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Some Results of Photoelectric Measurements of the Vertical Downward Component of Day Light in the Adriatic

Neki rezultati fotoelektričkih mjerenja vertikalne komponente dnevnog svjetla u Jadranskom moru

by

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INTRODUCTION

A number of chemical processes are caused in sea water by the penetration of light, the photosynthesis being the most important one. The correct interpretation of the physiological processes presupposes the knowledge of water properties since it is they and the water depth that are responsible for variations in the intensity and spectral composition of light. Although measurements involving the illuminance of sea water layers somewhere are included in the regular oceanographic investigations, this problem was barely tackled in the Adriatic area. A few recults referring to waters off Rovinj (1,2) and in the area off Drvenik and Biševo Islands (2) are the only data. In this paper the results of measurements of the dependance of vertical component of daylight on the depth for some middle Adriatic areas, the equipment and some working experiences have been reported. The measurements took place from August 11th to September 1st, 1955.

EXPERIMENTAL PART

Fig. 1 shows the Photometric Box made of nickel plated steel 2.5 mm thick containing the photocell. Photoelectric current was measured by means of a spot light galvanometar (Radiometar GVM 22) which vas mounted on gimbals in order to reduce its swinging. A separate selenium photovoltaic cell, also suspended on gimbals — in the horizontal position — was connected with another microampermeter continuously indicating the daylight illuminance on the deck. Following light detectors were used in the course of measurements: 1. selenium photovoltaic cell, Electrocell (sensitivity 450 μA/lm, 15 cm^2 active surface), 2. vacuum Sb-Cs photocell, Institut za Elektroniko, Ljubljana (sensitivity 80 μA/lm, 7.5 cm^2 active surface) and 3. gas filled Ag-O-Cs photocell, Institut za Elektroniko, Ljubljana (sensitivity 200 μA/lm, 5.5 cm^2 active surface). Colour glass filters (Schott, Jena) 2 mm thick were applied: blue BG3, blue BG12, green VG8, orange OG5 and red RG2. In adition to these filters, interference filter (Carl Zeiss, Jena) were also used for some measurements, the later having considerably narrower transmittance bands (nominal velues: λ_{max} 463, 544, 575, and 637 mμ).

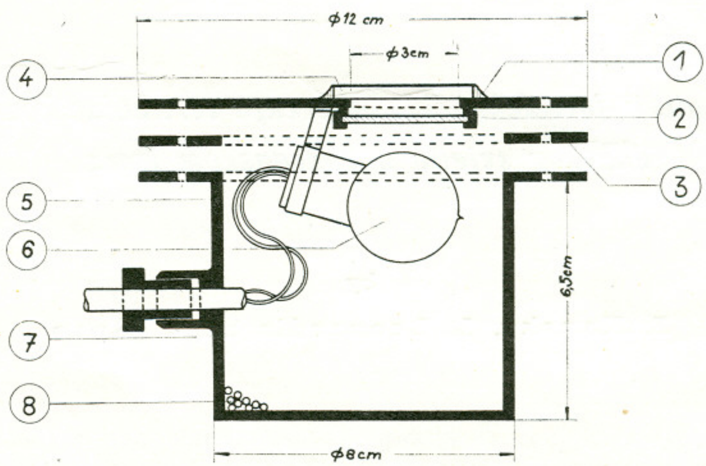

Fig. 1. Photometric Box. 1. Plastic gasket, 2. filter, 3. rubber gasket, 4. opal glass window, 5. box, 6. photocell, 7. cable inlet, 8. silicagel.

The measurements were performed at the folloving depths: immediately bellow the surface, 0.1, 1, 2.5, 5, 7.5, 10, 15 and 20 metres etc. The readings were recorded by immersing and lifting of the photovoltaic cell. In this way two values for each depth were obtained.

As a consequence of wave motion, the depth of the water layer above the photocell varied according to the rhythm of the waves. The curlled water surface, moreover, atlernatively refracts, converges and diverges light which caused the light intensity to fluctuate. The smaller the water depth the greater were the errors of measurements due to wave motion. The average value of the photoelectric current may be measured with satisfactory accuracy in two ways. By means of a very inert measuring circuit the fluctuation of galvanometar deviations may be reduced to a considerable extent. On the other hand a considerable number of readings within a given time interval (large enough compared with the oscillation period) can be performed and their mean value can be computed. The errors of our measurements which were performed in the later way, are estimated to $\pm 5\%$.

All the measurements took place at noontide, mostly between 11 a.m. and 2 p.m. when the sun altitude shows minimum changes within the time interval.

