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Oli and Gas Explorations via Satellite Remote Sensing Techniques for AL_Nasiriya

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Abstract

This study investigates data set as satellite images of type multispectral Landsat-7, which are observed for AL_Nasiriya city, it is located in southern of Iraq, and situated along the banks of the Euphrates River. These raw data are thermal bands of satellite images, they are taken as thermal images. These images are processed and examined using ENVI 5.3 program. Consequently, the emitted Hydrocarbon is extracted, and the black body algorithm is employed. As well as, the raster calculations are performed using ArcGIS, where gas and oil features are sorted. The results are estimate and determine the oil and gas fields in the city. This study uncovers, and estimates several unexplored oil and gas fields. Whereas, the real oil and gas exploration is high costly regarding to actual existed ones in proportional to human and equipment. For future, it is intended to perform domain oil and gas exploration in order to compare between the presented results of this study with the actual existed ones.

Keywords: AL Nasiriya, Iraq, ENVI, ArcGIS, oil exploration, black body, gas, remote sensing, emissivity, ETM+.

استكشافات النفط والغاز باستخدام تقنيات الاستشعار عن بعد عبر الأقمار الصناعية لمدينة الناصرية

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الخلاصة

تبحث هذه الدراسة في مجموعة البيانات كصور فضائية من النوع Landat-7 متعدد الأطياف ، والتي تم رصدها في مدينة الناصرية، والتي تقع في جنوب العراق ، حيث تقع على ضفاف نهر الفرات. هذه البيانات الأولية عبارة عن نطاقات حرارية لصور الأقمار الصناعية، تم التقاطها كصور حرارية. حيث تمت معالجة هذه الصور وتحليلها باستخدام برنامج ENVI 5.3 ، ثم تم احتساب الهيدروكربون المنبعث ، بالإضافة إلى ذلك تم استخدام خوارزمية Black Body. ثم تم إجراء العمليات الحسابية النقطية raster calculations باستخدام تطبيق ArcGIS ، حيث يتم فرز معاملات الغاز والنفط. اما النتائج فهي تقدير وتحديد حقول النفط والغاز في المدينة. لقد بينت هذه الدراسة ، قدرت العديد من حقول النفط والغاز غير المستكشفة لحد الان. وذلك لأن التنقيب الحقيقي عن النفط والغاز مرتفع التكلفة، وخصوصا فيما يتعلق بالتنقيب الفعلي الموجود وبما يخص تكاليف الإفراد والمعدات. اما بالنسبة للمستقبل، هناك توجه من أجل المقارنة بين النتائج المعروضة بهذه الدراسة والنتائج الفعلية الموجودة في مجال استكشافات النفط والغاز.

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1. Introduction

Remote sensing has been shown to be a powerful tool for monitoring a multitude of various earth phenomena. Whether it be monitoring of environmental qualities in various ecosystems or urban planning, remote sensing takes its place as a key mapping tool in several disciplines. Remote sensing used for downstream and upstream applications such as pipeline mapping [1], wellsite planning, and detection of environmental change, therefore oil and gas resource mapping is one of the main applications of remote sensing [2]. Remote sensing also widely used in oil and gas exploration, from high - resolution visual data sets like WorldView or RapidEye to radar data and multi - spectral / hyperspectral data sets [3]. The oil slicks detection is a substantial remote sensing intention for both environmental applications and oil exploration [4]. Regarding exploration, enduring or frequent oil slicks could indicate to the occurrence of undersea oil seeps [5]. Whereas environmental applications, initial sensing of anthropogenic oil slicks could produce potential protection of critical habitats in well timed, and support in discovering polluters [3]. Furthermore, the replicated endeavors are performed to improve remote sensing techniques for oil slick detection [6]. These techniques used the total affordable electromagnetic spectrum from Ultraviolet (UV) through microwave wavelengths [2, 7], but with mixed results. The most fruitful efforts were in the UV where oil fluoresces, but this region has poor atmospheric transmission [1]. Thus, the satellite observations became very difficult. In addition, oil slicks are discovered in the reflected and visible infrared (IR) part of the spectrum. On the other hand, the features of spectral reflectance of different crude oils are deviated [7]. For example, when produce slicks that differ in color from pale yellow through brown to black. Moreover, the complication appears in reflectance measurements according to the fact says that, the surface roughness alters the reflectance of water, because of the backscatter of sun glint from wave sides oriented at the specular angle, such as does the occurrence of sea foam. Consequently, the reflectance differentiates the water than oil at any afforded wavelength in the visible, and near-infrared (NIR) [2], which may vary with the sea state. Therefore, there is not sole processing algorithm capable for determining all oil slicks in the spectrum reflective region. In both the thermal infrared and microwave regions of the spectrum [4, 8], oil has a lower emissivity than water, resulting in a brightness temperature contrast that may be used for oil slick detection [9]. However, variations in real kinetic temperature of water can produce false targets, and oil slicks and surrounding water may not be at the same temperature. Finally, the smoothing effect of oil on water has been detected by radar in the microwave region of the spectrum. Furthermore, several other reasons than the presence of oil for relatively smooth patches of water, so the risk of wrong objectives is high once more. In spite of, oil slicks are repeatedly detected via different spectrum regions [2], but there is no single technique could be developed that obviously and reliably, which can detect all oil slicks. As well as, the current best practice is to employ valuable combined techniques, this including airborne radar [10], and a combined IR/UV line scanner for slick detection [1]. Oil and seawater emissivity, and how this spectral behavior used in comparatively unsophisticated multispectral thermal infrared of oil slicks detection [4, 8]. In this study, the hydrocarbon exploration using thermal remote sensing would is considered.

