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Research of Physical and Chemical Properties and Characteristics of Sapropel Kuskanatau and Drained Bottom of the Aral Sea

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ABSTRACT: This paper presents the results of a comparative study of the physicochemical properties of sapropel taken in the Kuskanatau area and sedimentary rocks of the drained bottom of the Aral Sea. The purpose of the study was to determine the chemical composition, structure, moisture capacity and potential for using these natural materials as raw materials for agricultural, construction and environmental technologies. Particle size distribution, acidity, organic matter content, ash content, and elemental and mineral composition of the samples were analyzed. It has been established that Kuskanatau sapropel is characterized by a high content of organic carbon, nitrogen and humus substances, which indicates its value as a natural organic-mineral fertilizer. To study the component composition and properties of sapropel, thermal analysis was carried out and powders of sampled samples of Kuskanatau sapropel and dried bottom of the Aral Sea of Karakalpakstan were analyzed using SEM. At the same time, elemental compositions of these samples were determined using an energy dispersion analyzer. The results obtained can be used to develop technologies for reclaiming degraded soils and creating environmentally friendly meliorants. The work is of practical importance for the rational use of natural resources and the restoration of ecosystems in the Aral Sea region.

KEYWORDS: Sapropel, Kuskanatau, drained bottom of the Aral Sea, physical and chemical properties, chemical composition, organic matter, mineral components, environmental assessment, natural raw materials, soil reclamation, reclamation, organic mineral fertilizer, thermal analysis, trace elements, agriculture.

I. INTRODUCTION

Currently, in Karakalpakstan there is a problem of soil improvement in conditions of a shortage of water resources. The unique physicochemical properties of sapropel explain a wide range of applications. They can be used both as fertilizer and as a mineral additive that helps restore the lost soil structure. Due to the ongoing drying of the Aral Sea, the quality of soils is deteriorating, as the salt layer is growing (chloride, sulfate, carbonate and other salts) [1]. The amount of soils salinized to varying degrees in the Southern Aral Sea is almost 95%, and in the Muinak territory closest to the zone of the Aral ecological crisis - 99% [2].
Taking into account the current unfavorable condition of agricultural land, it is necessary to develop acceptable complexes of measures to maintain the fertility of irrigated land, which can improve such soils with the greatest effect and at the same time be accessible to agricultural producers. It should be noted that in most large agricultural industries, the application of a microelement containing fertilizers (boron, copper, molybdenum, manganese, zinc, cobalt, iodine, etc.) to the fields has noticeably decreased, although the plant needs them only in very small

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quantities, but without them the plants cannot develop normally [3]. Hence the need to use sapropel directly as an agronomic fertilizer, as well as the use of various preparations obtained on their basis, which contains various trace elements and organic matter, is of great socio-economic importance, especially for the Karakalpakstan region [4].

II. RELATED WORK

Sapropel research occupies an important place in geochemistry and sedimentation ecology. Works [5] reveal the mechanisms of sapropel formation in the Mediterranean Sea using model experiments, demonstrating the effect of oxygen regime and climatic fluctuations on the accumulation of organic matter. The authors [6-7] conducted a geochemical and mineralogical analysis of sapropel S1, establishing differences between the eastern and western Mediterranean and confirming the relationship between bioproductivity and sedimentation. The study [8] showed the possibility of extracting biologically active substances from freshwater sapropel, which emphasizes its applied significance. Works [9-10] studied hydrobiological and biogeochemical features of sapropel formation in lakes of Western and Eastern Siberia, noting the influence of hydrological conditions. The study [11] revealed the processes of diagenetic transformation of sapropels of the Baikal region. In European studies [8,12], special attention is paid to environmental aspects and the influence of heavy metals [13]. Sapropels of northern lakes have been studied in Kazakhstan as a promising raw material for organic farming [14]. Works [15], as well as reports [16] on the drained bottom of the Aral Sea demonstrate geochemical and environmental changes in the Aral Sea region, which creates the basis for comparative analysis with sapropels of other regions.