RESULTS AND DISCUSSION

The results are shown in Figs. 2 to 6. In order to make possible the comparison of results, the extinction curves have been drawn in such a manner that — with the exception of Fig. 6 — the illuminance at a depth of 1 metre was taken as a 100% one. The results of measurements obtained in the Bay of Kaštela are shown in Figs. 2, 3, and 4. As expected, the curves are not straigth lines, and therefore not in conformity with the Lambert — Beer law.

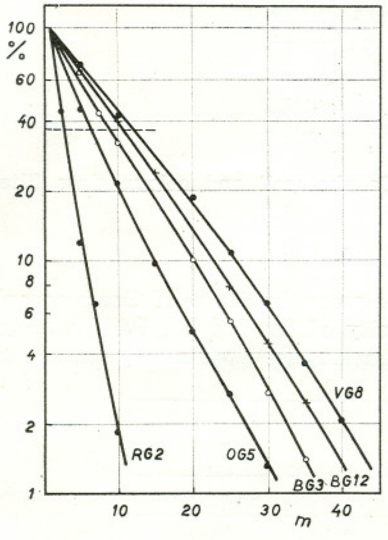

Fig. 2. The bay of Kaštela, Aug. 15, 1955. Selenium photovoltaic cell and colour glass filters. Bottom depth 42 m.

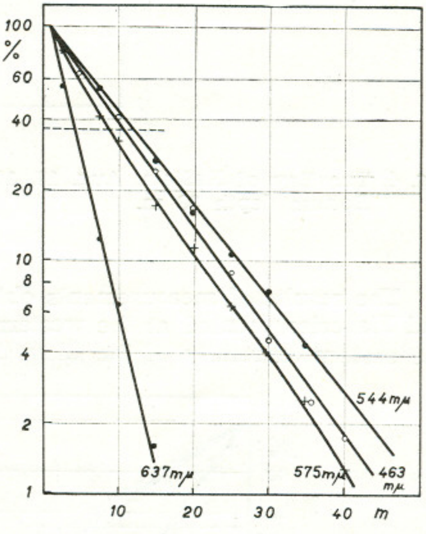

Fig. 3. The Bay of Kaštela, Aug. 15, 1955. Selenium photovoltaic cell and interference filters. Bottom depth 42 m.

The sea water in this area is highly transparent for the green component of light, while the extinction ability greatly increases toward red and blue portions of the spectrum. By comparing Figs. 2 and 4, we can easily find out that the results of measurements obtained using a Sb-Cs photocell are practically the some as those obtained by means of a selenium photovoltaic cell. Both kinds of measurements were made within a two days period and no essential change in transmittance — as far as the sea water in the said area is concerned — could be observed. We can also find out, by comparing Figs. 2 and 3 that similar results were obtained by using interference filters and colour glass filters.

It is interesting to note that our curves do not display the usual knees of higher absorption at depths ranging between 3 and 15 metres. The period of the year (August) seems to be responsible for that, since this is the time during which population density is approaching to its lowest degree.

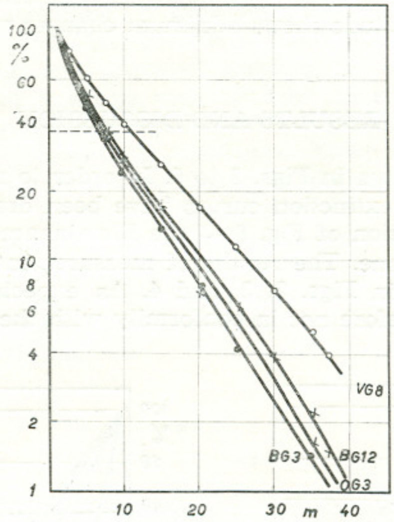

Fig. 4. The Bay of Kaštela, Aug. 17, 1955. Sb-Cs photocell and colour glass filters. Bottom depth 38 m.

The results of measurements obtained between Institute of Oceanography and Fisheries, located at the western extremity of the Marjan Peninsula, and the eastern extremity of the Čiovo Island, on August 23rd and 24th, are not

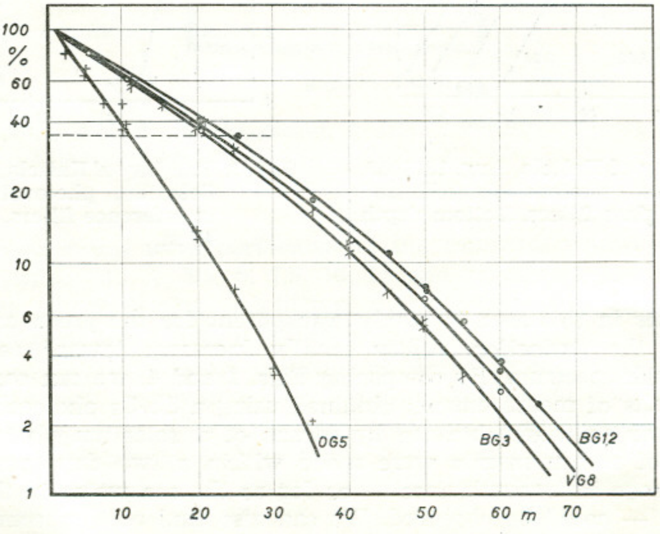

Fig. 5. Off Šolta Island, 2 nautical miles WSW of Maslinica Village, Aug. 29, 1955. Sb-Cs photocell and colour glass filters. Bottom depth 95 m.

much different from those obtained in the Bay of Kaštela. This is why the diagrams have not been included while the results are presented in Table I. The light transmittance of sea water is somewhat higher in the former than in the later area.

