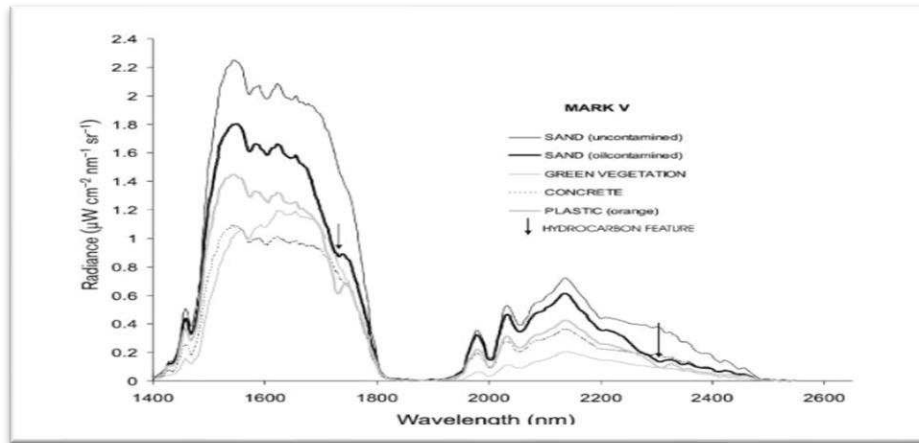


Figure 3. Diagram of the curve of the spectral behavior of hydrocarbon materials in the range of 1.73 and 2.3 mm

4. IMPLEMENTATION

In order to detect and identify the presence of hydrocarbons, it was decided that the hydrocarbon index developed by Kavzoglu et al. in an article entitled "detecting hydrocarbon leakage using remotely sensed images (Kavzoglu, 2006) to be applied on the aster image. The ester image goes back to 2005, the time after the occurrence of a large hydrocarbon leakage in the Shadegan wetland area, which could be effective for this purpose. According to field research and inquiries at that time, the

presence of many leakages in that area has been confirmed. The relationship of this index is as follows:

$$INDEX = \frac{B_{4,B8} - B_{7,B8}}{B_{4,B7} - B_{5,B6}} + 0.5$$

In Formula 1, parameter B represents the number of bands in a satellite image. Hydrocarbons are seen in the infrared range, and because the formula (1-4) is applied to the ester cropped image, the bands are in the SWIR range.