III. RESEARCH OBJECTS AND METHODS

The object of research in this study is the sapropel of the Kuskanatau field, located 130 km from Nukus in the Bozatau region, and the drained bottom of the Aral Sea of Karakalpakstan, which is located 400 km from Nukus.

IV. RESEARCH MATERIAL AND METHODOLOGY

Thermograviometric analysis of crushed samples of Kuskanatau sapropel and dried bottom of the Aral Sea were carried out using a thermoanalytical DTG-60 system manufactured by Shimadzu, equipped with a type K thermocouple (Low RG Silver) and porcelain crucibles. All experiments were conducted under an inert nitrogen atmosphere with 80 ml/min of argon. The measurement temperature range was 25 to 900 °C at a heating rate of 10

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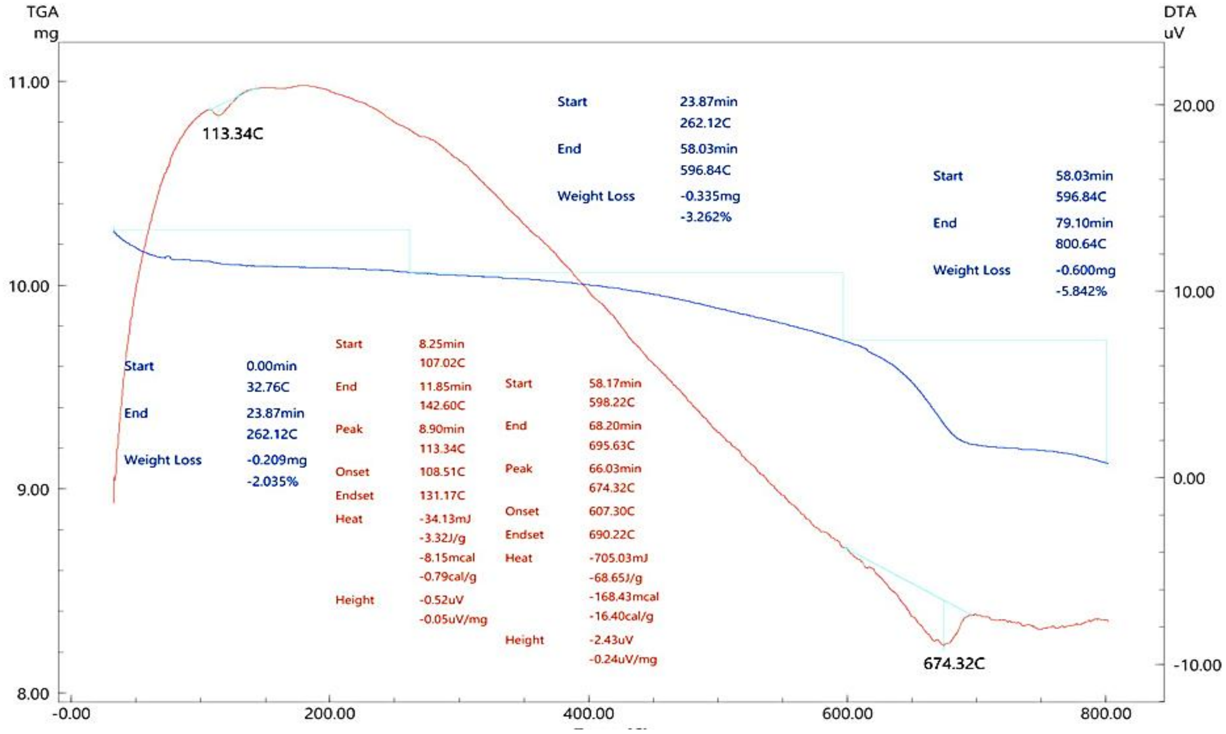

