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# Voltammetric in situ measurements of heavy metals in soil using a portable electrochemical instrument

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**Abstract**

This paper presents a portable electrochemical instrument capable of detecting and identifying heavy metals in soil, in situ. The instrument has been developed for use in a variety of situations to facilitate contaminated land surveys, avoiding expensive and time-consuming procedures. The system uses differential pulse anodic stripping voltammetry which is a precise and sensitive analytical method with excellent limits of detection. The identification of metals is based on a statistical microprocessor-based method. The instrument is capable of detecting six different toxic metals (lead, cadmium, zinc, nickel, mercury and copper) with good sensitivity.


*Keywords:* Voltammetry; Electrochemical instrumentation; Heavy metals; Soil analysis

## 1. Introduction

Heavy metals in land and natural water may have a detrimental effect on both human health and the environment [1–3]. Apart from the direct threat to health or the environment, water or land contamination can cause economic and financial damage. Therefore, the necessity of monitoring the presence of heavy metals at various points in industrial processes [4], in natural water [5] and on agricultural [6], urban and industrial sites [7,8] is highly important. The use of the instrument described in this paper offers substantial advantages over existing detection techniques, which are generally complicated to use, expensive and time-consuming [9,10].

When assessing an area of land for potential heavy metal contamination, the typical procedure which is presently followed involves the collection of a large number of soil samples, their transportation back to a laboratory [11], their pre-treatment according the detection method that will be used to determine the composition (e.g. atomic spectrometry, ICP-MS, electroanalysis), and then time-consuming data analysis and interpretation by trained personnel. Consequently, the process is slow and specialist-labour intensive. Further, the majority of samples are typically negative, yet are subjected to costly laboratory analysis. A portable instrument that can be used in the field can save resources by employing costly analysis only on positive soil samples.

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This paper describes the development of a field-portable electrochemical instrument which is capable of gathering real-time quantitative data on a range of heavy metal contaminants. The instrument is able to determine the oxidation state of the metal, which is a measure of the metal's toxicity. The unit has been developed for soil analysis in the field.

## 2. Instrumentation

### 2.1. Sensor

The sensor uses disposables screen-printed working electrodes (Fig. 1a) rather than the more common hanging mercury drop electrodes (HMDE) which are used by most traditional laboratory instruments. Apart from the size and cost difference, an important advantage of solid (screen-printed) electrodes is that they do not require the use of toxic mercury. The considerable toxicity of mercury has led some countries to ban its use completely and, as a result, alternative electrode materials are sought for use in stripping analysis [12,13]. Fig. 1b shows the sensor with the plastic cartridge which has been designed for the soil analysis. The plastic cartridge provides the mechanical support to the cell and is also the sample reservoir. The reservoir has been designed to accommodate the soil sample (Fig. 1c).

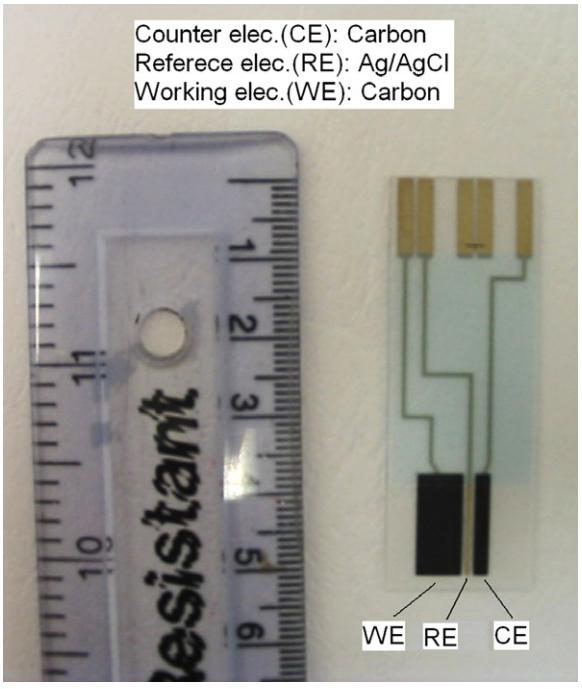


Fig. 1a. Screen printed sensor.

Fig. 1b. Plastic cartridge.

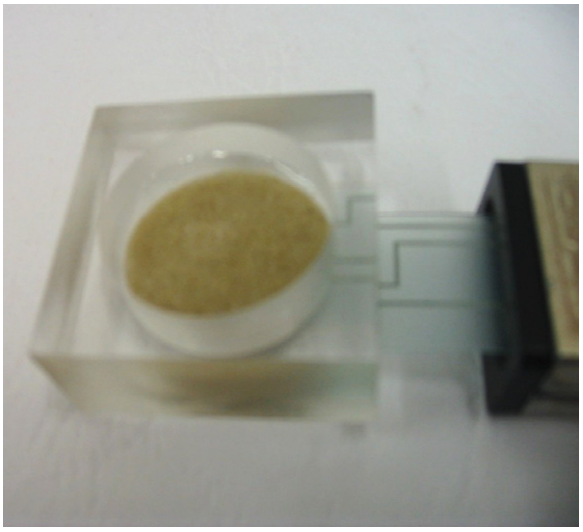

Fig. 1c. Sensor with soil sample.

### 2.2. Electronic hardware

A block diagram of the instrumentation system is shown in Fig. 2. The heart of the system is a 16 bit microcontroller which generates the excitation sig-