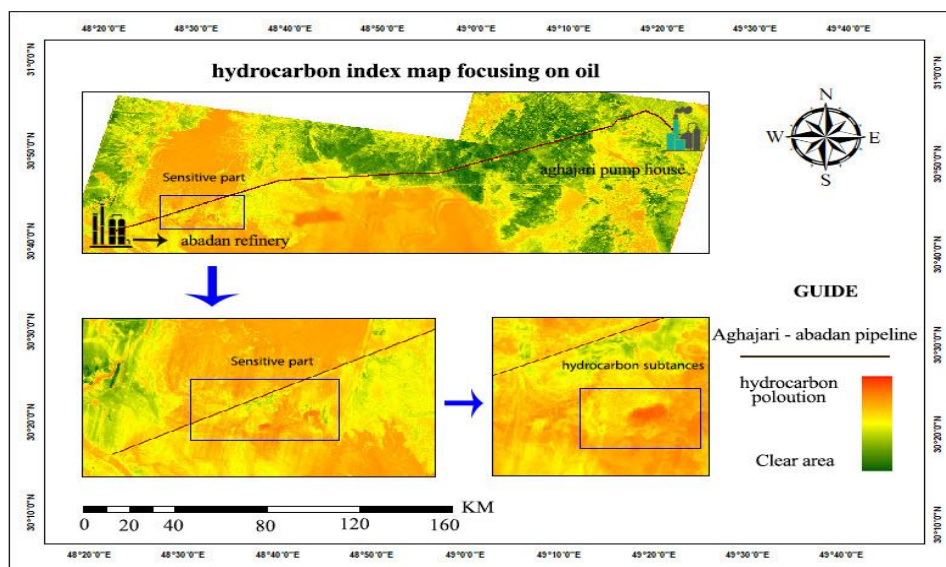


Figure 4. Hydrocarbon index map focusing on oil pipelines

5. EVALUATION AND VALIDATION

In the previous steps, the way of detecting and identifying hydrocarbons through processing ester image and applying hydrocarbon index on the ester image was described, and the areas contaminated with hydrocarbons were identified on the ester image. For validation and identification of whether the areas marked on the image really indicate the presence of hydrocarbons, spatial statistical methods should be used to validate the introduced methods. Many methods have been introduced for spatial analysis. In this study, the statistical methods of Moran's insulin algorithm and hot spots analysis were used, each of which has been described in detail below.

5.1. Cluster and non-cluster Analysis (Moran Insulin)

The statistical distribution of spatial phenomena can be obtained by using cluster and non-cluster map analysis. The map obtained from the cluster and non-cluster analyses can show the apparent similarity or non-correlation of most clusters in a random distribution. The output of this analysis can distinguish statistical clusters with a high value and degree of contamination from statistical clusters with low value and degree of contamination and non-clusters in which a large amount has been surrounded by small amounts from non-clusters in which a small amount is surrounded by a large amount. The results of this analysis can confirm the presence or absence of identified hydrocarbons. Figure 3 shows the results of clustering and correlation in areas where the presence of hydrocarbons has been confirmed. As shown in the figure, that is displayed in the part named as the sensitive area.

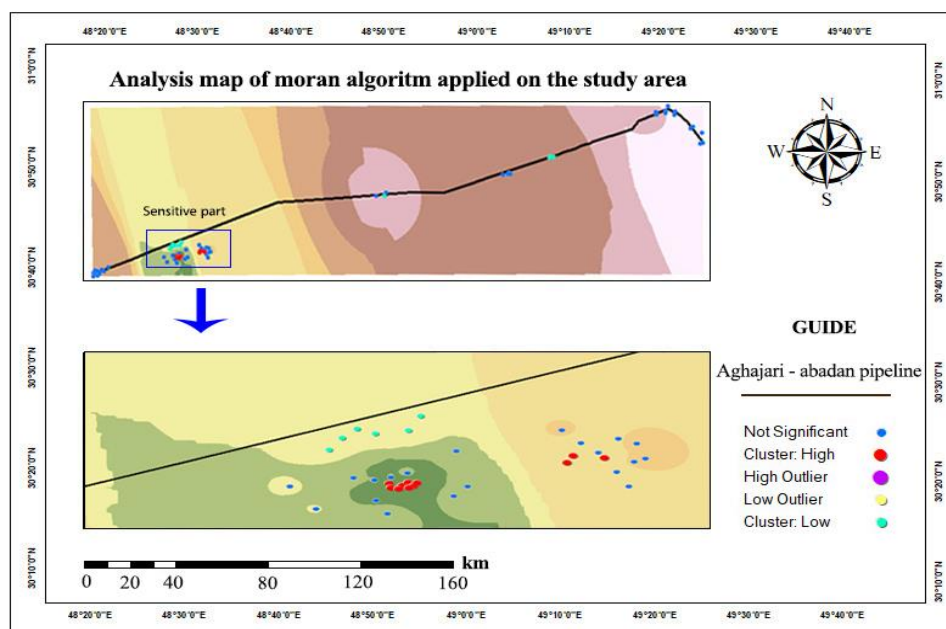


Figure 5. Analysis map of Moran algorithm applied to the study area

In order to validate, the maps obtained from hot spot analysis can be considered as an optimal choice for separating areas contaminated with hydrocarbons from clean areas. Dark blue areas (cold spots) are areas where low amounts of little pollution have occurred, and dark red areas (hot spots) are areas where high amounts of relatively high levels of pollution have occurred. This information can be used for spatial analysis and planning for passive defense in sensitive areas. Figure 4 is the map of the hot and cold spots analyses, which have been applied to the study area. As can be seen in the figure, the red dots located in the sensitive part and in the combination of information layers at the decision level were also introduced as a possible area of hydrocarbons have been identified with a

