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ON THE ATTENUATION OF LIGHT IN THE SEA

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(Text-figs. 1 and 2)

Recently Jones & Wills (1956) have related the attenuation of light in the sea and in estuarine waters to the concentration of suspended solid matter. The attenuation was measured with an *in situ* hydrophotometer with a beam acceptance angle of approximately 3·20°. The concentration of suspended materials was determined by filtering in the case of natural samples or by adding known weights of kaolin or mud to tap water. In the discussion of their data and methods they have made application of the diffraction theory for opaque particles relatively large compared to the wave-length of light.

It seems worthwhile to extend the discussion in terms of electromagnetic theory for scattering of light by small relatively transparent spheres of the order in size of the wave-length of light. From an analysis of this type it may be possible to roughly estimate the predominant size of the material present in the water which was examined.

Fig. 1 (adapted from Burt, 1954) shows the theoretical extinction due to scattering as a function of particle size for uniform suspensions of small spherical particles. Extinction was computed for green light (550 mμ, approximately the centre of the visual response curve and thus corresponding to the centre of response curve of the hydrophotometer used by Jones & Wills) for 1 mg per litre suspensions of mineral material with a relative refractive index of 1·15 and a density of 2·65. The latest computations of Mie scattering for a refractive index of 1·15 were used (Pendorf, 1956). The solid lines are for light scattered in all directions, while the dashed line shows the theoretical extinction corrected to exclude light scattered into a cone of half angle 3° centred about the forward direction. The latter approximates the field of acceptance of the hydrophotometer.

Fig. 2, showing the experimental measurements of extinction v. concentration, is taken from Jones & Wills. Lines have been added which represent the theoretical relationship between extinction and concentration from the dashed line in Fig. 1. In making a rough comparison between the data and the theoretical results it should be kept in mind that a size range is present in each sample with particles of different density, shape and refractive index.

For the natural water samples taken from the Thames and the sea near Plymouth the predominant size range lies between 2·5 and 10 μ with a wide scatter between individual samples. There is a trend toward increase in particle size in the more turbid samples. The Thames Estuary samples tend to have larger particle sizes than those taken near Plymouth. The suspensions which

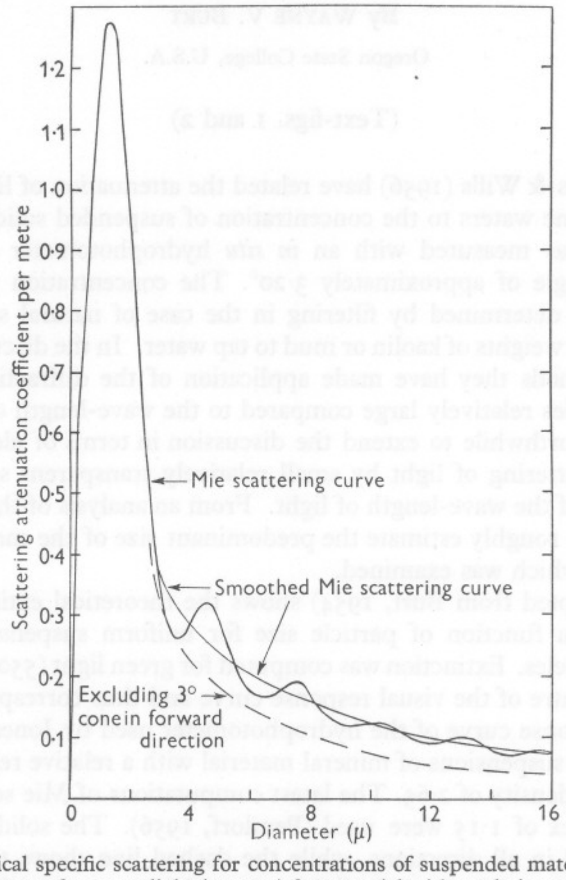

Fig. 1. Theoretical specific scattering for concentrations of suspended material of 1 mg per litre. Calculations are for green light (550 mμ) for material with a relative refractive index to water of 1·15.

were made up of Thames mud and tap water have predominate particle sizes near 3 μ, while the Kaolin suspensions probably have much smaller particles around 0·2 μ in diameter.

The anomalous change in slope near the origin in the data for Kaolin and Thames mud suspensions may be due to fine material around 1·2 μ in diameter in suspension in the tap water which would displace the Kaolin and Thames mud suspension lines upward. Another possibility is that the dispersion may vary with the concentration at very low concentrations.

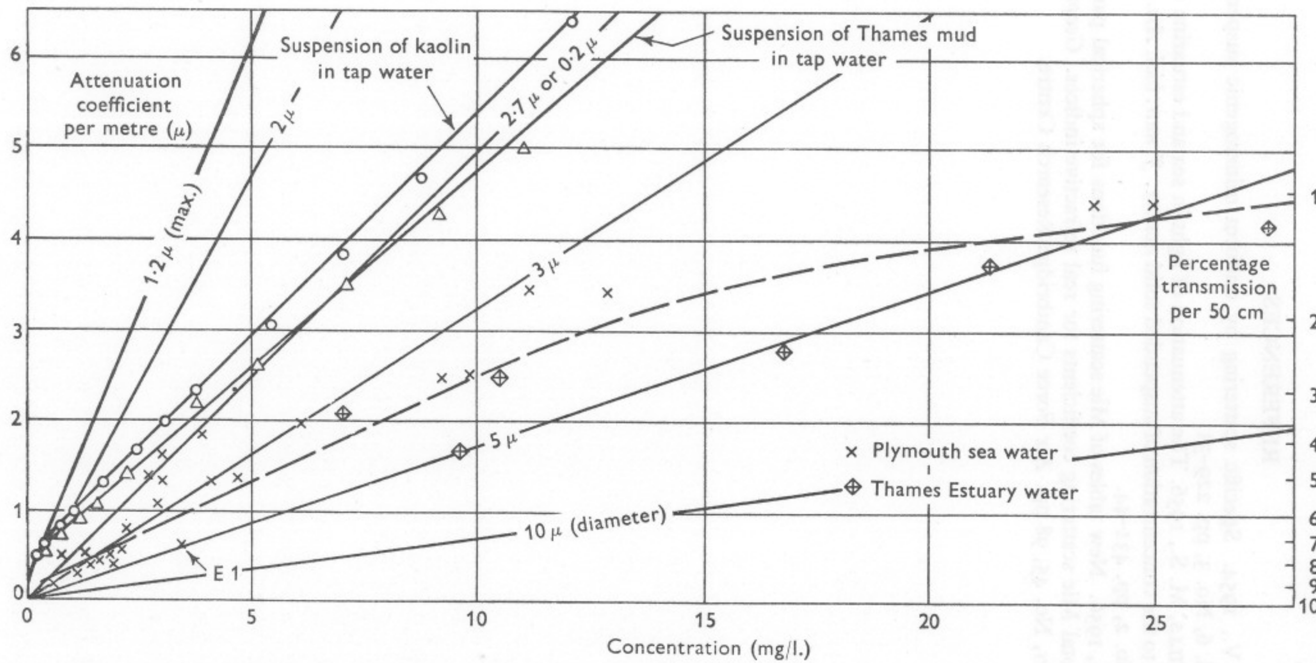

Fig. 2. Relation between attenuation coefficient per metre and concentration of suspended solid matter (from Jones & Wills, 1956). The solid lines have been added to show theoretical attenuation due to scattering by small particles with diameters of 0·2, 1·2, 2, 2·7, 3, 5 and 10 μ. E1 refers to a hydrographic station south of the Eddystone.

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