ASSESSMENT OF REMOTE SENSING CAPABILITY BY GROUND SPECTROMETRY DATA IN VIEW OF MONITORING OF OIL-CONTAMINATION AREAS AND MAN-CAUSED WASTE STORAGE PLACES

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ABSTRACT:

In this work the optical-spectrometric data on optical reflectance spectra taken from spill ail and pure/mazut-contaminated soils are presented.

1.INTRODUCTION

Sudden increase in oil production volumes has given rise to ecological problems throughout the Kazakhstan oil filed areas. In particular, some problems are caused by spill ails, soil mazut contamination and man-caused waste pollution of lands. As a result, a necessity in land monitoring by remote sensing technique occurs.

Reliability of the data obtained as a result of remote sensing is assessed usually by an extent of coincidence between the solar emission reflectance spectra taken from natural objects under study (samples of soil, vegetation, water systems, etc.) by means of the space-base spectrometric systems and the corresponding spectra taken by field-spectrometry instruments in special subsatellite test sites (see, e.g., [1]–[3]). That's why remote sensing techniques are used successfully when solving ecologic problems throughout the regions provided by reflectance optical spectrum libraries for both the conventionally pure and man-caused contaminated natural objects.

In this work we make an attempt to assess, basing on ground spectrometry data, opportunity for control of spill ail, the soil mazut-contamination level and search for the unapproved man-caused waste storage/disposal places in the oil fields by remote sensing techniques

2. INVESTIGATION TECHNIQUE AND OBJECTS

In view of spectrometric studies, we have chosen three ready test areas.

The first area represents fresh spill ails around the bad-immured oil well.

The second area is the territory of many-year storage of dirty oils and man-caused waste. This area is characterized also by enhanced level of radioactive emission.

The third area represents old spill ails around desolate oil well, which was closed more than ten years ago. In this area the spots are available of heavily mazut-contaminated soils covered with layers of stony oil slag as well as a region of weak mazut-contaminated soils along the border between spill ail and conventionally pure soils.

Sample spectrometric studies were carried out by means of the spectrometers FTIR 8300 (Japan), Specord M-80 (Germany) and СФ-256 UVI (Russia).

3. EXPERIMENTAL RESULTS AND DISCUSSION

In the test areas we took, in total, several dozens of reflectance spectra from the samples of liquor and solid oil as well as soils contaminated by mazut to various levels.

In figure 1 several reflectance spectra taken from spill ail samples, mazut-contaminated soils and rather "pure" soils (coastal alt-marshes) are given as an illustration.
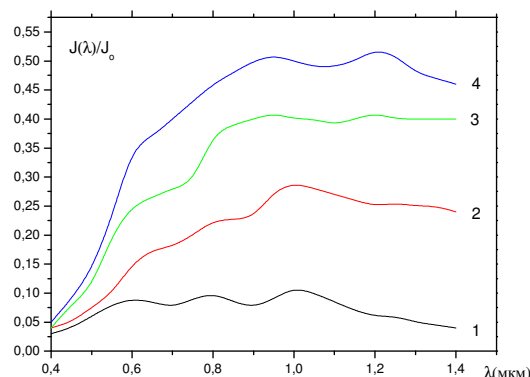

Figure 1. Optical reflectance spectra taken from test site samples
1. spill ail around waste wells;
2. «strongly» mazut-contaminated soil;
3. «weakly» mazut-contaminated soil;
4. relatively pure soil (coastal salt-march)

. It should be marked that the presented spectra are similar to those obtained at field conditions by portable radiometer. Figure 1 shows that optical reflectance spectra taken from coastal salt-marsh and spill ails differ strongly in the intensity; and this circumstance can be used to identify spill ails and mazut-contaminated areas.

The obtained optical reflectance spectra were used to determine coefficients S and Q, presented in Table 1. The coefficient S is

similar to the NDVI index and, in course of space picture analyzing, will characterize colority of objects under study.
The coefficients S and Q are determined as follows:

$$S = \frac{\mathrm{Imax - Imin}}{\mathrm{Im}ax + \mathrm{Im}in} \tag{1}$$

$$Q = \mathrm{Im}ax / \mathrm{Im}in \tag{2}$$

where I_{max}, I_{min} are the maximum and minimum values of the reflected emission intensity within visible range of solar emission.
Nevertheless, in our opinion, characterization of an object color by reflectance factors, determined following generally accepted technique, is more correct. . If the intensity of optical emission incident onto a specimen is denoted as I_0, and the intensity of reflected signal as I_λ, then the reflectance factor for a specified wavelength can be determined by the relation [4]:

