Spectral-optical properties of dissolved organic matter in different aquatic systems

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WHITE SEA STUDENT WORKSHOP ON OPTICS OF COASTAL WATERS
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Absorption of light by dissolved organic matter (CDOM)

Dissolved organic matter (DOM) is present in all types of natural water. Its typical concentrations in water are low, but the DOM is a significant organic carbon reservoir on the Earth, exceeding the organic matter of all living organisms.

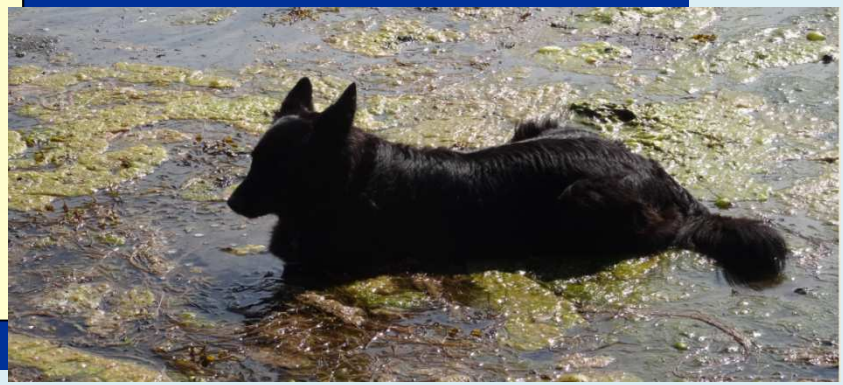
Humic substances

Гуминовые вещества – это более или менее темноокрашенные азотсодержащие высокомолекулярные соединения преимущественно кислотной природы (Орлов Д.С. , 1990, с.48)

Humic substances – a series of relatively high molecular weight, yellow to black colored substances formed (in soil) by secondary synthesis reactions. (Stevenson, 1994, p. 33)

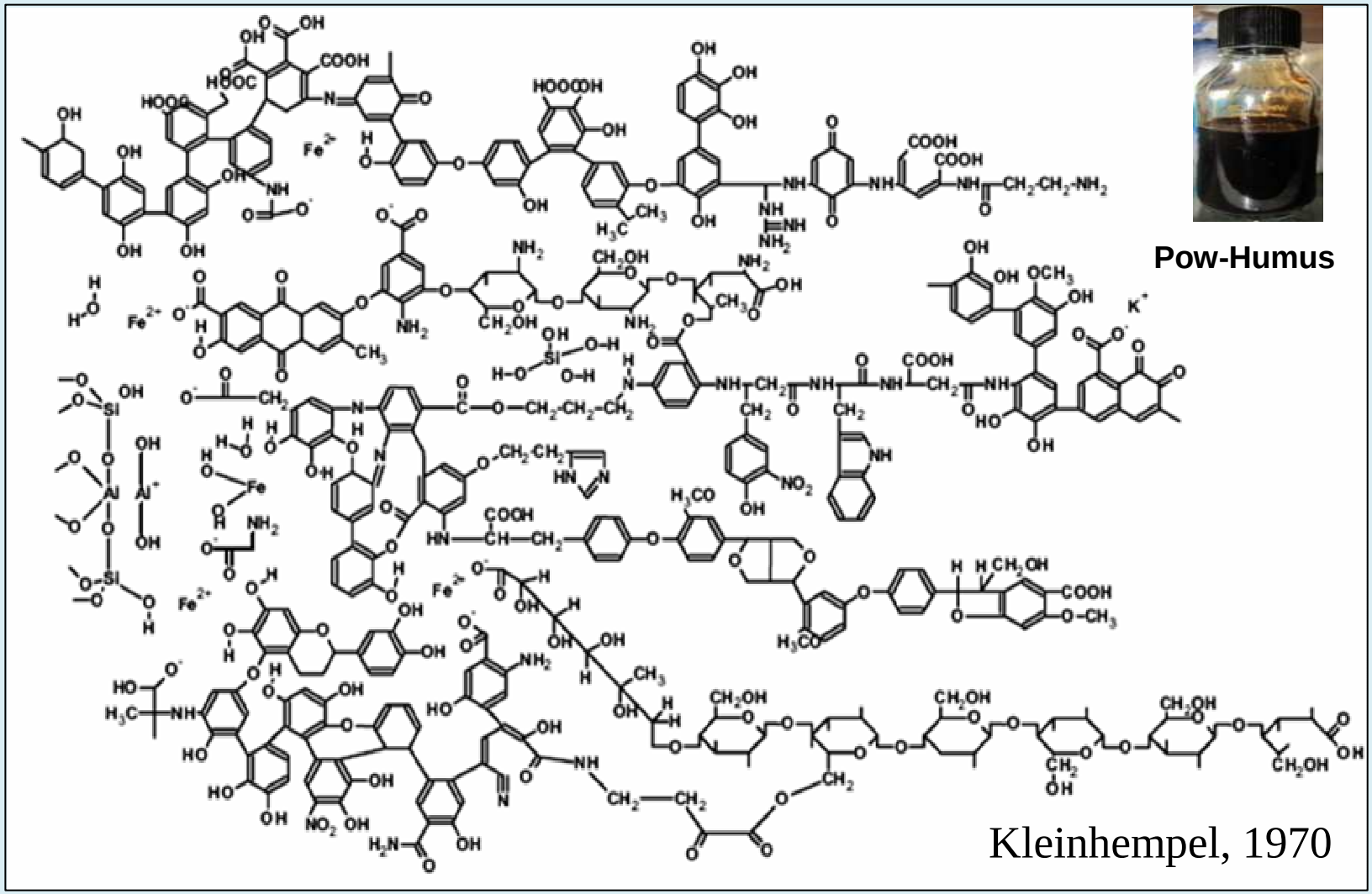
Humic substances are a general category of naturally occurring, biogenic, heterogeneous organic substances generally characterized as yellow to black in colour, of high molecular weight, and refractory. (Aiken et al. 1985)

