SOME ASPECTS OF THE MICROWAVE RADIOMETRY AND SPECTROELLIPSOMETRIC TECHNOLOGIES FOR MONITORING AQUATIC SYSTEMS

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ABSTRACT

In this paper, we propose as a result of the connection systems for the collection of multi-channel remote information (microwave and optical) models of functioning of the investigated area the water environment and artificial intelligence to synthesize GIMS-technology that delivers forward-looking assessment of the functioning of the corresponding portion of the hydrosphere. Expected results from this work will allow us to evaluate the temperature, salinity, the concentration of inorganic and organic substances, etc. ensuring the release of forward-looking estimates and abnormal areas.

Also compact measuring - information multi-channel spectroellipsometric system for monitoring the quality of aquatic environment, that is based on the combined use of spectroellipsometry and training, classification, and identification algorithms is described. Some experimental data and calculations are given. Assessment of the system precision is realized for water reservoirs located in South Vietnam.

GENERAL CHARACTERISTICS OF REMOTE RADIOPHYSICAL METHODS

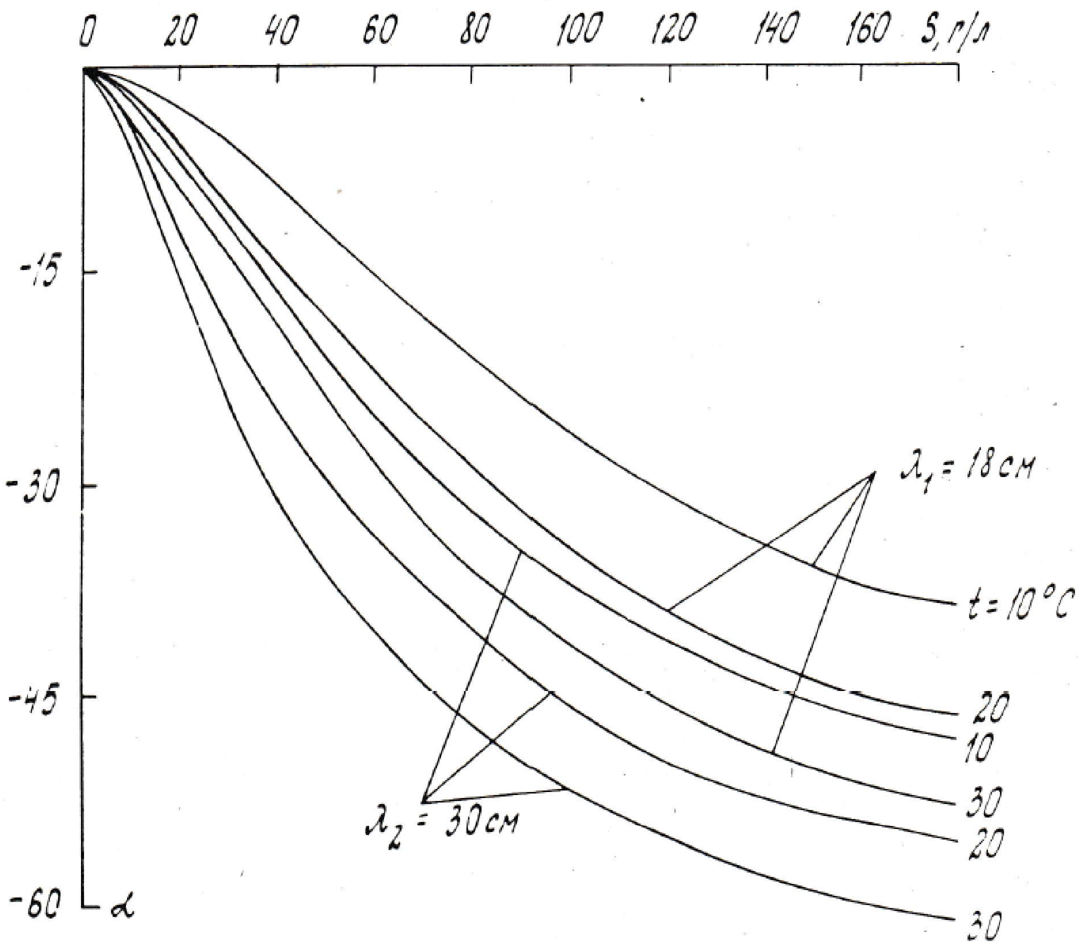
For the study of the natural environment, remote sensing methods are becoming increasingly important. These methods are based on the registration of own or reflected and scattered electromagnetic radiation. Depending on the nature of the recorded electromagnetic radiation, both active and passive sensing methods are used. Active methods are based on the analysis of signals reflected from the objects under study and use the relationship between the characteristics of backscattering and the physical parameters of objects. Passive methods are based on the reception of the intrinsic radiation of the investigated objects. The measured characteristics of the radiation field are closely related to the physical and geometric properties of natural objects. The main disadvantage of radiophysical remote sensing methods is the relatively low spatial resolution compared to the optical method.

