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Application of voltammetric techniques for water classification and monitoring in a volcanic environment

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The continuous monitoring of water in harsh environments, even for “change detection” purposes, has usually to face with many challenging technological aspects.

The usage of a voltammetric technique, with an original signal analysis approach, can provide an overall indicator of the characteristics of the water under measure.

The fundamental idea is to keep track of chemical variations without using a classical analytical approach, but extracting an aggregate information from the complex signal pattern obtained by pulsed voltammetry measurements. This study is aimed to develop a low-cost and affordable method for the continuous monitoring of a natural resource, particularly promising for the detection of its changes over the time.

Various approaches have been proposed in literature to make multi-sensor systems for wet-chemical applications such as: ion selective and non-selective (glass) electrodes, lipid/polymer membranes, SH-SAW (Shear Horizontal Surface Acoustic Wave) devices, spectrophotometry and voltammetry; systems based on these principles are sometimes referred to as “e-tongues”, and have been recently proposed in literature for classification and quality control of beverages, including drinkable water, with very promising results.

Voltammetry is a mature family of methods, extensively used in analytical chemistry; pulse voltammetry, with the aid of a suitable signal analysis support, has proven to be one of the most attractive techniques for classification and change detection purposes [C. Krantz-Rulcker et al., “Electronic tongues for environmental monitoring based on sensor arrays and pattern recognition: a review”, Analytica chimica acta, 426 (2001), 217-226].

The possibility of applying such a technique to the continuous monitoring of hy-

drothermal water is discussed here. This work will go through the description of:

- the architecture of the instrument which has been developed to perform laboratory tests,
- the essential signal processing steps,
- an experiment made on water samples taken from spatially distributed sites in the area of Campi Flegrei (Naples, Italy) and surroundings.

The test-set is based on a potentiostat which drives three Working Electrodes (WEs), made of different solid metals, and a stainless steel plate which acts as a Counter-Electrode. The time series of the current signal flowing through each WE gathers the needed information after adequate signal processing.

The only wetted parts of the system are the solid metal electrodes and the reference one, which can easily withstand the contact with high temperature water and are even quite inexpensive to maintain and change when dealing with chemically aggressive environments.

The data series (samples of the current signal), that is obtained after a sequence of pulse excitations, is processed taking selected coefficients of its Discrete Cosine Transform (DCT). Then, a sub-space which provides adequate information content is generated (feature extraction) and the observations are represented in the space generated by the first features (typically three). Each observation (vector which represents the results of each measurement session) is then projected into the feature space, and its location represents the information to be interpreted.

A foreseen application consists into using intelligent systems for triggering an automatic sampler or for sending a message to instructed people when such projection moves outside known boundaries, which may represent an anomalous condition of some interest.

A preliminary check of the discrimination capability of the system has been performed with the above said water samples as well as with commercial bottled mineral water, and results are shown.

Future development of this work will include the experimentation of such an apparatus for continuous usage, installed on a monitoring site for a long enough period.