Figure 1. TG-DSK sapropel Kuskanatau

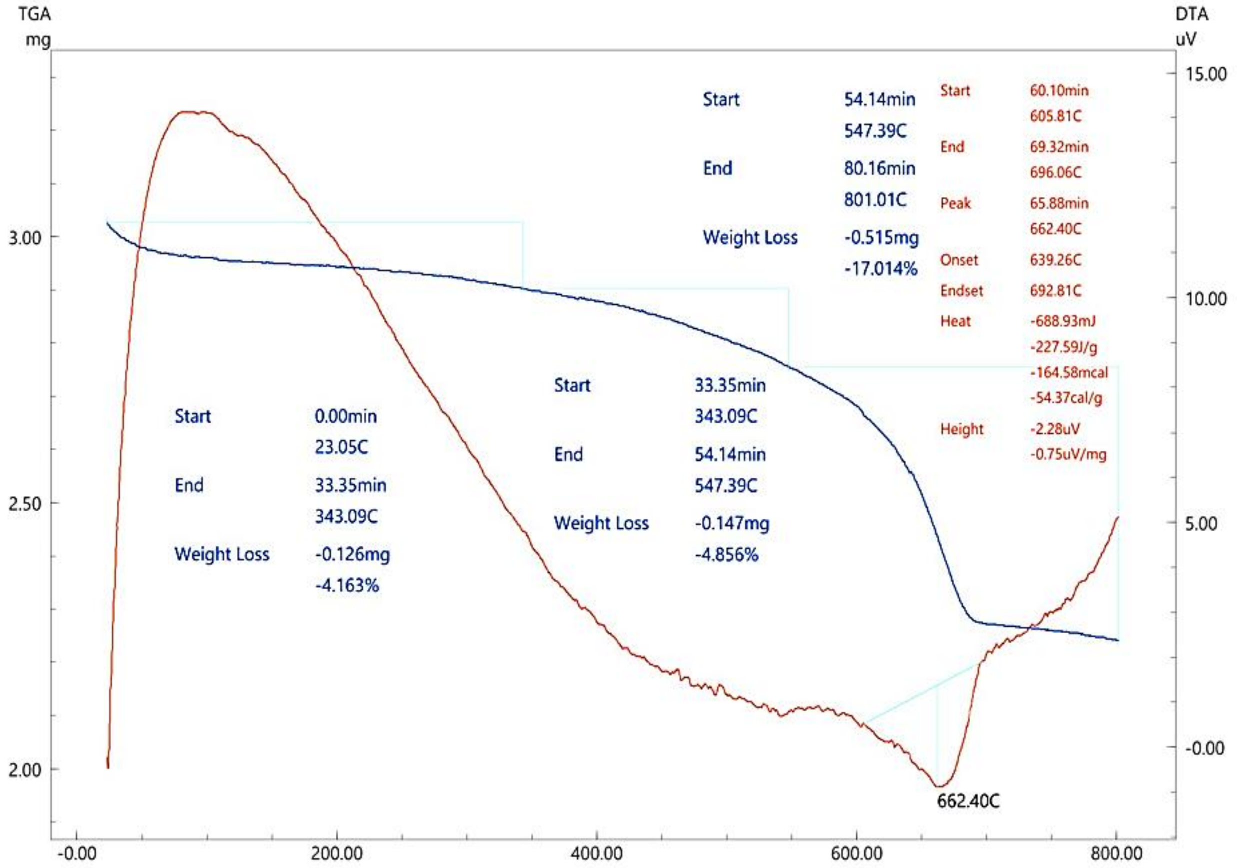

Figure 2. TG-DSK sapropel of the drained bottom of the Aral Sea

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°C/min. The system was calibrated using indium (In) as the standard substance. Data processing and plotting were performed using the Shimadzu Lab Solutions TA Start Window software package [17-20]. The obtained thermograviograms of crushed sapropel and instrument printouts are shown in Figure 1 and 2.

The morphology and energy dispersion spectra of sapropel powder surface samples were examined using a SEM-EVO MA 10 scanning electron microscope from Carl Zeiss, Germany. The acquired electron microscopic structure images are presented in Figures 3 and 4.