$$K_{ref} = \frac{I_\lambda(\lambda)}{I_0} \tag{3}$$

In our case the value of I_0 equals $I_0=1$, whereas the current value I_λ is determined from the optical reflectance spectra normalized to I_0. If we wish to estimate a certain value of the reflectance factor within a specified wavelength range (e.g., in visible wavelength range $\lambda=0.4$ to 7.6μ), then we are to take as I_λ the area under the spectral curve ranging from $\lambda_1=0.4\mu$ to $\lambda_2=0.76\mu$, i.e.,

$$K_{ref} = \int_{\lambda_1}^{\lambda_2} \frac{I(\lambda)}{I_0} d\lambda \tag{4}$$

where $I(\lambda)$ is the experimental (real) function of the optical reflectance spectrum shape function, normalized to I_0. In this case a value of I_0 is the area under rectangle with the base $\Delta\lambda = \lambda_2 - \lambda_1$ and the height $\int I(\lambda_1)d\lambda = 1$.
Values of K_{ref} we obtained are also given in Table 1. Table demonstrates that K_{ref} of spill ail is higher by a factor of almost 5 than that of coastal salt-marsh.

№	Object Name	S	Q	K refl.
1	Spill ail	0.57±0.02	2.6±0.2	1.09±0.005
2	Strongly mazut-contaminated soil	0.60±0.02	7.0±0.02	0.15±0.01
3	Weakly mazut-contaminated soil	0.70±0.02	10.5±0.3	0.34±0.02
4	Relatively pure soil (coastal salt-marsh)	0.84±0.03	13.0±0.4	0.42±0.02

Table 1. Values of the coefficients S, Q_u and K_{refl}, derived from the spectra depicted in fig. 1.

Then we obtained the optical reflectance spectra from samples taken in various points over the spill ail cross section These spectra were used to contour spill ail spots by dependence of the reflectance factor K_{ref} on a distance to oil well: $K_{ref}=f(r)$. The data obtained are given in Table 2.

Place of study	R , m	K$_{refl}$
Site 1	0	0.09
	10.0	0.09
	20.0	0.15
	30.0	0.15
	45.0	0.16
	60.0	0.17
	75.0	0.40
	100.0	0.42
Site 2	0	0.20
	10.0	0.21
	20.0	0.18
	35.0	0.25
	50.0	0.22
	60.0	0.41
	100.0	0.42
Site 3	0	0.10
	10.0	0.10
	25.0	0.11
	40.0	0.12
	60.0	0.34
	100.0	0.38

Table 2. Calculated dependence $K_{refl} = f(r)$

Table shows that the dependence $K_{ref}=f(r)$ is stepped, and for spill ail around the well in point 1 two steps are observed in the dependence curve $K_{ref}=f(r)$. The first step corresponds to boundary between liquor oil and strongly mazut-contaminated soil. Here the optical reflectance factor varies by 50 to 70% with the inaccuracy of determination comprising ±3 to 5%. The second step corresponds to the boundary between spill ails and conventionally pure soils. Here K_{ref} varies by leaps and bounds by a factor of 3 to 5. Naturally, such enormous change in K_{ref} is determined with ease by space-base spectrometric systems.
The data presented in Table 2 make it possible to estimate sizes of spill ail around oil wells. For instance, according to table 2, a distance between the well and the spill ail boundary in point 1 equals 70 m. A distance r ≥ 70 m corresponds to conventionally pure territory– coastal salt-marsh. Hence, spill ail around the well occupies about 1.5 hectare.
With the dependence $K_{ref}=f(r)$ one can separate the area adjacent to the well where the lowest value of the reflectance factor is observed, $K_{ref} \sim 0.9$. This section of oil spot of the area about 0.3 hectare corresponds to a site with fresh crude oil, i.e., in this well, seemingly, sealing is broken.

Table 2 shows that for spill ail around the well in point 3 and for the area of man-cased waste storing (site 2) a single step is available in the dependence $K_{refl}=f(r)$. Here, in the region of transition from strongly mazut-contaminated grounds to conventionally pure soils, K_{refl} varies by several. These variations are recorded in the solar emission reflectance spectra in course of remote-sensing technique monitoring.

4. CONCLSION

Thus, out data prove that even insignificant mazut contamination in soils leads to noticeable changes in characteristics of optical reflectance spectra. These changes are quite detectable by remote sensing techniques. Hence, quire reliable area monitoring against oil contamination can be carried out by remote sensing techniques in combination with field spectrometry.

5. REFERENCES

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