Microwave radiometers are used as passive means of remote sensing. They can record the power of radio emission, its polarization and, in some cases, its spectral composition. In all cases, the radiation power is measured. Therefore, the main characteristic of the instruments is sensitivity. Radiometers "feel" changes in radiation energy of the order of - 1.4-10-25 J, i.e. allow us to register very small variations in radiation intensity caused by temperature changes or changes in emissivity. High sensitivity of microwave radiometers allows their successful application for solving various remote sensing problems.

OPTICAL METHODS IN MONITORING WATER SYSTEMS

As against microwave area of an electromagnetic spectrum the seen range is used more effectively in systems of monitoring of water objects. It is connected by that energy of a sunlight or artificial light streams intensively cooperates with the water environment. Different sites of a spectrum of a sunlight are absorbed by water differently. The minimum of absorption of light is observed on length of a wave 470 nm, in a blue part of a spectrum which energy decreases twice already on depth 47m.

MINERALIZATION DEPENDENCE OF THE RADIO BRIGHTNESS CONTRAST ON DECIMETER WAVES AT DIFFERENT VALUES OF TEMPERATURES



The radiation-mineralization dependence in a wide concentration range is essentially nonlinear. It can be seen from the figure that three characteristic sections can be distinguished on the dependence, corresponding to different concentration ranges, two of which are well approximated by a quadratic dependence, and one by a linear one.

ESTIMATES OF SPATIAL-TIME VARIABILITY OF THE CHARACTERISTICS OF THE AQUAGEOSYSTEM OF THE GULF KARA-BOGAZ-GOL ACCORDING TO RADIO-PHYSICAL MONITORING DATA

