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Batley G E & Florence T M. Determination of the chemical forms of dissolved cadmium, lead and copper in seawater. *Mar. Chem.* 4:347-63, 1976.
[Analytical Chemistry Section, Australian Atomic Energy Commission Research Establishment, Lucas Heights, NSW, Australia]

A novel analytical scheme was proposed to permit the measurement of seven different classes of heavy metal species in natural waters. The scheme is based on measurements using anodic stripping voltammetry before and after different transformation and separation steps. [The *SCI®* indicates that this paper has been cited in over 105 publications, making it the most-cited paper from this journal.]

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For some years prior to 1976, there had been growing worldwide interest in the measurement of different chemical forms (speciation) of metals in waters to define more accurately the toxic metal fraction. At the time, our research at the Australian Atomic Energy Commission (AAEC) was directed towards the development of analytical methods to provide baseline data for heavy metals in waters adjacent to a proposed (but never built) nuclear power station at Jervis Bay, New South Wales.

To achieve the necessarily low concentrations, and being electroanalytical chemists, we adopted anodic stripping voltammetry (ASV) as the technique of choice. This technique was still in its infancy, and in the course of our work we carried out a number of fundamental studies on the application of ASV to the analysis of seawater and marine organisms at both a hanging mercury drop and a thin mercury film electrode. We also examined, in independent studies, the use of UV irradiation to destroy organic matter and release organically bound metals, and the use of a chelating resin to extract ionic or weakly bound metal species from water.

It occurred to us that if we combined these treatment procedures, which could selectively separate or transform specific chemical classes of metals, with the ability of ASV to discriminate labile vs. bound metal, it might be possible to obtain concentration data for a large number of different groupings or classes of metal species.

After little effort the scheme that formed the basis of our paper was formulated, and all that remained was to carry it out on some real live samples. At the time we did not possess a UV-irradiation rig and were using the rig at the CSIRO Division of Fisheries and Oceanography at Cronulla, some 15 km away. To apply the full analytical scheme required some eight hours per sample, including collection, filtration, and UV irradiation at Cronulla; transportation to our laboratory for initial analyses; a return trip to Cronulla to collect the sample after four hours' irradiation; and then back to Lucas Heights again for further analysis. Needless to say, each sample necessitated a rather exhausting day's effort.

This paper attracted interest because it was the first to propose a systematic scheme for speciation analysis. It has since spawned many other schemes of varying complexity. T.M. Florence recently reviewed electrochemical approaches to trace-element speciation.[1] Our paper was timely in that in the mid-1970s environmental authorities were becoming conscious of the need for speciation measurements, but there were few published methods available that they could apply. Since that time, however, our own research has been directed with some success to simpler methods designed to specifically measure the bioavailable or toxic metal fraction. Since then, also, our division has been split off from the AAEC to become part of CSIRO, although remaining at the Lucas Heights site, where our interest in environmental trace analysis has continued.

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[1] Florence T M. Electrochemical approaches to trace element speciation in waters: a review. *Analyst* 111:489-505, 1986.

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