Physics of Light in the North Coasts of Persian Gulf (Bushehr province) during Winter Season

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(Received 23 November 2010; accepted 30 August 2011)

Abstract

We present a study to field measurement and laboratory experiments of light for university students in physical oceanography. During 6th to 8th of February 2009 in two stations of Bushehr province central coasts, sampling of sea water and other effective physical parameters were carried out. The effects of laser light in 532, 659, and 980nm on the collected water samples in two different stations were studied. Then light attenuation coefficient and the amount of light penetration percentage for these stations at different depths were calculated. According to the results of this study, light attenuation coefficient in the first station, the wave length for red and infrared lights is more than the wave length for green light. For red and infrared wave lengths the amount of light absorption in the first station is more than the second one. The salinity, temperature, and cloud cover parameters are not effective in the amount of light absorption. The effective factor in increasing the amount of light absorption in this station than the second station is water turbidity.

Keywords: Laser, Light attenuation coefficient, Lambert law, Light absorption, Bushehr coasts, Persian Gulf.

Resumen

Se presenta un estudio de medición de campo y experimentos de laboratorio de luz para estudiantes universitarios de oceanografía física. Durante el 6 al 8 de febrero de 2009 en dos estaciones de la provincia de Bushehr costa central, se tomaron muestras de agua de mar y se midieron otros parámetros físicos efectivos. Fueron estudiados los efectos de la luz láser 532, 659 y 980nm en las muestras de agua recogidas en dos regiones en estaciones diferentes. A continuación, se calculó el coeficiente de atenuación de la luz y la cantidad del porcentaje de penetración de luz para estas estaciones a diferentes profundidades. De acuerdo con los resultados de este estudio, el coeficiente de atenuación de la luz en la primera estación, la longitud de onda de luz roja e infrarroja es mayor que la longitud de onda de luz verde. Para longitudes de onda roja e infrarroja de la cantidad de absorción de la luz en la primera estación es más que en la segunda. La salinidad, temperatura, y los parámetros de la cubierta de nubes no son eficaces en la cantidad de absorción de la luz. El aumento del factor de eficacia de la cantidad de absorción de la luz en esta estación de la segunda estación es la turbidez del agua.

Palabras clave: Láser, coeficiente de atenuación de la luz, Ley de Lambert, absorción de la luz, costas de Bushehr, Golfo Pérsico.

PACS: 42.68.-w, 41.20.-q, 03.50.-z **ISSN 1870-9095**

I. INTRODUCTION

One of the effective factors that cause lots of changes in marine environment is light. Because of enormous effect in composing new organic material and primary production via plants, light is one of the important ecological factors through photo synthesis operation. Survival of all life and ecosystems in the ocean depends on organic material synthesis from inorganic material, which for this synthesis to occur 4 major factors are needed: light, nutrients (phosphate, nitrate, nitrite and silicate), carbon dioxide and water, where sufficient amount of the two latest factors can be found in the sea but the limiting factors of this synthesis are light and nutrients [1]. Because of countries development and the growing population we are facing the increasing pollution sources of the sea, as one of the limiting factors of light in the sea are polluting materials. Polluting materials such as oil material, industrial wastes, mud and sludge and solid wastes cause decrease of light penetration in sea water and consequently decrease of photosynthesis [1].

The amount of temperature and salt dependence on absorption of visible and infra red light attenuation in sea water. Water absorption coefficient in the region of infra red spectrum shows a high dependency on temperature, whereas in the region of visible light, it’s less dependence on water temperature. In the visible spectrum the effect of salinity amount on the amount of light absorption is negligible but the effect of salt in infra red spectrum for light absorption calculation is of importance [2]. Theisen-Kunde *et al.*, studied the dependence of temperature on the amount of light absorption in infra red wave lengths [3]. In their study the amount of light transfer in different temperatures for two different wave lengths of infrared spectrum was determined, and according to Lambert law the absorption coefficient was calculated. Torabi Azad yields the amounts of light attenuation coefficient and absorption percentage at different depths in north coasts of Persian Gulf according to field measurements at 1994 and 1995 [4]. By a research Attenuation of submarine Photosynthetically Active Radiation in relation to the concentrations of Optically Active Constituents in a range of water types around the United Kingdom was Studied [5]. A description of seasonal changes of light attenuation coefficient in selected points of the Oder River in the Szczecin region was reported. It demonstrates that applying a modified and approximate formula for light attenuation coefficient is an effective method for interpreting changes. The formula was used earlier for analysis of time changes of roily oil products [6].