from Perminova I.V.



Yellow substance, Gelbstoff, chromophoric dissolved organic matter (CDOM)

Humic substances

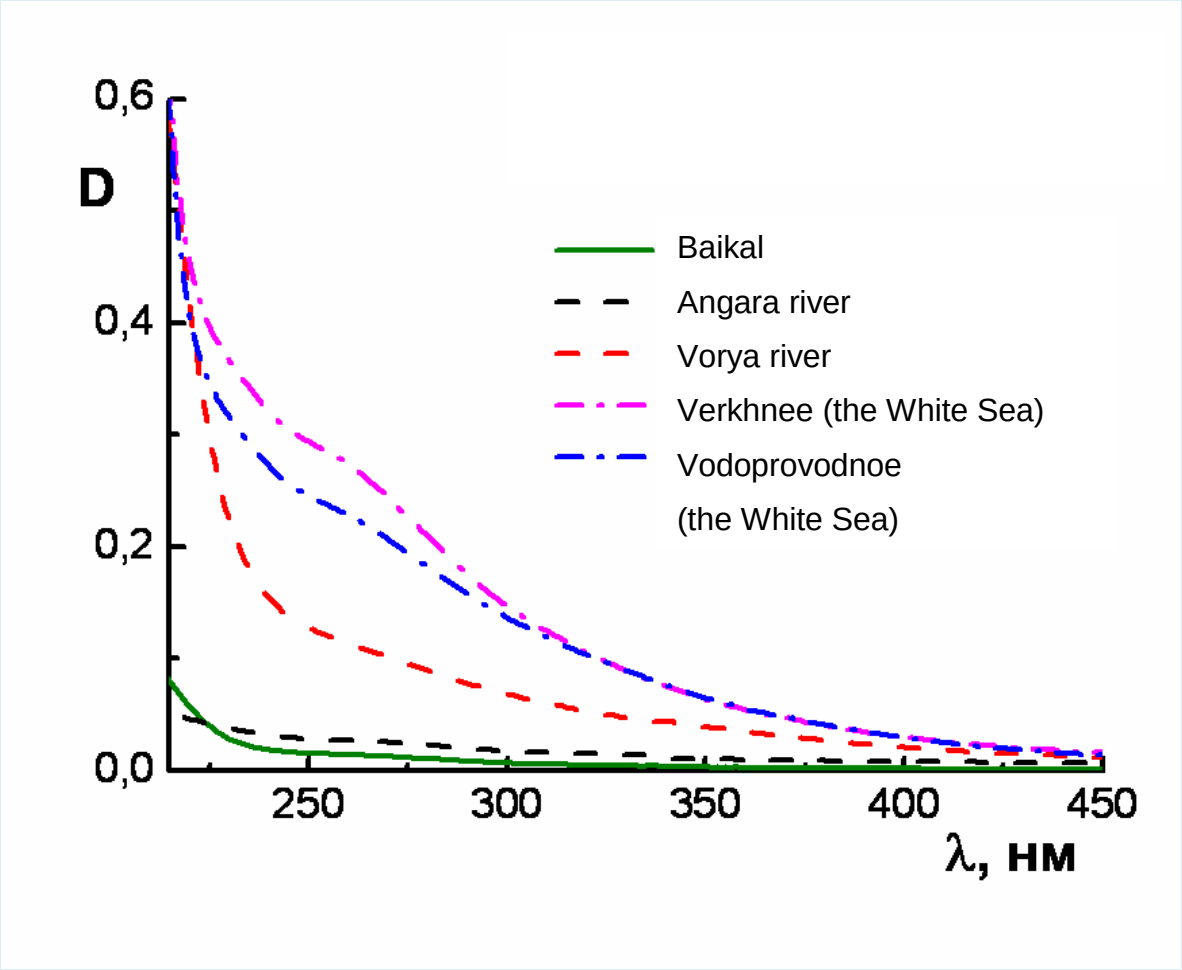