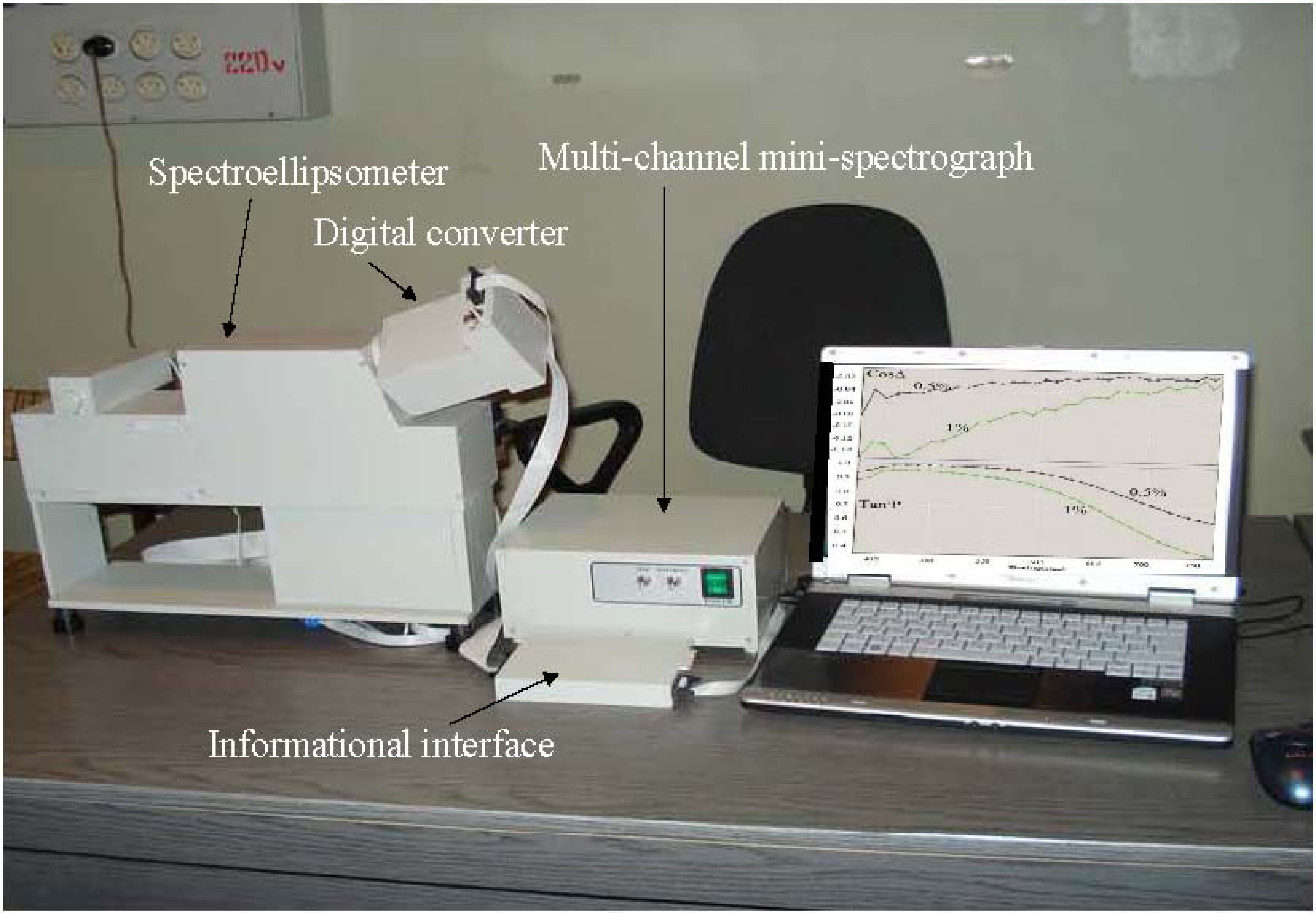
Map of the state of the aqua-geosystem of the Kara-Bogaz-Gol from 29.10.1984
1-brine; 2-wet salt; 3-top salt, bottom water; 4-dry salt.

Map of the distribution of radio brightness of temperature gulf Kara-Bogaz-Gol on a wave of 18 cm
1-40-70; 2-71-100; 3-101-130; 4-131-160; 5-161-190; 6-191-220; 7-221-250; 8-251 and more.

MODEL MAP SCHEME OF THE DEPTHS OF THE GULF KARA-BOGAZ-GOL ON MARCH 15, 1982 INITIAL DATA 1974 (DEPTH DISCRETATION STEP 20 cm).

An analysis of the stability of the results of calculating the time variation of various characteristics of the bay from the frequency of measurements showed that with an interval between surveys not exceeding 3 months, the error of recovery and forecast does not exceed 20%

MULTI-CHANNEL SPECTROELLIPSOMETRIC SYSTEM(MCSS)



TECHNICAL CHARACTERISTICS MCSS

Characteristic	Quantitative indicator
The spectral range	365 – 780, nm
Spectral resolution	10, nm
Number of spectral ranges	8
Time of recording the light flux	0.15, sek
Long-term stability	0,1-0.5%.
Measuring device dimensions:	
diameter	250
length	400
Measuring instrument weight	No more 3 kg
Power consumption	No more 30 watt
Sources of radiation: a complex of LEDs	Wavelength, nm
UVLED365-SMD	365
VL380-3528	380
VL400-3228	400
RLCU-415	415
SMC470	470
SMC525	525
SMC660	660
SMC780	780
Te rms of use:	
operating temperature	15°-35°C
relative humidity	95% at a temperature 20^{o}C.

