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ADENOSINE TRIPHOSPHATE (ATP) IN THE MARINE ENVIRONMENT - A BIBLIOGRAPHY

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ABSTRACT

This bibliography lists published works on adenosine triphosphate (ATP) detected in the marine environment. Over 100 citations are listed in four categories: field measurements; macroscopic organisms; benthic populations; and papers on analytical methods.

INTRODUCTION

This bibliography lists the major published works describing the determination of adenosine triphosphate and reporting concentrations detected in the marine environment. Adenosine 5'-triphosphate (ATP) is a biosynthetic compound used by organisms for storage and transfer of energy within the cell. ATP has been found in all cells examined and is essential to the functions of the cell e.g. biosynthesis, active transport, contraction, motility, etc.

A method for determining adenosine triphosphate in oceanic waters was first proposed by Holm-Hansen and Booth (1966). This sensitive assay uses a chemiluminescent reaction of luciferin and the enzyme luciferase with ATP in the presence of magnesium and oxygen. The following
two step reaction has been proposed:

(1) \[ \text{LH}_2 + \text{ATP} + \text{E} \xrightarrow{\text{Mg}^+} \text{E-LH}_2-\text{AMP} + \text{PP} \]

(2) \[ \text{E-LH}_2-\text{AMP} + \text{O}_2 \xrightarrow{\text{hv}} \text{E-L-AMP} + \gamma v \]

where:

- \text{LH}_2 = \text{luciferin (substrate)}
- \text{E} = \text{luciferase (enzyme)}
- \text{ATP} = \text{adenosine triphosphate}
- \text{AMP} = \text{adenosine monophosphate}
- \text{PP} = \text{pyrophosphate}
- \text{L} = \text{dehydroluciferin}
- \gamma v = \text{photon of light}

In practice, environmental samples to be analyzed for ATP are collected on filters, extracted either in boiling tris [tris(hydroxymethyl)aminomethane] buffer (Holm-Hansen, 1969; Holm-Hansen and Karl, 1978) or in a cold sulfuric acid solution (Karl and LaRock, 1975a) and preserved until analyzed. The extraction procedure rapidly inactivates ATPase and other nucleotide degradative enzymes and extracts.

The assay procedure uses a photometer to detect the light generated by the luminescent ATP reaction. By comparing sample values with values from known standards, the ATP concentration of samples can be calculated. For more details on techniques, see Karl and LaRock (1975a) or

The concentration of particulate ATP in marine samples is useful in evaluating the distribution of microplankton and in estimating the distribution of microbial biomass. Conventional methods of estimating biomass of microorganisms in marine waters include direct microscopy, plating of viable cells, measurement of chlorophyll or other pigments, or total organic carbon measurements. These methods have limitations, the major obstacle being the presence of relatively large amounts of detrital material in the water column and the difficulty of discerning living versus non-living particulates. As ATP is rarely found outside living cells, the measurement of ATP is a rapid and accurate means of detecting living cells in the large volume of detrital material from water column samples. The specificity of the luciferin-luciferase reaction with ATP provides researchers with a reliable microbial biomass indicator (see Holm-Hansen, 1973a).

Since the first vertical profiles of microbial ATP in the water column were published, measurements of ATP and other nucleotides have expanded to include studies of ATP in macroscopic zooplankton, sediment microbial populations, and benthic organisms. The bibliography is divided into sections dealing with the nature of the published research. The four categories are field measurements, macroscopic organisms, benthic populations, and papers on analytical methods. Some citations
appear in more than one section when appropriate. Literature on fresh-
water aquatic systems which might be useful to investigators has not
been examined and is therefore not reported. Only method papers dealing
exclusively with marine samples are included.

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FIELD MEASUREMENTS (cont.)


FIELD MEASUREMENTS (cont.)


MACROSCOPIC ORGANISMS


MACROSCOPIC ORGANISMS (cont.)


BENTHIC ORGANISMS


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