2. Approach and Data Set

The investigated data set is a satellite image for Al_Nasiriya city southern of Iraq. The data source of landsat-7 satellite image is the website of the United States Geological Survey (USGS). They are satellite images multispectral landsat-7 for March 2001; these images show hydrocarbon content [4]. Band1of these data, which is Landsat 7 ETM+ enhanced thematic mapper [5] plus that are examined using Environment for Visualizing Images (ENVI 5.3) [10]. These raw data handled by preprocessing phase as will be mentioned in section 3, and then calibrated. Hence, they are processed using the atmosphere process, which eliminates the noise of influential atmosphere. However, the process of Emissivity calculation estimates oil particles radiance corresponding to 0.972 value, note that the oil and gas (hydrocarbon) emissivity is 0.972 not content unites. Moreover, the high gain of Band2 for these data is investigated using black body algorithm [9], which is performed for image recognition. Consequently, emitted Hydrocarbon is extracted. As well as, raster calculation performed using ArcGIS, where gas and oil features are sorted. Then, the raster converted into vector of polygons, this is achieved in order to estimate and determine the oil fields. This investigation observed the satellite images of type multispectral [5] Landsat-7. The Thermal bands are taken as thermal images, and processed as mentioned in next sections. This is performed using ENVI 5.3 program.

3. Thermal remote sensing

The thermal remote sensing is based on the infrared portion of the spectrum, and measures the emitted thermal energy [8]. This, thermal remote sensing is kind of passive remote sensing, since it discover natural emitted radiation. Most thermal remote sensing is located in the 3-5 μm and 8-14 μm wavelengths [2]. As well as, the pre-processing is performed after applying the black body algorithm, which is applied to the concerned images. Thus, the output of this algorithm is fed to the input of some other algorithms, while an enhanced image should be the conclusive result [9]. Undoubtedly, image enhancement algorithm also have pre-processing steps, while an enhanced image could still be used as an input for other algorithms. Additionally, there is one term used in remote sensing images captured at different times; hence, it called relative radiometric calibration. In this preprocessing step, researches used both images to normalize one another image, and in ENVI, there is a method of radiometric calibration inside the radiometric correction [10]. This method takes only one image at a time and calibrates only that image of HDR file information. Thereafter, the atmospheric corrections are achieved, where the solar radiation is reflected by the Earth's surface to the satellite sensors are adjusted by their interaction with the atmosphere [3]. The aim of applying an atmospheric correction is to find out the rightful surface reflectance measurements, and to regain the physical parameters of the Earth's surface, including surface reflectance [9]. This is performed by emitting the atmospheric effects from the satellite images. On the other hand, the atmospheric correction is undoubtedly the most influential part of the pre-processing for satellite remotely sensed data [3]. Thus, the correction is particularly imperative in variant states, where multi-temporal images have to be compared and analyzed. Such as, in agricultural applications, when there are several vegetation indices applied for monitoring objectives, hence the multi-temporal images would be used [1]. Then, the integration of vegetation indices from remotely sensed images with other hydro meteorological data is extensively used for monitoring natural hazards for instance the droughts. As far as calculate emissivity are concerned, the emissivity of the material surface is the emitting energy efficiency as thermal radiation [8]. Whereas, the thermal radiation is electromagnetic radiation, and it could include both visible (light), and infrared radiation [21], which is invisible to human being eyes. The thermal radiation from very hot objects is simply visible to the human being eye [8]. However, quantitatively the emissivity is the ratio of the thermal radiation from a surface to the radiation from an ideal black surface at the same temperature as given by the Stefan–Boltzmann law as in equation 1, which is used to calculate the materials emission value in the satellite images [8]. This ratio ranges from 0 to 1. The surface of a perfect black body with emissivity = 1, it emits thermal radiation at ratio about 448 watts per square meter at room temperature 25 °C, 298.15 K, with respect that all real objects have emissivity less than 1.0, and emit radiation at correspondingly lower ratios.