STRUCTURE OF STANDARD SPECTRAL IMAGE OF WATER SOLUTION

Et. Num.	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	B
1	A_{11}	A_{21}	A_{31}	A_{41}	A_{51}	A_{61}	A_{71}	A_{81}	A_{91}	B_1
……										
n	A_{1n}	A_{2n}	A_{3n}	A_{4n}	A_{5n}	A_{6n}	A_{7n}	A_{8n}	A_{9n}	B_n

Notation: A_1 is the square occupied by spectral curve, A_2 is the maximal value of spectral curve, A_3 is the minimal value of spectral curve, A_4 is the distance between wavelengths with minimal and maximal values of spectral curve, respectively; A_5 is the maximal derivative of spectral curve; A_6 is the maximal value of second derivative of spectral curve; A_7 is the number of spectral curve maximums; A_8 is the average value of spectral curve; A_9 is the wavelength corresponded to average value of spectral curve; B is the chemical element concentration.

DATA PROCESSING ALGORITHMS

An identification of spectral image for unknown water solution is realized by means of comparison his vector – identifier with elements of the EDB. Depending from used optical device spectral image of water solution can be represented by one or two vector-identifiers calculated with the use of rule described in Table . Final identification is realized by means of search in the EDB of vector – identifiers which are minimal distance from considered vector-identifier $Q=\{X_1,\ldots, X_n\}$ of given water solution. Distance between vector-identifiers is calculated with the use of the following formula:

$$\delta = \min_n \rho(Q - Q_n) = \frac{1}{2n} \min_i \left[\sum_{j=1}^{n} \left| X_j - A_j^i \right| + \sqrt{\sum_{j=1}^{n} \left(X_j - A_j^i \right)^2} \right] \qquad (1)$$

Use of (1) gives better result in comparison with the application of other known criteria of closeness between spectral curves. That is why in this case there is minimal risk to miss the situation with dangerous pollution of water reservoir. In common case, usually the following methods are used:

- *Cluster analysis*. In this case two types of clusters are formed for CosΔ and TanΨ where Δ and Ψ are ellipsometric angles corresponding to complex amplitude reflection coefficients for two different polarizations. Decision is made by weighted values (1) or independently for each polarization.
- *Algorithm of discrepancy between spectra*. It is assessed average distance between the ordinates for both spectra and spectrum of studied case and decision is made taking into account minimal value of this distance.
- A*lgorithm of discrepancy between etalon vectors*. In this case, decision is made taking into consideration of minimal δ.
- *Inverse task solution.* This algorithm is based on linear dependence of optical spectrum on the concentration of chemical elements in water solution. In this case, sub-definite system of linear algebraic equations is solved.

APPLICATIONS

The MCSS can be used in different fields where the quality of water should be estimated or the presence of a particular set of chemical elements should be revealed. The MCSS solves these problems by real-time monitoring of the aquatic environment. In the stationary version it allows the tracking of the dynamics of water quality in a stream, and when placed on a ship, it allows the measurement of water parameters along the route.