II. RESEARCH METHODOLOGY

During of 6 to 8 February 2009 in two stations of Bushehr province central coasts sampling of sea water and physical parameters such as electrical conductivity, salinity, temperature with depth, height and wave period, speed and wind direction, air temperature at sea surface were carried out almost simultaneously. Figure 1 shows the geographic position of Bushehr province and the stations under study.

FIGURE 1. Geographic situation of Bushehr province and study stations.

Sampling of sea water for studying the optical characteristics was carried out using the Nesskin water sampler apparatus a 50 centimeters depth. Geographic position of sampling stations and relevant amount of physical parameters are shown in Table I.

TABLE I. Geographic position of sampling stations and relevant amount parameters.

Station's No.	Longitude (Degree)	Latitude (Degree)	Salinity (g/Kg)	Conductivity (ms)	Air Temperature (°C)	Cloud Cover	Wind direction
1	50°4847˝	28°5345"	35	46.9	22	5/8	South-west
2	51°035˝	28°3938˝	35	46.2	22	1/8	South-west

Samples of sea water were transferred to laboratory and were placed under laser light radiation (Fig. 2). In this study second harmonic Nd – YAG green laser light with 532nm wave length, red diode laser with 659nm wave length and infra red with 980nm wave length were used. Out put power of second harmonic Nd – YAG laser, red diode laser and infra red laser used in this research were 100, 110, 105m watt, respectively. Power of Laser apparatus were calibrated with dynameter 11S.1.2. The wave length used were determined using spectroscopy method. With regard to result of this study the amount of light attenuation coefficient for two samples of sea water at different wave lengths were calculated (Table II). For calculating the amount of light attenuation coefficient Lambert law ($I = I_0 e^{-ux}$) were used, where I_0 is light intensity of Laser, I is light intensity after passing through sea water sample, x is thickness of the dish containing sea water and μ is attenuation coefficient [7, 8].

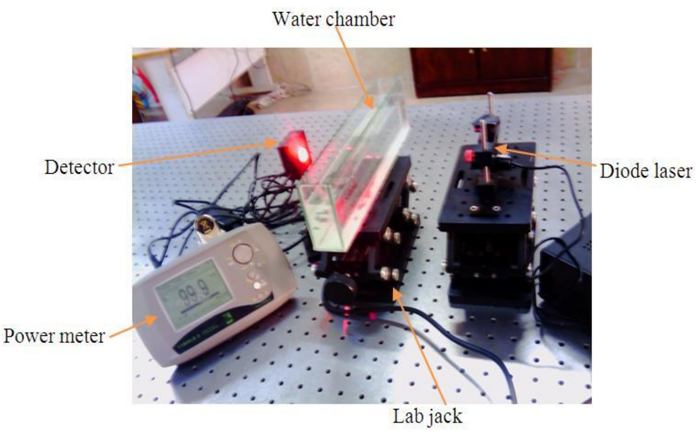

FIGURE 2. Set up of the experiments.

TABLE II. The amount of light attenuation coefficient at different Laser wave lengths.

Laser light	Light attenuation coefficient at first station (m^{-1})	Light attenuation coefficient at second station(m^{-1})
Green light	0.019	0.029
Red light	0.023	0.007
Infra red light	0.453	0.431

Light attenuation coefficient is a function of light's wave length and depends on the amount of absorption and light scattering. The coefficient μ depends mainly on the absorption of light in the water and to a lesser extent on scattering [7]. The amount of light attenuation coefficient was measured with respect of performed experiment's result at different wave lengths. Then with using the Lambert law the amount of light intensity with depth in two stations was calculated. Light intensity vs. depth curve was plotted using the Excel software (Figs. 3 and 4). Also the way of sea water physical parameters affecting the light absorption of these two stations were analyzed.