Pow-Humus

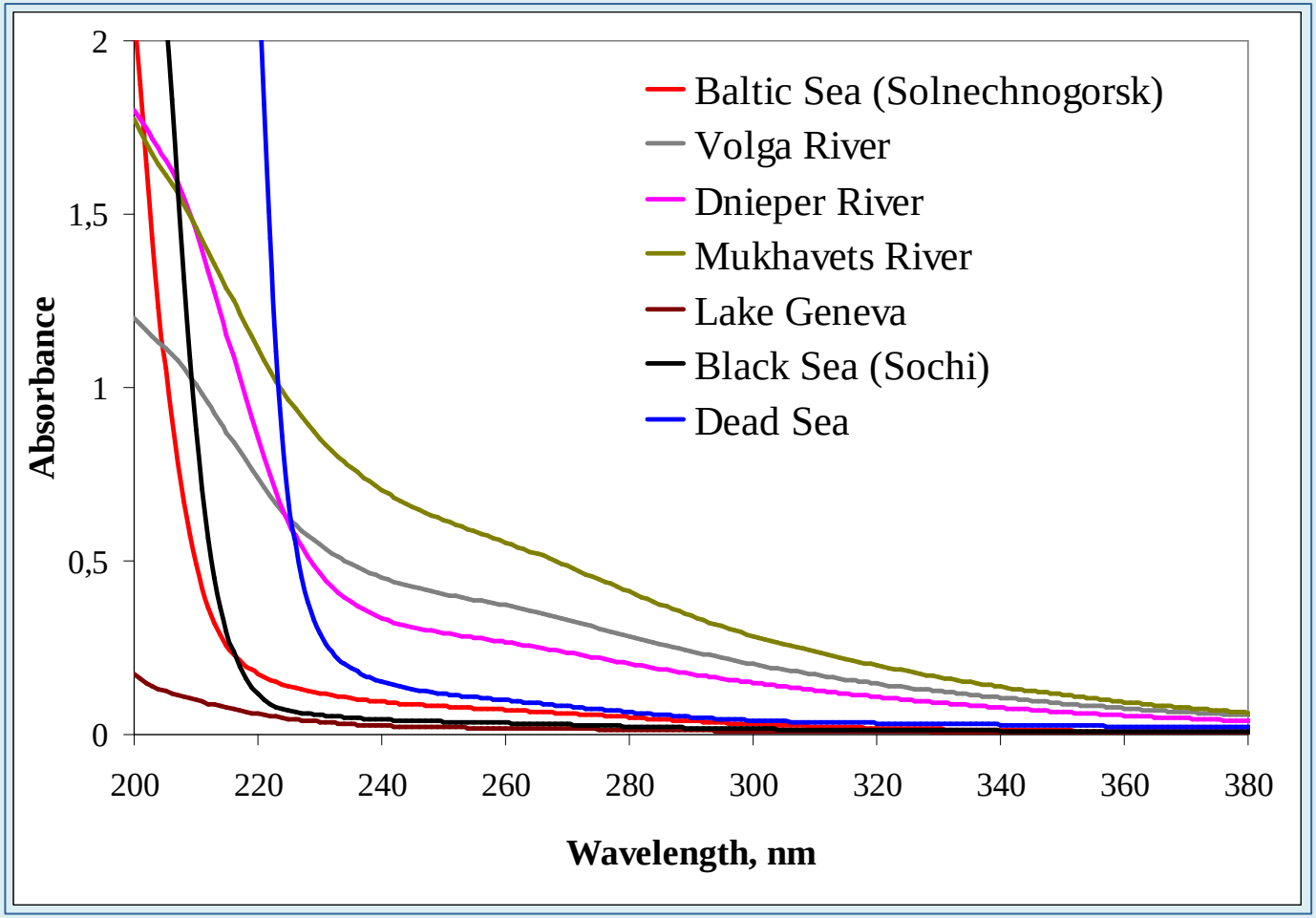
Kleinhempel, 1970


Suwannee River, Georgia, USA
SRNOM
international
standard 1R101N
CSRNOM=40 mg/L
Trubetskaya O.E.