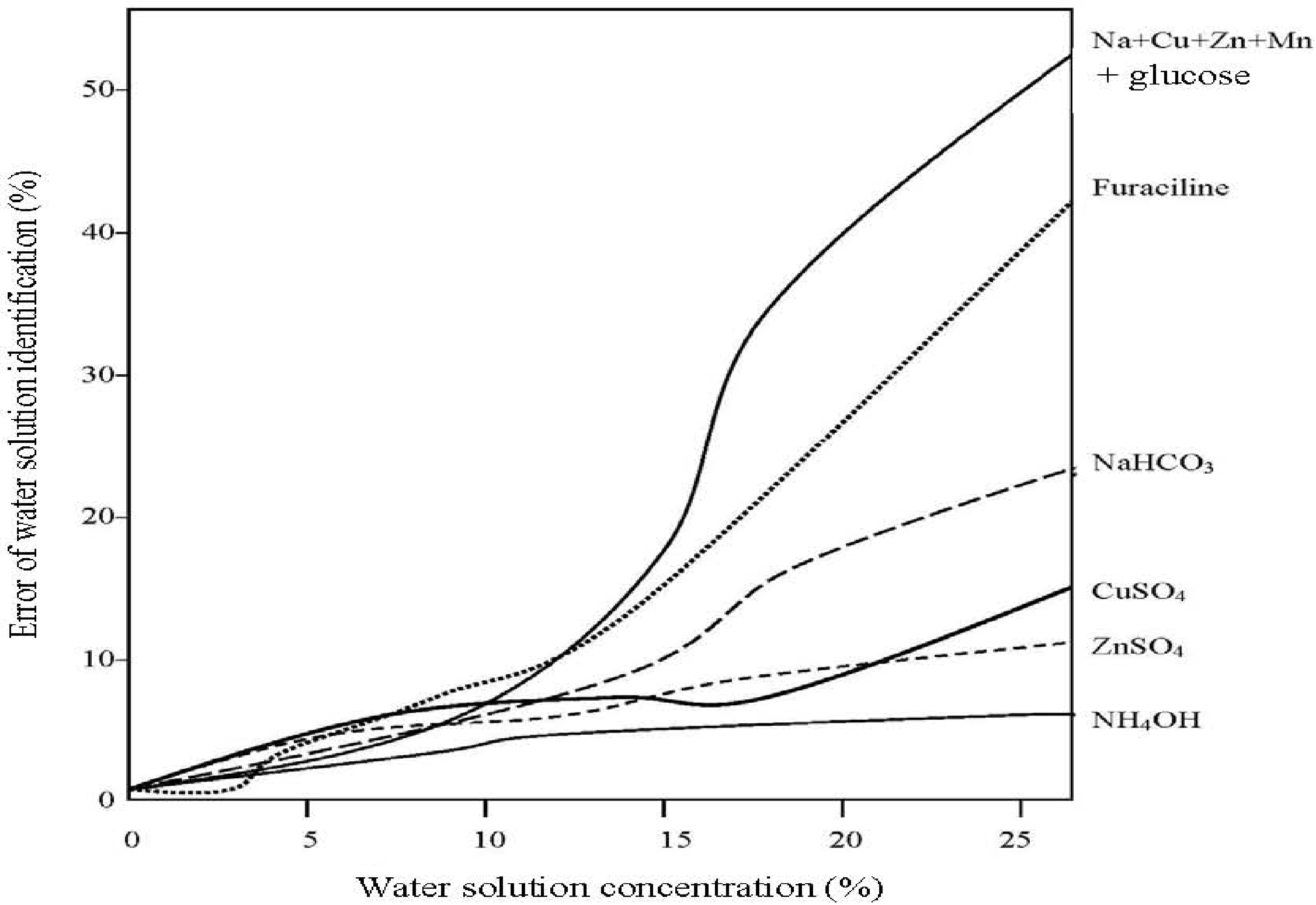
The functionality of the MCSS can be extended by increasing the volume of standards in the knowledge base.