V. RESEARCH RESULTS

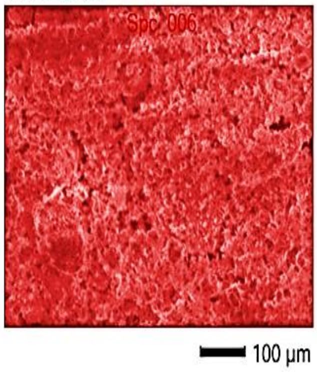
As a result of decoding the thermograms of Fig. 1, the following two endoeffects were revealed: 1 – 113,34 °C; 2 – 441,34 oC. As can be seen from the figure, the first endoeffect is due to the loss of physically bound moisture, the 2nd endoeffect is due to the loss of chemically bound moisture. On the DTG curve at 262,12-800,64 °C, due to the removal of adsorptive moisture from the samples, the weight loss is 2,035-5,842%. Further to the interpretation of the thermograms of Fig. 2, only one endoeffect is observed due to the release of a chemically bound molecule (inter-tank water) and is noted at 662,40 °C.

Samples of the Kuskanatau sapropel and the drained bottom of the Aral Sea of Karakalpakstan are heterogeneous in structure. Figures 3 and 4 show 2 samples of different shapes. The picture shows characteristic granular structures that represent various minerals in the rock composition. Uneven surfaces and differences in particle size may indicate the physical and chemical processes to which the rock was subjected.

Analysis (Figures 3 and 4) shows that sapropel consists of oxygen, calcium, silicon, carbon, iron, aluminum, magnesium and potassium. The accompanying table shows the percentages of elements in the sample (wt %) and their standard deviations (σ). Oxygen occupies the largest percentage, followed by calcium and silicon.

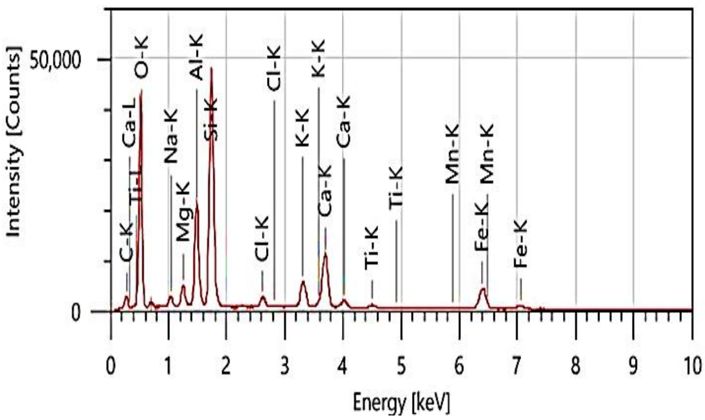
Smp_073

Sem_SED_099



Signal SED
Landing Voltage 20.0 kV
WD 13.6 mm
Magnification x190
Vacuum Mode HighVacuum

Items	Value
measurement conditions	
Acceleration voltage	20.00 kV
Probe current	-
Magnification	x 190
Process time	T3
Measurement detector	First
Live time	30.00 seconds
Real time	42.50 seconds
Dead time	29.00 %
Count rate	67219.00 CPS

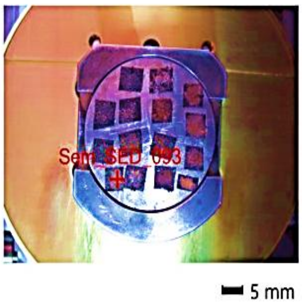


Display name	Standard data	Quantification method	Result Type
Spc_006	Standardless	ZAF	Metal

