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Capability Evaluation of Satellite Images (IRS) in Total Cadmium Density Identification of Sarkhun Plain's Topsoil (Bandar-e-Abbas)

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Abstract. In recent years, heavy elements concentration in soil has been become a crucial problem in many parts of the world. There is no information about heavy elements contribution in soil of Hormozgan province. Therefore, this study is aimed to survey local changes of cadmium in vicinity of Bandar-e Abbas city. A number of 120 compound topsoil samples from 0 to 10 cm depth of soil were gathered in regular sampling from 100 km^2 of farmlands and virgin lands. The mean measured density of the total cadmium was 0.37 mg/kg soil. The obtained results of statistical analysis and pollution distribution map showed that the average of cadmium density in the studied region is above international standard which is the result of local farmlands. Total cadmium density has a significant correlation with bands 2, 3 and 4 of IRS-P6 LISS-III Satellite. The results showed that the main reason for high cadmium density is unplanned fertilization, especially phosphate one.

Keywords: IRS Satellite Images, Spatial Distribution, Sarkhun Plain, Remote Sensing.

1. Introduction

Soil is not only a foundation for human living place, but also considered as a major compound of the environment. Penetrating in soil, pollutants may cause water and air pollution and also food chain contamination. These substances change levels of soil fertility and reduce its efficiency. With growing cities, the concern about heavy elements in the soil has been raised. One of the most important and famous substances which causes environmental and health damages is heavy elements. Natural, industrial, and agricultural activities send these elements into the soil. Also, using waste water, organic and animal fertilizers can help to increase the level of the pollution (11). Agricultural activities like using fertilizers, compost, swage wastes, urban and industrial activities are the main sources of unnatural soil pollution with heavy elements (9). Among the heavy elements, cadmium has been added to the food chain by weathering process of phosphate rocks and phosphate fertilizers (10).

It has been for two decades that the satellite images have turn into very useful devices for soil evaluation and quantitative characteristic survey. Examples are surveying the levels of carbonate, organic matter, total nitrogen, or total clay (2). Laboratory methods comparison shows that using VNIRS images (visible-near-infrared) could be a fast and cheap way to do that. The spectroscopic images were applied to assess levels of heavy elements contamination, in China Nanjing soil, by Wu et al (15). They reported that remote sensing has a high capability to survey and zoning of heavy elements of soil. There is no available information about spatial distribution of heavy elements in Hormozgan province. Determination of topsoil pollution rate with heavy elements is crucial due to the importance of the province in industrial and agricultural aspects like the

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gas refinery which is placed at 15km east of Sarkhun Plain or Bandar-e Abbas – Sirjan road located in east of the plain.

2. Materials and Methods

Sarkhun plain, with 100 km^2 as surface, is located in north of Bandar-e Abbas and placed between 27 ° 23’ to 27° 27’ Northern Latitudes and 56° 19’ to 56° 28’ Eastern Longitude with the mean elevation of 10m from sea level and 100mm as mean annual rain, the main land uses of the area are, industry, agriculture and pasture (Fig.1).

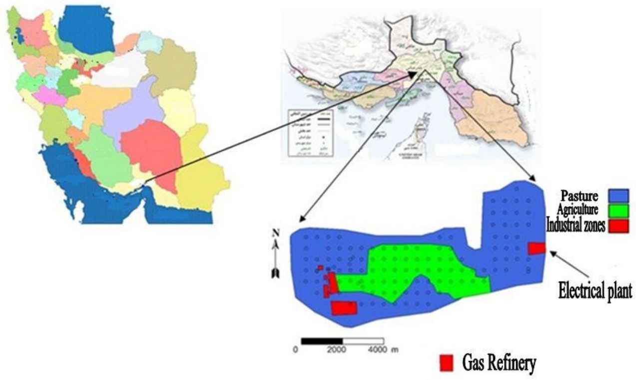

Fig. 1: Sampling point positions in different land uses

Systematic sampling has been done in rural region with approximately 900 meter distance between each two sampling points. The geographical position of the sampling points has been specified on a 1:25000 map and re-indicated with Geographical positioning system (GPS). In order to gather 120 compound samples, one sampling point had been considered as a center of a triangle and 3 other samples, with 30 m as a distance from central point, were taken. All these 4 samples were mixed due to gain one compound sample. This method has been continued to gather all needed samples. The compound samples were air dried, sifted with 2mm sieve and digested by presented method of Sposito et al. (4). Cadmium concentration was identified by Atomic Absorption Spectrophotometer. All satellite image analyses, such as Digital elevation model (Fig.2), were done with ILWIS 3.3 software (14).

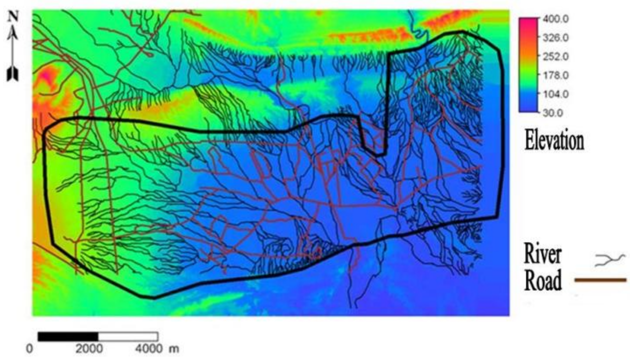

Fig. 2: Digital Elevation Model and Hydrology network

Statistical description was accomplished by Statistica 8.0 software (12). Band sensor properties which were used in this survey are listed in table 1. The map of pollution zoning was obtained with Surfer 7 software (5).