The sea water is much more transparent in the area off Šolta Island, about two nautical miles WSW of Maslinica Village, than in the Bay of Kaštela. The spectral transmittance is also different in both areas (Fig. 5). The maximum transmittance occurs here in the blue and not in the green section of the spectrum.

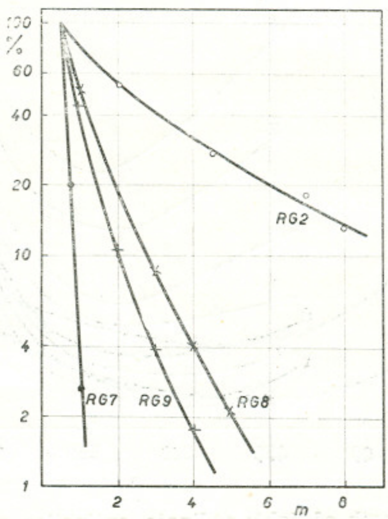

Fig. 6. Head of pier in front of the Institute building, Aug. 25, 1955. Ag-O-Cs gas photocell and colour glass filters. Bottom depth, 7.5 m.

Water highly absorbs the red and infrared spectral light. The results of measurements concerning this part of the spectrum are shown in Fig. 6. Since the depths involved in our measurements were rather small, it was difficult to perform them from a rocking boat. This is why we immersed the photometric cell from the pier located in front of the Institute building, at a distance of 5 metres from the pier.

Our measurements enable us to determine the mean value of the extinction coefficient K or its reciprocal value D which may be read directly from the diagram. Values D are presented in Table I.

The determined values of K and D allow a comparison of spectral transmittance between the water of the Adriatic Sea and those of some other seas and oceans, as shown in Fig. 7. As results from such comparisons, the degree of transmittance in the Adriatic inshore waters (Curve B) is above the average value of transmittance valid for inshore waters generally. Moreover, the sea water of the area lying off Šolta Island (Curve A) is much more transparent than the average ocean water — it is almost as transparent as the clearest ocean water. The data relative to other waters (Curves 1 to 6) are given according to Utterback (3).

Golubić (2) who measured the penetration of daylight in Limski Kanal (Fig. 7, curve II) and off Biševo Island (Fig. 7, curve I) arrived at similar conclusions. However, the results of measurements of the forementioned author differ at higher wave lengths from ours. In such measurements it is necessary to take into the account the transparence of filters and spectral characterictic of the photocell. For this reason it seems to us that Golubić when interpreting his measurements with filter RG2, ascribed to the measured values to high wave lengths.

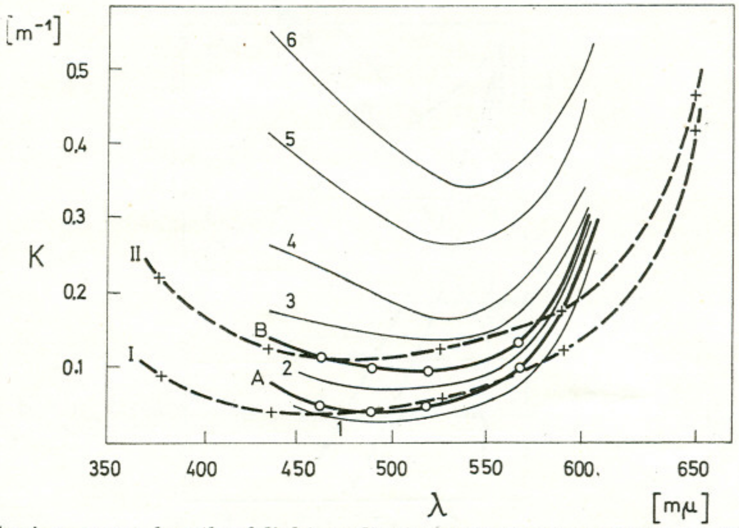

Fig. 7. Abscissa, wave length of light; ordinate, extinction coefficient. 1. Ocean water of minimum absorption, 2. ocean water of medium apsorption, 3. ocean water of maximum absorption, 4. inshore sea water of minimum absorption, 5. inshore sea water of medium absorption, 6. inshore sea water of maximum absorption, A. Adriatic sea water from off Šolta Island, B. Adriatic sea water from the Bay of Kaštela, I. Adriatic sea water from off Biševo Island, (2) II. Adriatic sea water from Limski Kanal (2).