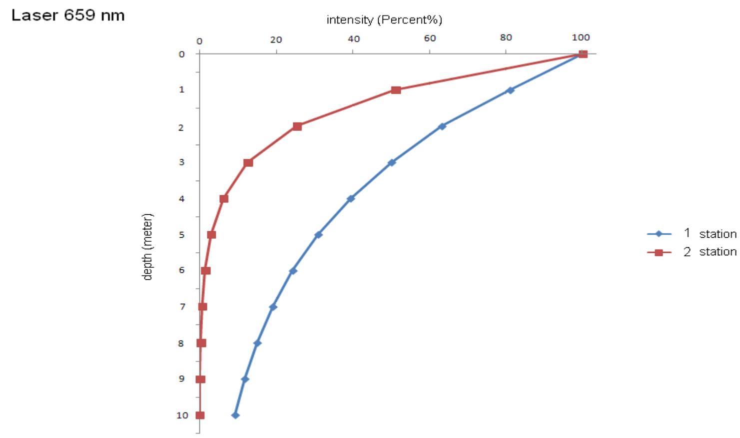

FIGURE 3. Light intensity variations *vs.* depth curve in two stations for red light laser (659nm).

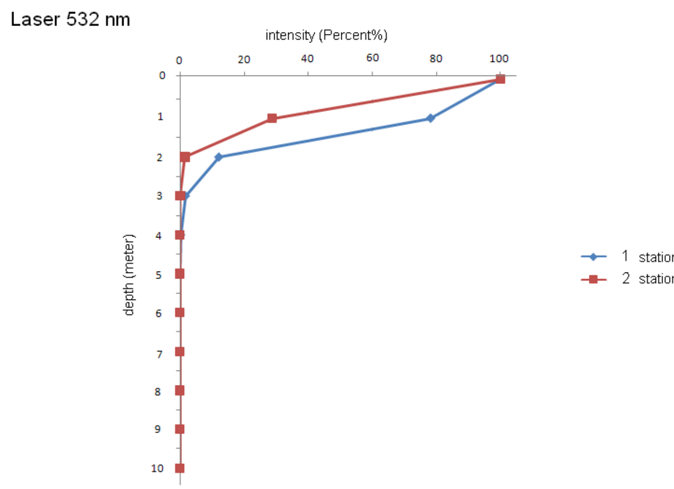

FIGURE 4. Light intensity variations vs. depth curve in two stations for green light laser (532nm).

III. DISCUSSION AND CONCLUSION

From Table II results, light attenuation coefficient in station one for red and infra red light wave lengths were more and for light with green wave lengths are less. In second station light with green wave length had the most penetration and light with red and infra red wave lengths had a little penetration and they scattered and absorbed very fast.

In the second station absorption with red wave length had the least amount, so it had the most penetration into sea water. Comparing the amount of light attenuation of these two stations, it shows that the second station's water had more opacity and light penetration in it must be less.

From light and depth curves it's obvious that in red light wave length the amount of light penetration at first station was the highest, so that till the depth of 10 meters 90% of the light was absorbed and scattered and only 10% of the light reaches this depth. While for other wave lengths and the second station maximum penetration is till the depth of 7 meters. With respect to Table II the effect of physical parameters such as air temperature, salinity and wind direction in both stations are the same. Even the level of cloud cover in the second station is less but light penetration in first station is more. So according to this items its obvious that at first station because of lesser turbidity and being lactated in coastal currents with high speeds at winter, the amount of light penetration into water is more. For this reason for photosynthesis and production of organic material, this station which is located at Bushehr coasts is more convenient toward second station adjacent to Delver coasts. According to this research's results, the amount of light penetration for all wave lengths at depths which are more than 10 meters had limitations, ecological wise, two separate regions can be specified from each other based on intensity of light at winter: regions till the depth of 6 meters which are subject to light and with photo synthesis process, organic material can be produce easily; and regions beneath the depth of 6 meters till bottom in which photosynthesis had its limitations.

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