Absorption spectra

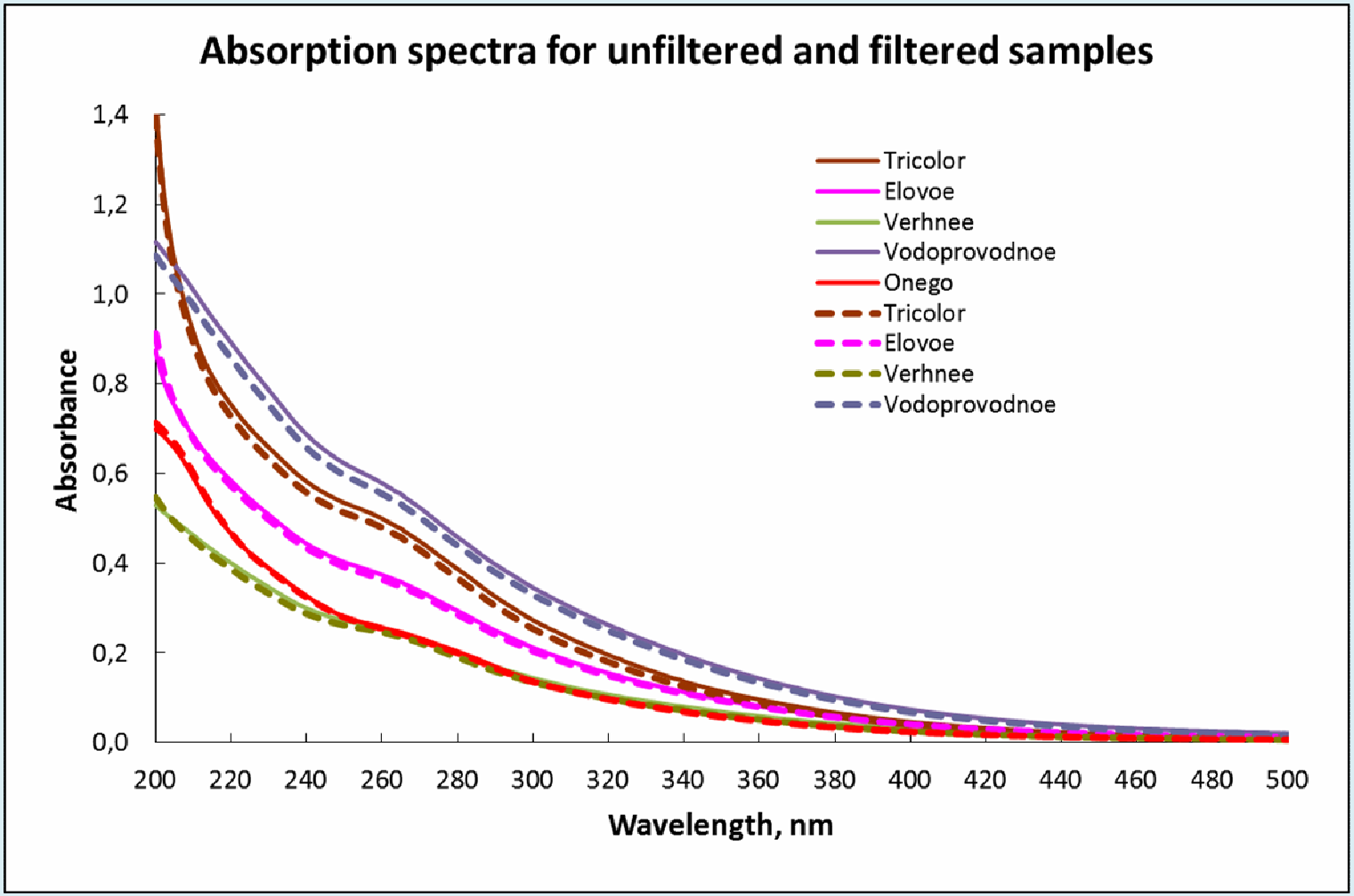


Absorption spectra



Water sampling sites

Absorption spectra



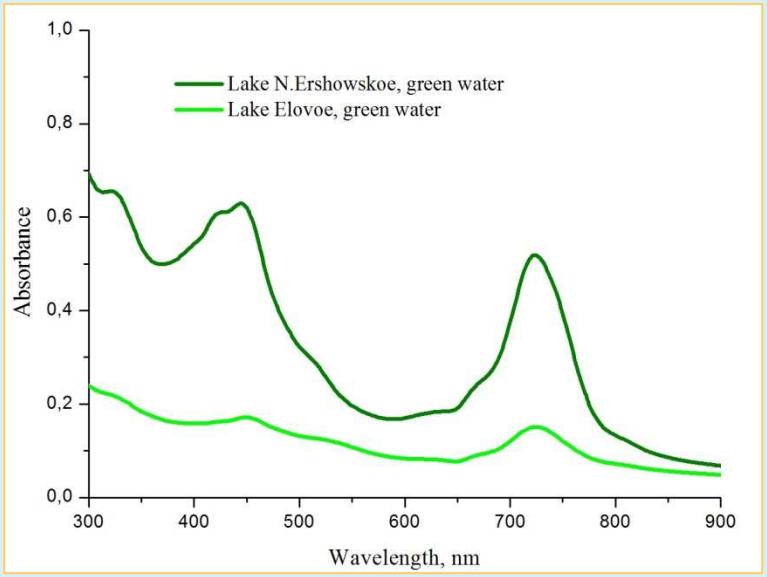
Absorption of light by phototrophic microorgamisms

