

andere Formen wird sich durch Vermehrung des Beobachtungsmaterials den gegebenen Darstellungen manch wertvoller neuer Zug hinzufügen lassen. Eh.

W. R. G. ATKINS. The Phosphate Content of Fresh and Salt Waters in its Relationship to the Growth of the Algal Plankton, *Journal Mar. Biol. Assoc.*, (1923), N. S. XIII, 119—150; *Ibid.* (1925), N. S. XIII, 700—720; *Ibid.* (1926), N. S. XIV, 447—467.

Prior to the work of ATKINS and of MATTHEWS, the determination of phosphorus in natural waters had fallen somewhat into disrepute, owing partly to the minute and apparently insignificant amount usually present and partly to the difficulties of technique and consequent uncertainty of the results.

Using the colorimetric method of DENIGÈS, Dr. ATKINS has reduced the determination of phosphate to a rapid and simple operation, accurate to ± 0.001 mg. per litre, and requiring a sample of only 100 cc. of water. It is essential in this, as in many other analytical methods, to carry out the determination as soon as possible after collection of the samples, as delay may lead to either increase or decrease of the apparent phosphate concentration — the former by disintegration of minute organisms and solution of the glass, the latter by bacterial metabolism. Numerous estimations of phosphorus have been made, on both fresh and sea waters, and much light has been thrown upon the rôle of this element in the annual cycle of algal metabolism and upon the seasonal variations in its concentration in the sea.

The phosphate content of a diatom culture was followed, until all the phosphate was used up. It was ascertained that 1 gm. of P_2O_5 is required, during the initial stages of vigorous growth, for the production of 9×10^{21} diatoms (*Nitzschia closterium*). The vernal diminution in phosphate content affords a means of estimating the organic production of a given column of sea water, and the result obtained, though admittedly based on certain assumptions, is in remarkable agreement with that deduced from alkalinity values, viz. 1.4 kg. of algal plankton per square metre of sea surface, the plankton being distributed throughout the 70-metre column in which photosynthesis may be supposed to occur.

Determinations made over a series of years, at the International Hydrographic Stations on the lines "E" and "N" in the English Channel Area, show very definitely that the phosphate content of the sea water is at a maximum (about 0.036 mg. per litre) in winter, falling to a minimal value (almost zero) in the late spring and early summer, in evident relation to the varying abundance of the algal plankton. These values are very close to those of MATTHEWS, obtained at a neighbouring station, but by a different method; another series, from the North Sea, while showing the same general seasonal trend, and agreeing so far with RABEN, differs rather widely in its numerical values from the results of that investigator. The annual cycle is completed by the disintegration of plant and animal remains at the approach of winter, restoring the phosphate content of the

surface waters to the original level, but quite apart from this seasonal and superficial cycle, there is abundant evidence, from each of the great oceans, that the deeper waters, containing 0.05—0.08 mg. P_2O_5 per litre, form a great reserve of phosphate, which may become available when brought to the surface by upwelling currents.

The concentration of phosphate, given adequate illumination, is shown to be a limiting factor to plant-growth. Silica never appears to be completely exhausted, but nitrate and phosphate may, and in fact not infrequently do, reach the zero level, in the surface layers. Under these conditions, plant growth, and therefore animal growth, must cease, until seasonal or other changes restore the balance. Tropical seas, highly insolated even in winter, show a less marked rhythm of phosphate content than those of temperate zones, while in arctic latitudes, the seasonal phosphate variation is greater, leading to a very abundant summer development of the phytoplankton.

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