The oil and gas exploration results are shown in Figure-1, and the difference is clear, especially when show the actual existed fields as in Figure-2.

$$E_{\lambda,b} = \frac{c_1}{\lambda^5 [e^{\left(c_2/\lambda T\right)} - 1]} \quad \text{... … … …} \quad (1)$$

Where :

$E_{\lambda,b} = \text{Emissivity}$

$c_1 = 3.742 \times 10^8 \ \frac{W.\mu m^4}{m^2}$

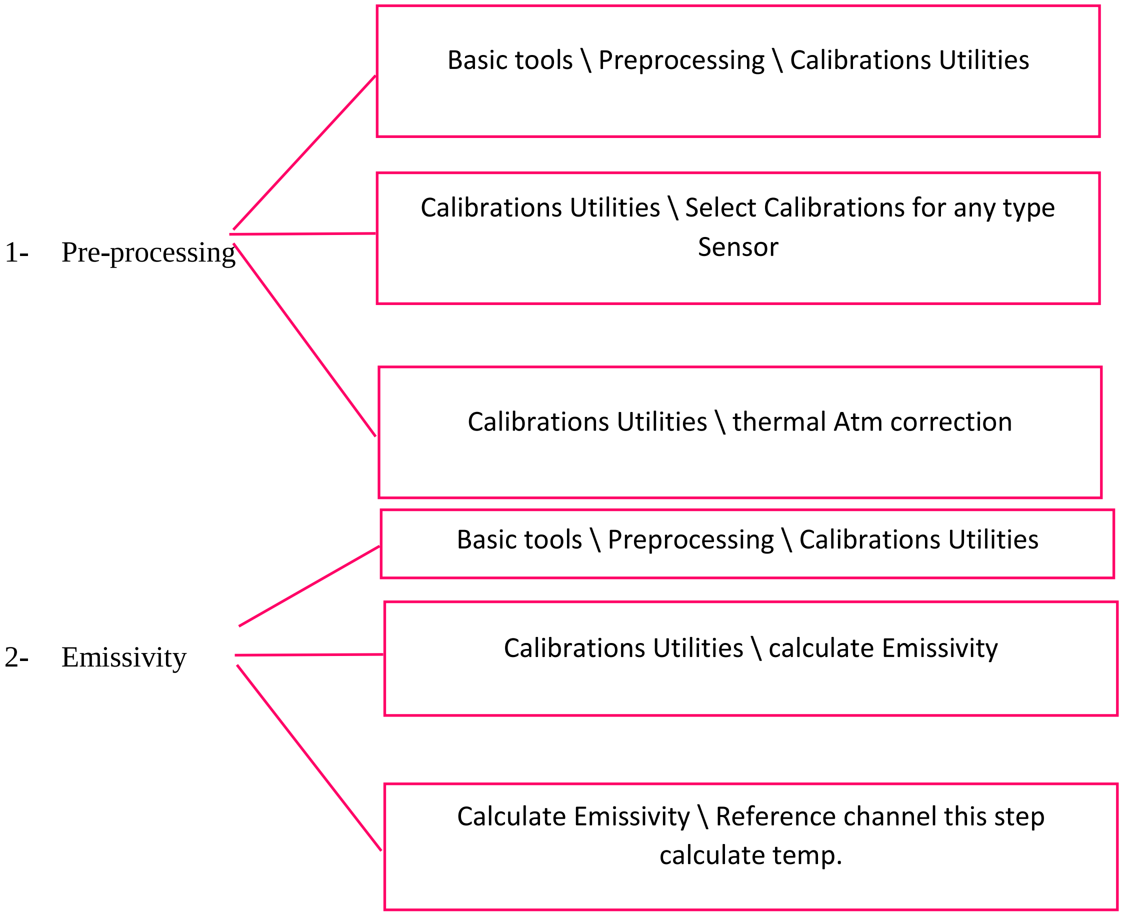
$c_1 = 1.439 \times 10^4$ μmk

$\lambda = \text{wavelength}$

$T = \text{temperature}$

μm: Micrometer

This approach employs ENVI 5.3 program as in the following steps:



3- Classifies the results depends on the histogram of the resulted image, and create regions for each range in image histogram.
4- Lining up layout of these results in the heat map

It's concluded that Al_Nasiriya has uncovered oil and gas fields, which are not explored untill now. As represented in Figure-1, where the estimated fields are distributed on AL Nasiriya city map. These fields are more than existed ones, and their exploration process using remote sensing and GIS techniques is very cheap, easy, and highly rapid comparing to the expensive and heavy work in classical procedures for oil and gas exploration.