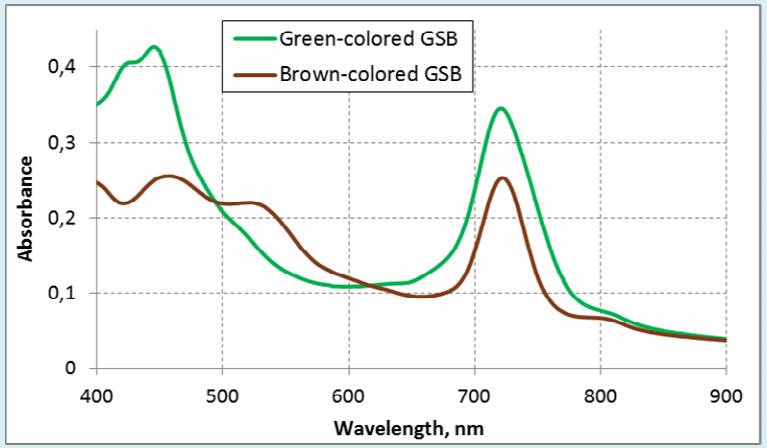
The colour of water samples from Kislo-Sladkoye lake, N.Ershovskoe and Trekhtzvetnoe lake

Absorption of light by phototrophic microorgamisms

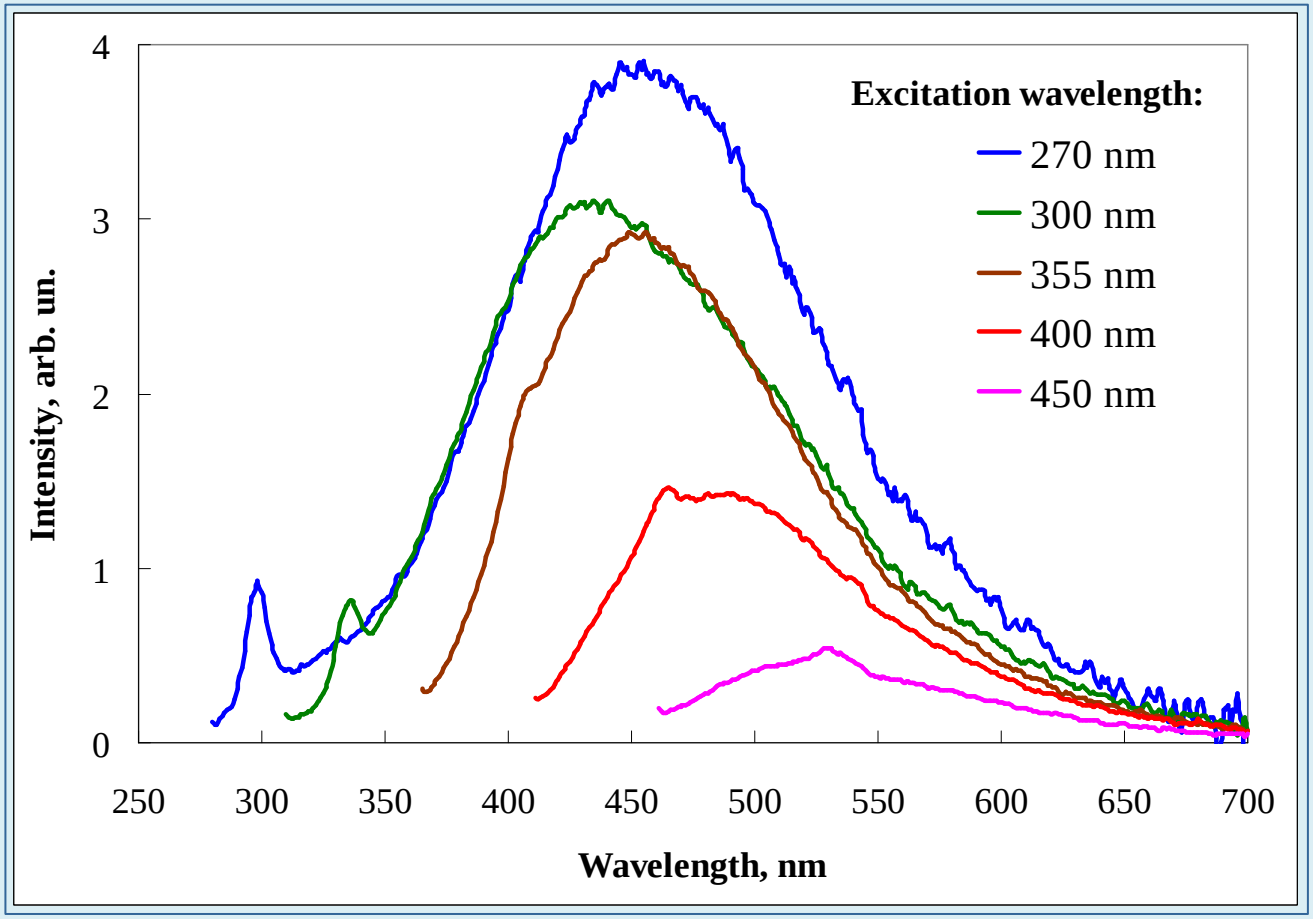
The water samples from Trekhtzvetnoe lake

