DESIGN AND REALIZATION OF AN INEXPENSIVE TRANSMITTANCE AND FLUORESCENCE METER: INITIAL REPORTING

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Abstract

We describe here the design, laboratory implementation and performance of an inexpensive yet reliable beam attenuation meter for coastal ocean measurements. In its final operational form it is anticipated to be capable of measuring backscattering and fluorescence as well. Given that these parameters are indicators of coastal ecosystem health, low cost optical instruments become valuable tools for activities such as coastal engineering, fish-farming and water quality monitoring in recreation areas.

Keywords : Monitoring, Instruments And Techniques, Coastal Management.

Introduction

The use of optical instruments for monitoring the state of coastal waters has emerged as a common practice during the last decade [1]. It is achieved by measuring specific inherent optical properties, such as scattering, absorption, beam attenuation and fluorescence. Backscattering and beam attenuation are resuspension proxies, while absorption and fluorescence are CDOM and chlorophyll indicators. In the project reported here, the main goal is to build a cheap but reliable optical instrument using widely available off the shelf components. It will be capable of measuring beam attenuation, backscattering, and fluorescence. The instrument in its final field version, will aim towards groups involved in activities such as coastal engineering, water pollution monitoring in recreation areas and fish-farming. At this stage the beam attenuation (transmittance) mode has been implemented in the laboratory and we present here the first results.

Design and implementation

The configuration for the beam attenuation mode incorporates a GaAlAs ultra-bright LED emitting 3000 mcd at 660 nm where gelbstoff absorption is negligible. The emerging 20° light cone is focused via an f=+20 mm biconvex to a $\sim$ 1 mm pinhole for conditioning, and a collimated beam with a diameter of 15 mm is shaped with the aid of an f=+50 mm lens. The beam travels through an attenuation path 130 mm long and then is refocused to a silicon photodiode which has an active area of 1.75 mm and is fitted with a dichroic red filter. The LED is driven by a current modulated at 1 KHz and electronically maintained to guarantee stability of light intensity. The reverse biased photodiode is wired to a trans-impedance mode operational amplifier and after that, the signal is further amplified and filtered by a narrow second order band-pass filter. The effect of any changes in ambient light intensity is eliminated by this stage of selective gain. This signal is then passed through a low-power, precision, true rms-to-dc converter. The output of the system provides a voltage which is linearly dependent on the intensity of the incident modulated radiation. The digital subsystem is responsible for the task of digitizing the dc output voltage of the analogue subsystem. All the circuitry is powered by a single battery by implementing a virtual ground technique.

Calibration and testing

The suspended particle concentration in coastal regions of Eastern Mediterranean ranges from $\sim$ 100 mg/l at river mouths to 5-10 mg/l at typical coastal waters. For this reason the calibration and performance testing of the instrument was carried out with suspensions of kaolin (a pure scatterer [2]). The procedure involved the preparation of an initial kaolin suspension at a concentration of 500 mg/l which was successively diluted by adding distilled water to produce several samples. Prior to each measurement, vigorous stirring ensured that the particulate material remained in suspension.

Experimental results and a fitted calibration curve are depicted in Figure 1. The instrument's response to concentrations up to 62 mg/l is notably linear (correlation coefficient 0.997). Cross-calibration with commercially available transmissometers is under way.

Conclusions

The initial laboratory version of the instrument appears to be stable and sensitive enough for typical field measurements. The value of the materials used does not need to exceed 100 euros. Laboratory experiments are in progress for the pure scattering and fluorescence modes. Here the same electronics are used, however the geometry changes. For chlorophyll fluorescence measurements, the sample excitation is achieved by two opposite to each other ultra-bright LEDs placed at an angle of 40° to the photodiode, and emitting a 20° light cone at 470 nm.

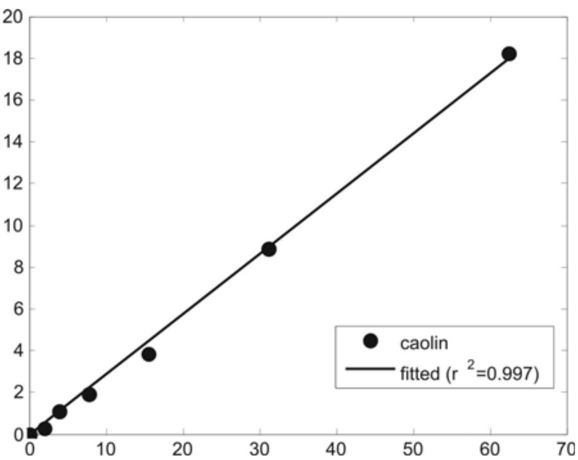

Fig. 1. Beam attenuation coefficient as a function of suspended kaolin concentration.

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