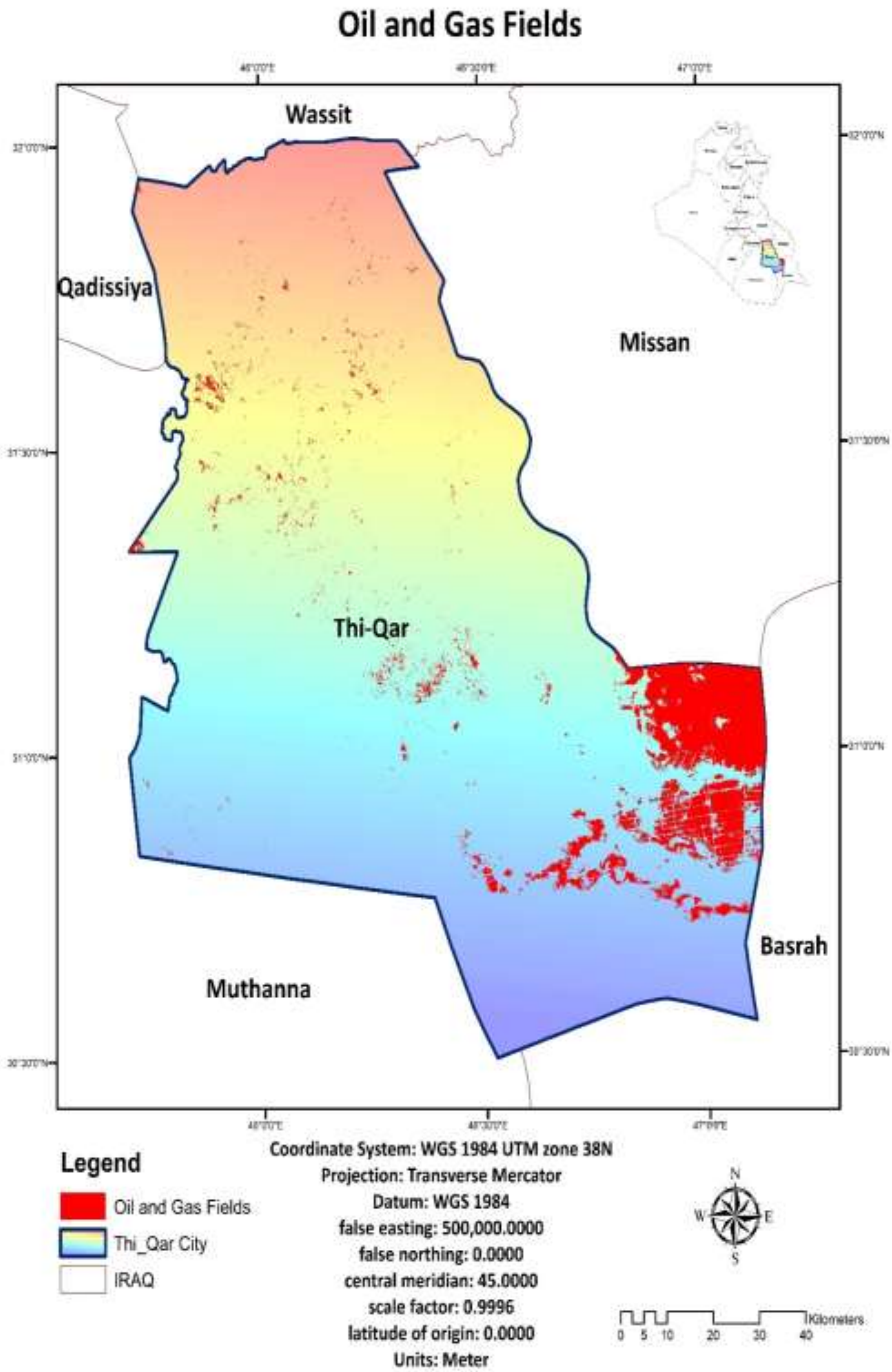


Figure1-AL Nasiriya (Thi_Qar) map with expected oil and gas fields in red color according to black body estimation