Absorption of light by phototrophic microorgamisms



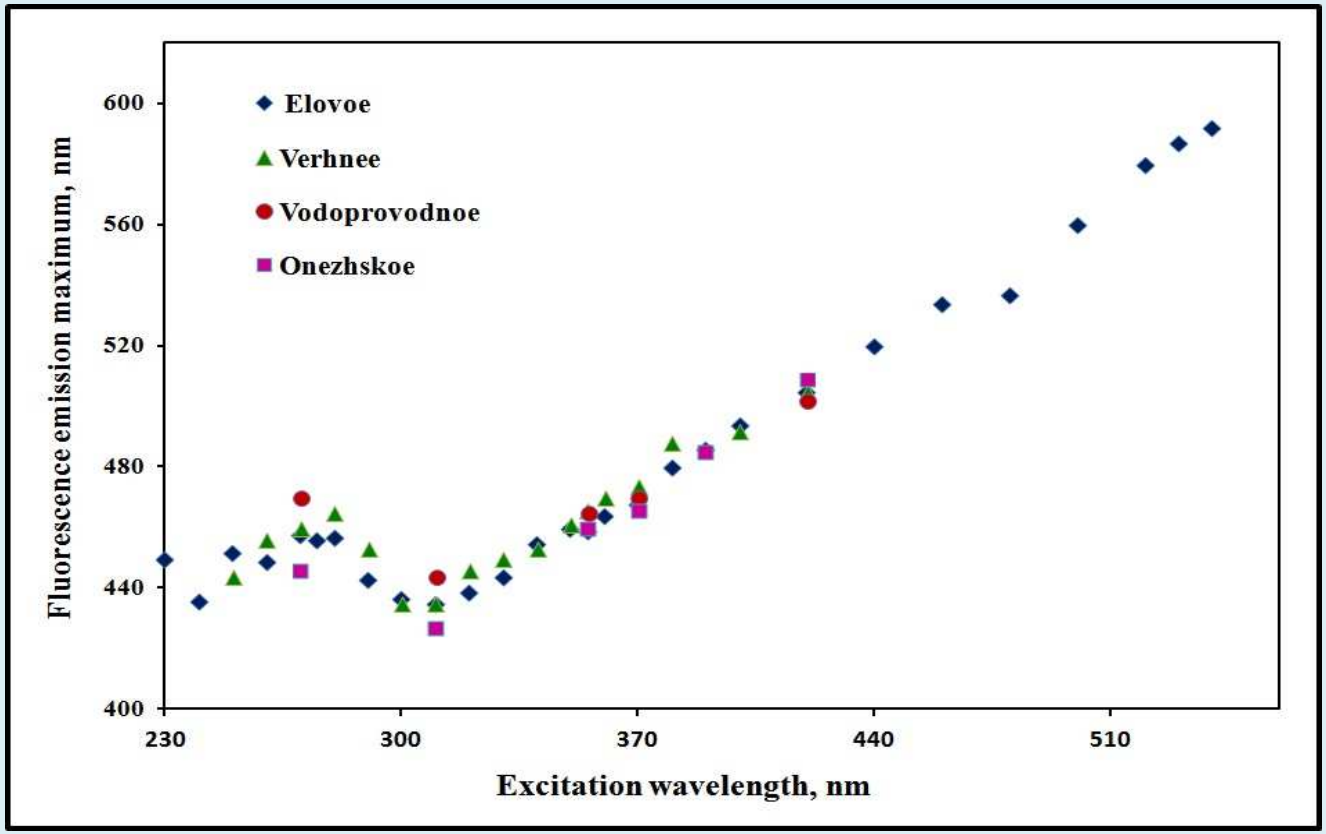


CDOM fluorescence spectra



Fluorescence spectra of surface water in Elovoe lake excited with λex=270-450 nm

Wavelength of emission maximum



So-called “blue shift” with magnitude about 20 nm is observed with change in excitation wavelength from 270 to 310 nm, what is typical for natural water.