COMPARATIVELY ASSESSMENT OF ALGORITHMS FOR RECOGNITION OF SPECTRAL IMAGES OF WATER SOLUTIONS

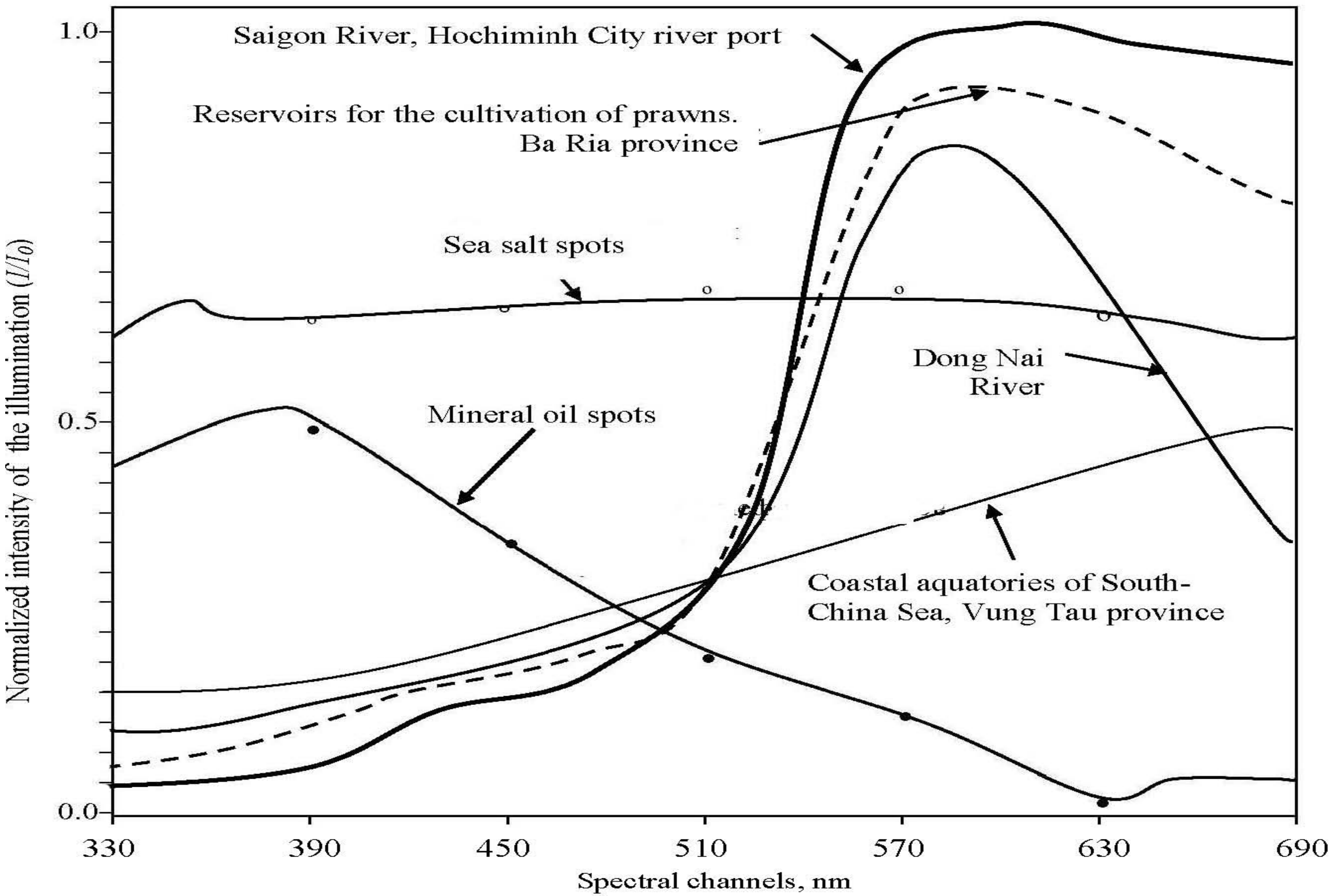
Identification algorithm and its error (%)

Object for study	Cluster analysis	Discrepancy between spectra	Discrepancy between vector-etalons with the use equation (1)	Inverse task solution
$CuSO_4$	15	12	8	7
NaCl	17	11	7	5
$NaHCO_3$	16	10	5	5
NH_4OH	21	13	9	6
$ZnSO_4$	22	12	8	6
Potassium iodite	13	10	6	4
Na+Cu+Zn+Mn+glucose	18	9	9	8
Furaciline	23	11	5	5
Bifidbacterium	14	10	4	4

DEPENDENCE OF SPECTRAL IMAGE IDENTIFICATION ON THE SOLUTION CONCENTRATION



SPECTRAL CHARACTERISTICS OF SOME RESERVOIRS LOCATED IN SOUTH VIETNAM



CONCLUSION

The main goal of the work is to create in the future compact information systems for monitoring the quality of the aquatic environment and to investigate their potential effectiveness. These systems are based on the application of microwave and optical methods and algorithms for learning, classification and identification. Realizing this goal will require the combined use of engineering and algorithmic tools that provide real-time measurement and processing of data. The technology of combined use of microwave radiometric and optical measurements and algorithms for detection and classification will make it possible to create an original system of hardware, algorithmic, modular and software tools for collecting and processing data on the aquatic environment with forecasting and decision-making functions.