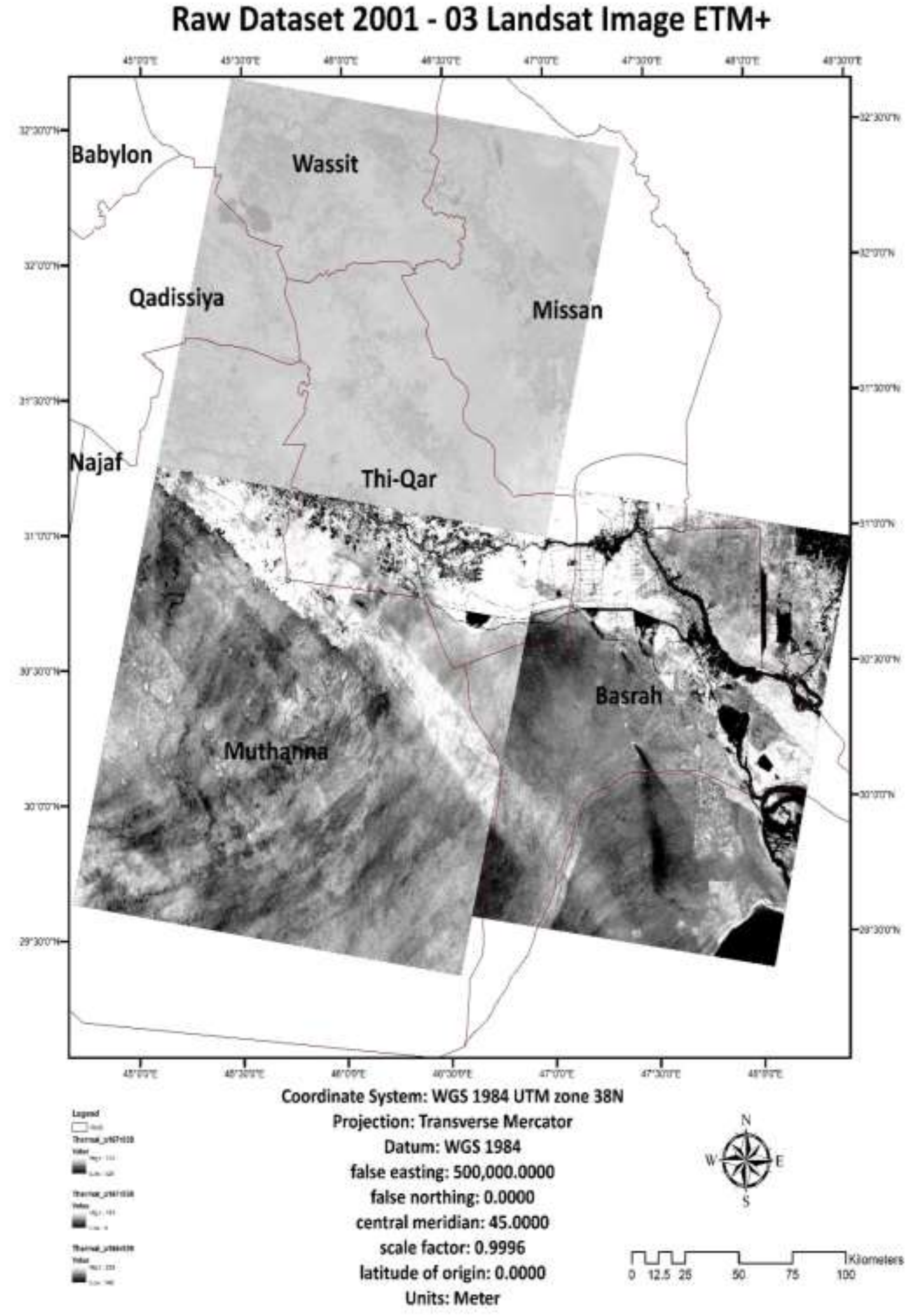


Figure 2-AL Nasiriya (Thi_Qar) actual map for already existed oil and gas fields (raw data)

4. Conclusions

This study aims to detect the oil gas fields in AL Nasiriya city with minimum cost, and employ the recent geoinformatics technology for this purpose. Whereas, this investigation observed the remotely sensing technology for thermal images. The emission of hydrocarbons have been explored in this research, thus it saves a lot of money for investment companies, where the informatics technology offers economic approaches. As a future perspective, it is highly recommended to employ the remote sensing techniques to consume the wasted money for oil and gas exploration.

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