Fluorescence quantum yield

$$\Phi = \frac{\text{number of fluorescence photons}}{\text{number of absorbed photons}}$$

Fluorescence quantum yield

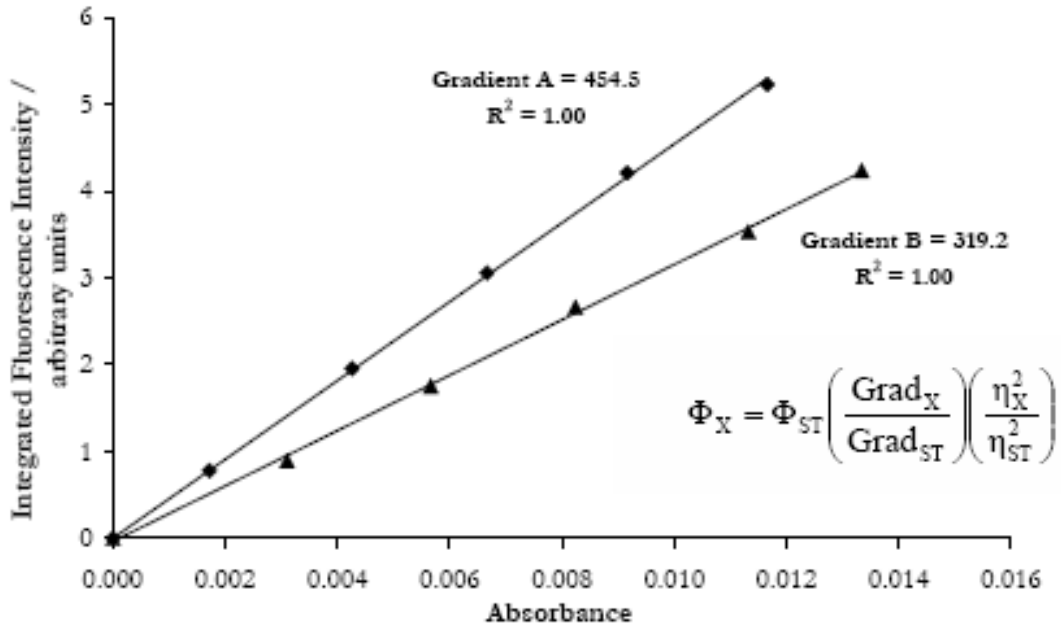


Figure 2: linear plots for two standard samples. The gradient for each sample is proportional to that sample's fluorescence quantum yield. Conversion into an absolute quantum yield is achieved through the equation given in the text.