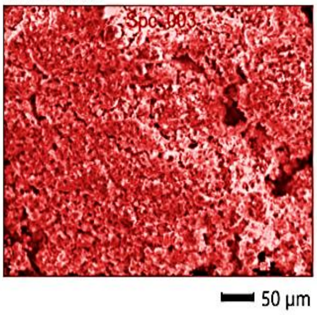
Element	Line	Mass%	Atom%
C	K	8.70±0.07	14.32±0.11
O	K	48.13±0.16	59.45±0.19
Na	K	1.10±0.02	0.95±0.02
Mg	K	1.47±0.02	1.19±0.01
Al	K	6.58±0.04	4.82±0.03
Si	K	16.29±0.05	11.46±0.04
Cl	K	0.88±0.01	0.49±0.01
K	K	2.77±0.02	1.40±0.01
Ca	K	6.53±0.04	3.22±0.02
Ti	K	0.48±0.01	0.20±0.01
Mn	K	0.10±0.01	0.04±0.00
Fe	K	6.98±0.06	2.47±0.02
Total		100.00	100.00
Spc_006			Fitting ratio 0.0126

Figure 3. SEM Images and Energy Spectrum of Kuskanatau Sample

Smp_073

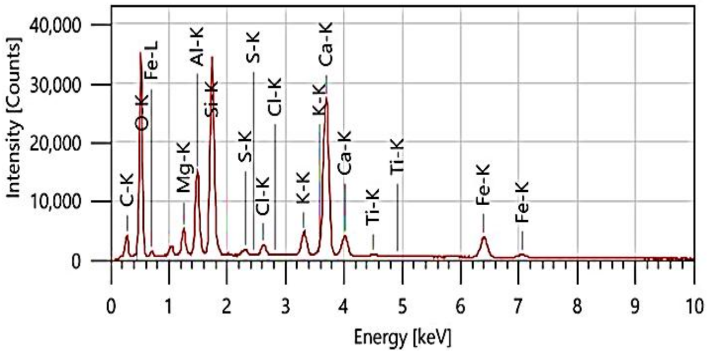


Sem_SED_093



Signal SED
Landing Voltage 20.0 kV
WD 13.7 mm
Magnification x270
Vacuum Mode HighVacuum

Items	Value
measurement conditions	
Acceleration voltage	20.00 kV
Probe current	-
Magnification	x 270
Process time	T3
Measurement detector	First
Live time	30.00 seconds
Real time	43.38 seconds
Dead time	31.00 %
Count rate	71488.00 CPS



Display name	Standard data	Quantification method	Result Type
Spc_003	Standardless	ZAF	Metal

Element	Line	Mass%	Atom%
C	K	9.66±0.06	15.94±0.10
O	K	48.67±0.17	60.29±0.22
Mg	K	1.52±0.02	1.24±0.01
Al	K	4.50±0.03	3.30±0.02
Si	K	10.94±0.04	7.72±0.03
S	K	0.33±0.01	0.20±0.00
Cl	K	0.75±0.01	0.42±0.01
K	K	1.92±0.02	0.97±0.01
Ca	K	15.70±0.06	7.76±0.03
Ti	K	0.38±0.01	0.16±0.00
Fe	K	5.64±0.05	2.00±0.02
Total		100.00	100.00
Spc_003			Fitting ratio 0.0156

Figure 4. SEM images and Energy dispersion spectrum of a sample of the drained bottom of the Aral Sea

This corresponds to the expected composition of serpentinite, which usually consists of magnesium silicates with various impurities. A low calcium content indicates the presence of carbonate phases or other minerals present in the rock.

VI. CONCLUSION AND FUTURE WORK

Physical and chemical compositions and characteristics of the sapropel of Kushkanatau, the drained bottom of the Aral Sea, were studied. Methods for determining the chemical composition and conducting physicochemical studies of sapropel are given. For this, thermal, electron microscopic studies were carried out on modern devices. The elemental sapropel compositions of the samples taken were determined using a scanning electron microscope and an energy dispersion analyzer (Inca, Oxford instruments, UK and EDS analysis).

The results obtained will be used to continue research work on the study of sapropels and obtain various drugs based on them, followed by wide applications in the country's agricultural production.

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