The above comparisons show that the daylight is relatively well transmitted in the waters of the Adriatic. Owing to different techniques of measurements applied in the course of our investigations, a slight displacement of curves may have occured, but, in our opinion, the ensuing differences were hardly able to change the picture to an essential degree. It is important, however, to emphasize that our measurements took place in August when the light penetrates the sea water very intensively. It is interesting to note that the curves belonging to both series of measurements (i.e. involving the waters of the Atlantic Ocean and Adriatic Sea) are of the same shape and that the absorption minima in both cases shift to greater wavelengths associated with a decreasing transparence.

The vertical downward component of illuminance on a clear sunny day, measured in lux units, is given only by the altitude of the sun — the quantitative ratio being computed with a considerable amount of accuracy (4) — from which we obtained the illuminance on the surface of the sea. This initial illuminance is then used for calibrating our extinction curves. There are difficulties, however, to be overcome regarding the physiological unit for illuminance, i.e. lux. One usually bypasses such difficulties by calibrating the extinction curves measured by means of light detector which has a spectral sensitivity approaching colour sensitivity of the human eye. In our case, it was a combination of a selenium photovoltaic cell and a glass filter VG8. The vertical downward component of illuminance (Fig. 8) for the noontide, in mid-August, by clear weather, is given in kilolux units with regard to depth.

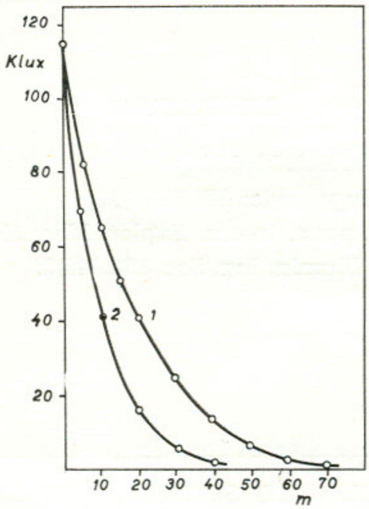

Fig. 8. Abscissa, water depth; ordinate, illuminance, expressed in kilolux units. 1. Off Šolta Island, 2. Bay of Kaštela. Selenium photovoltaic cell and colour glass filter VG8. August, 1955.

Our thanks are due, first of all, to the Institute of Oceanography and Fisheries, Split, for the initiative and assistence. We are also grateful to the following institutions for placing at our disposal some of their instruments, etc.: the Institute for Electronics, Ljubljana, for their galvanometar; the Laboratory gl. manuskrip for their glass filters; and the Zmaj Works, Ljubljana, for their anode batteries.

TABLE I.

Filters	average D (m)					
	Kaštela Bay		Čiovo Island		Šolta Island	
	Sb-Cs	Se	Sb-Cs	Se	Sb-Cs	Se
BG 3	5.7	7.7	—	—	19.7	21.0
BG 12	7.0	9.8	11.6	12.5	22.5	22.5
VG 8	9.7	10.7	12.2	13.0	21.0	19.0
OG 5	6.2	5.2	9.6	5.2	9.8	6.5
RG 2	—	1.7	—	8.3	—	2.4

SUMMARY

The absorption of daylight and the spectral transmittance of the Adriatic Sea water at three different positions were measured. The results have been compared with typical ocean and shore waters. Furthermore, the applicability of Sb-Cs and Ag-O-Cs photocells, Se photoelement and glass and interference filters for measurements of transmittance of the vertical component of daylight in the inshore waters of the Middle Adriatic region has been examined.

LITERATURE

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NEKI REZULTATI FOTOELEKTRIČKIH MJERENJA VERTIKALNE KOMPONENTE DNEVNOG SVJETLA U JADRANSKOM MORU

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KRATAK SADRŽAJ

Pregledana je upotrebivost Sb-Cs i Ag-O-Cs fotoćelija i Se fotoelementa te obojenih staklenih i interferencijskih filtera za fotoelektrična mjerenja osvjetljenosti u moru.

Izmjerena je ekstinkcija svjetlosti i spektralna propustljivost jadranske morske vode na tri različita mjesta u obalnom području srednjeg Jadrana i uspoređena sa tipičnim priobalnim i oceanskim vodama.

BILJEŠKE-NOTES, izdaje Institut za oceanografiju i ribarstvo, Split; izlaze povremeno. Odgovorni urednik: prof. S. Alfirević. Naklada 550 primjeraka. Tisak: »Slobodna Dalmacija«, Split