JY guide to recording fluorescence quantum yields

Fluorescence quantum yield

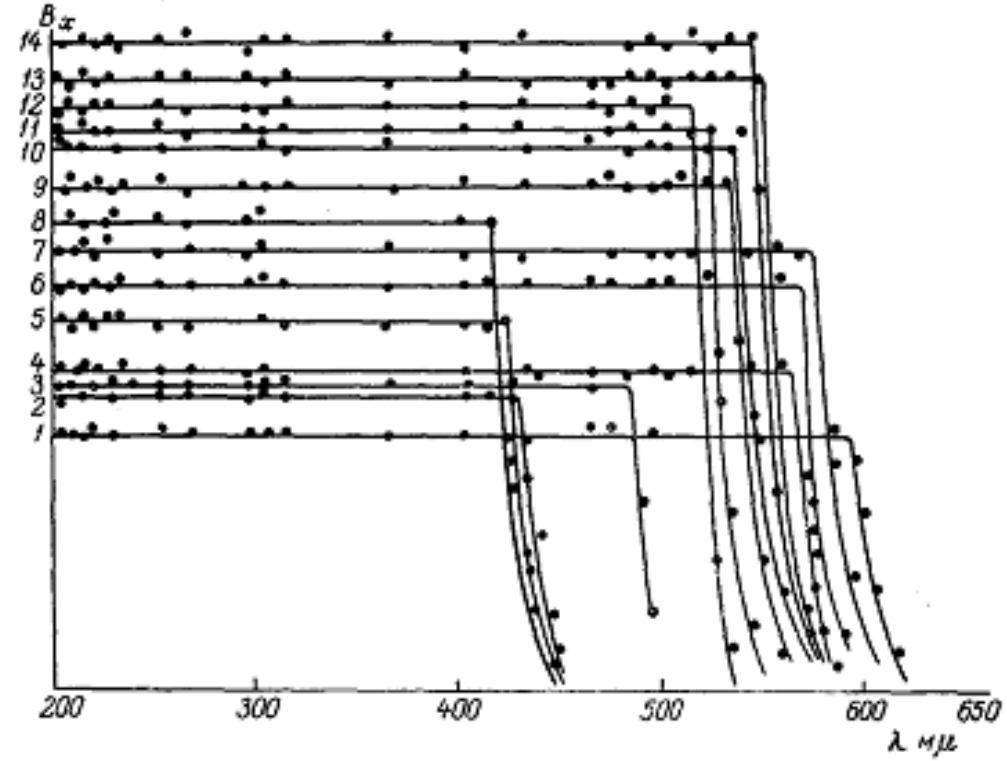
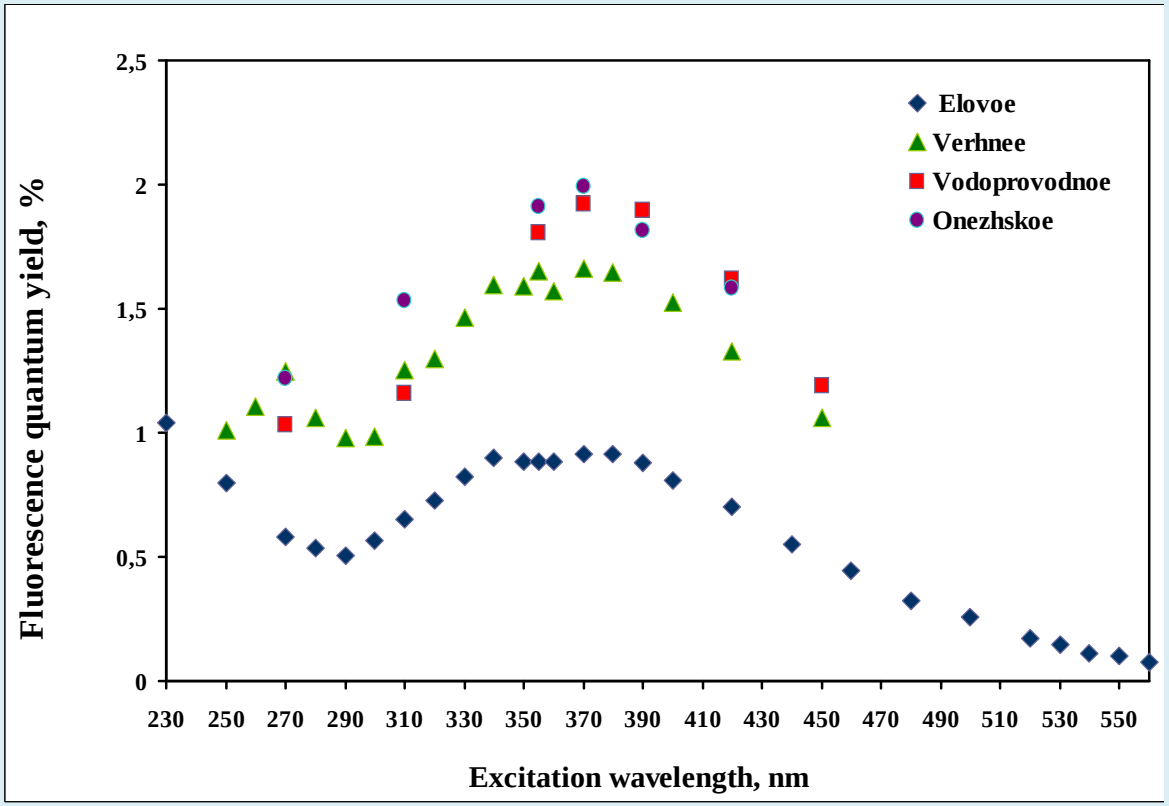


Рис. 1а. Квантовый выход люминесценции растворов в зависимости от длины волны возбуждающего света, по данным С. С. Соломина [196]: *1*—родамин; *2*—эскулин; *3*—урановое стекло; *4*—роза бенгальская; *5*—β-нафтол; *6*—родамин кислый; *7*—сульфородамин; *8*—хинин бисульфат; *9*—бензофлавин; *10*—эозин; *11*—трипафлавин; *12*—флуоресцеин; *13*—акридин; *14*—эритрозин.

CDOM fluorescence quantum yield



Fluorescence quantum yield reaches maximum at λex~370/380 nm and decreases monotonically thereafter.

Fluorescence quantum yield for CDOM in Elovoe lake for different depth and excitation wavelength

	Fluorescence quantum yield, %										
λex	*0 m*	*1 m*	*1,5 m*	*2 m*	*2,5 m*	*2,75 m*	*3 m*	*3,5 m*	*4 m*	*4,5 m*	*5 m*
270	0.58	1.14	1.25	1.85	1.62	1.49	1.36	1.45	1.18	1.38	1.40
310	0.65	1.37	1.22	1.85	1.64	1.63					1.08
355	0.89	1.97	1.82	2.50	2.04	1.88					
390	0.88	2.27	2.10	2.71	2.06	2.00	1.79	1.56	1.12	1.50	1.33
415				2.61	1.78	1.68					

Fluorescence quantum yield varies from 0.6% for the surface samples to almost 3% for the layer with maximum concentration of microorganisms.

Conclusions

Dissolved organic matter (DOM) of natural water due to presence of humic substances absorbs UV light and emit luminescence, its spectra are successfully used in solving such important tasks as the control of natural aquatic ecosystems and technological water environments. For the natural aquatic DOM in various types of natural aquatic systems (sea and river, freshwater and relic lakes) such spectral characteristics as the wavelength of the emission maximum in fluorescence spectrum, the fluorescence quantum yield, the spectral dependences of optical density.

Thank you for attention!