confidence level of 99% through this analysis. As can be seen in Figure 4, to analyze and use the hot spots algorithm, points as hot spots and points as cold spots must be considered first. In fact, hot spot analysis was applied to the results of Moran's insulin algorithm, and in the sections where high-value clusters were produced in terms of spectral and spatial correlation, points for hot spot analysis were considered. The results of this analysis display the accuracy of the presence of hydrocarbon materials, which was discussed in the methods introduced in this research study, that for the sensitive part in the study area, about 99% accuracy is known as an area with hydrocarbon pollution.

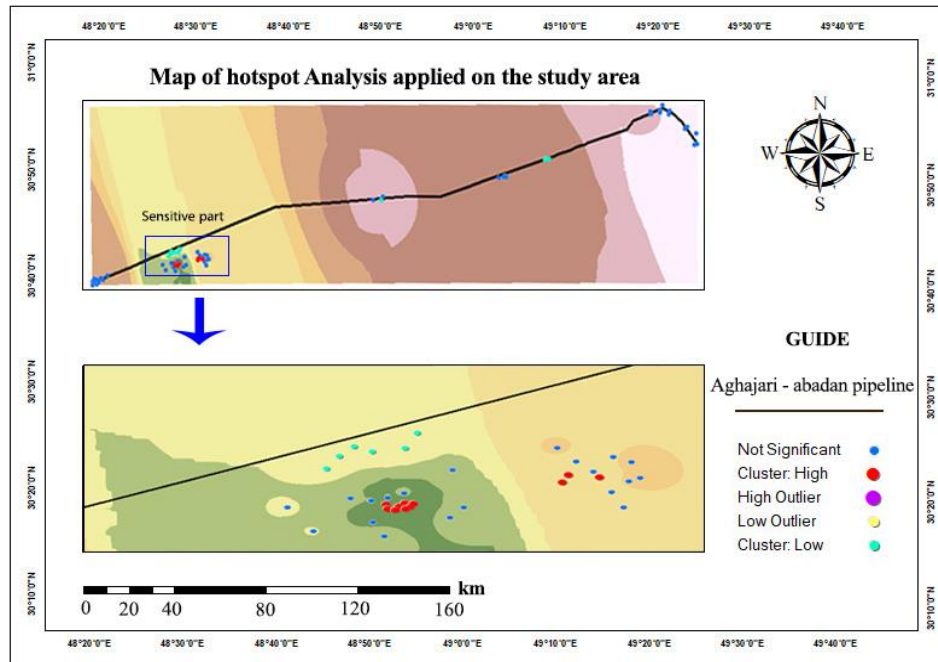


Figure 6. The map of hot spots analysis applied to the study area

6. RESULTS AND RECOMMENDATIONS

The results of this study indicated that remote sensing can be used as a useful and cost-effective tool to assess environmental hazards and identify hydrocarbon wastes in lands adjacent to oil pipelines. Various methods were investigated for the detection of hydrocarbons, and the application of hydrocarbon index on the ester image of the study area provided more acceptable results among the studied methods. Hydrocarbons can be detected in the SWIR range and can also be traced at 1.73. The upper edge of the hydrocarbon index displays areas contaminated with hydrocarbons and the lower edge of the hydrocarbon index indicates areas free of hydrocarbons. It should be noted that this method is used directly to identify hydrocarbons, but only the probability of leakages and pollution in an area can be calculated from this method. To attain accuracy and certainty about the presence of hydrocarbons in an area, it is necessary to conduct field visits, ground sampling, and study of environmental changes and factors that affect the soil type, vegetation, and surface temperature to identify the effective factors. It is also suggested to examine the band ratios of 1.2 and 4.9 on the ester image and the effect of hydrocarbons on vegetation.

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