Conversion of reflected satellite images into Radiance was done with modified images, which were presented by Marcham and Bocker (1987), and equation No.1.

Table 1: Band properties of LISS-III Sensor

Spatial Resolution (m)	Digital Number		Spectral Range	Band
	Maximum	Minimum		
23.96	255	53	Green	2
23.96	255	33	Red	3
23.96	231	17	Near Infrared	4

$$L_\lambda = \left(\frac{L_{\max\lambda} - L_{\min\lambda}}{Q_{cal\max} - Q_{cal\min}}\right).(Q_{cal\max} - Q_{cal\min}) + L_{\min\lambda}$$

Equation 1

Lmaxλ = Sensor maximum achieved radiation (watt. m-2.sr-1. µm-1)

Lminλ = Sensor minimum achieved radiation (watt. m-2.sr-1. µm-1)

Lλ = Sensor recorded radiation (watt. m-2.sr-1. µm-1)

Qcal max = Maximum digit of Pixel

Qcal min = Minimum digit of Pixel

By using No.2 equation, the recorded radiation was changed into reflection.

$$\rho_p = \frac{\pi . L_\lambda . d^2}{E_{sun\lambda} . \cos\theta}$$

Equation 2

3. Discussion

Cadmium concentration descriptive statistic is presented in table 2. The average of this element is 0.37 mg/kg which is higher than international standards, and it indicates a rising trend.

Two standard sources for total Cadmium concentration are shown in table 3.

Table 2: Cadmium Statistical abbreviation in the studied area

Variable	Total	Maximum	Minimum	Skew	The Median	Average
Cadmium	120	0.91	0.04	0.47	0.30	0.37

Table 3: Average Cadmium density (mg/kg)

Element	Global amount average	Natural amount
Cadmium	0.35	0.34

3.1 The Relations of Pearson Coefficient Correlation between Cadmium Total Density and Derived Reflection in Satellite Images

Coefficient correlations between heavy elements density and the reflection ratio gained from satellite images (IRS-P6-LISS III) are shown in table No.4.

Table 4: Coefficient correlation between Total Cadmium density and satellite reflection

Element	Green	Red	Near infrared
Cadmium	-0.39	-0.34	-0.27

Negative correlation between the reflection of bands 2, 3 and 4 of IRS satellite can be seen which is significant at the 0.01 level and 0.05 level. The more Cadmium is in the soil, the less reflection will be achieved, and thus, the negative correlation is its effect. By scrutinizing this correlation change trend, it can be revealed that band 2 has the strongest relationship with Cadmium. By increasing in band wavelength, the correlation will decrease. The existence of correlation between Cadmium and the band reflections can be involved with Iron absorption and soil Iron oxide. Kemper and Sommer reported that the rate of correlation between soil heavy elements and satellite band reflection depends on soil Iron and Iron oxide (13). No significant correlation has been seen between Lead (Pb), Zinc (Zn), Nickel (Ni) density and band images of satellite which can be the result of weaker bond between these elements and soil organic matter in contrast with Cadmium.

Studied in China farmlands near Changjiang River, Junfeng et al. analyzed the correlation between heavy elements and Visible-Near Infrared and among 7studied elements, Cadmium, Lead and Mercury showed significant relation with VNI (Visible-Near Infrared). Therefore, their strong bonds with organic matter were considered as the cause behind (7).

3.2 Spatial Distribution Map of Cadmium

Cadmium spatial distribution, the result of Blocky kriging, has been shown in figure No.4. With consideration of agricultural land use, the central part of the plain has the most concentration of Cadmium which can be related to human activities like fertilizing. Phosphate fertilizer is considered as one of the most important sources of Cadmium in soil.

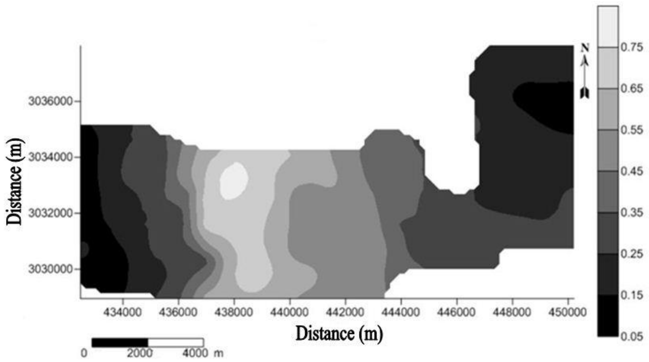

Fig. 4: Total Cadmium density spatial distribution in region's soil (mg/kg)

4. Conclusion

In this survey, the IRS satellite images capability to reveal the effects of urbanization on heavy element was deliberated. The average of total Cadmium density has been identified above standards and the interpolation maps, which were obtained by Surfer software, has revealed the pollution concentration in the central part of the plain and phosphate fertilizer can be perceived as the major reason, moreover, the correlation coefficient has shown reverse relation between Cadmium concentration and satellite bands (2, 3, 4). Therefore, IRS satellite images have high ability to uncover the presence of elements in soil. In a study (held by Modaish et al.1), it was determined that increasing in phosphate fertilizer can intensify the Cadmium deposit in plants. The survey was done in 3 different soil depths and they reached the conclusion that superficial depth has the most concentration.

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