Pergamon

Environment International, Vol. 24, No.7, pp. 699–701, 1998

0160-4120/98 $19.00+.00

PII S0160-4120(98)00069-5

RAPID COMMUNICATION

A NEW BIOMONITOR SYSTEM BASED ON MAGNETIC INDUCTIVITY FOR FRESHWATER AND MARINE ENVIRONMENTS

A. Gerhardt
LimCo International, Oststr. 24, D-49477 Ibbenbüren, Germany

M. Clostermann
ANT Bosch Telecom, D-71520 Backnang, Germany

EI 9805-144 M (Received 1 May 1998; accepted 11 June 1998)

A magnetic inductivity method was used to build an instrument for measuring different types of behaviours in aquatic organisms. This method can be used in biological early warning systems in freshwater and marine environments. ©1998 Elsevier Science Ltd

INTRODUCTION

Behaviour is the final outcome of a sequence of neurophysiological events including stimulation of sensory and motor neurons, muscular contractions, and release of chemical messages (Lagadic et al. 1994). Changes in behaviour appear to be among the fastest and most sensitive indicators of environmental alterations (Warner 1967).

Biological early warning systems have been developed for about two decades. The main aim is to detect pollution situations by use of early stress responses of sensitive test organisms in order to protect water quality of aquatic ecosystems from waste and industrial effluents. Most systems measure, often only on a qualitative basis, either one behavioural response (e.g., rheotaxis, locomotion, valve movements, opercula movements) or a physiological parameter (luminescence, fluorescence, photosynthesis, respiration) in bacteria, algae, bivalvia, planktonic Crustacea and fish (Gunkel 1994). The Multispecies Freshwater Biomonitor, based on the quadrupole impedance conversion technique, is capable of simultaneously recording different types of behaviours of all kinds of freshwater organisms (Gerhardt et al. 1994). This system records locomotion and ventilation of benthic crustaceans and insects, which have been "forgotten groups" in aquatic online biomonitoring (Gerhardt 1995, 1996; Gerhardt and Janssens de Bisthoven 1995; Gerhardt et al. 1998).

Until now, no biological early warning system for invertebrates in marine environments has been developed. This paper describes a new method based on magnetic inductivity, which is capable of measuring movements of all kinds of aquatic organisms in freshwater and marine environments.

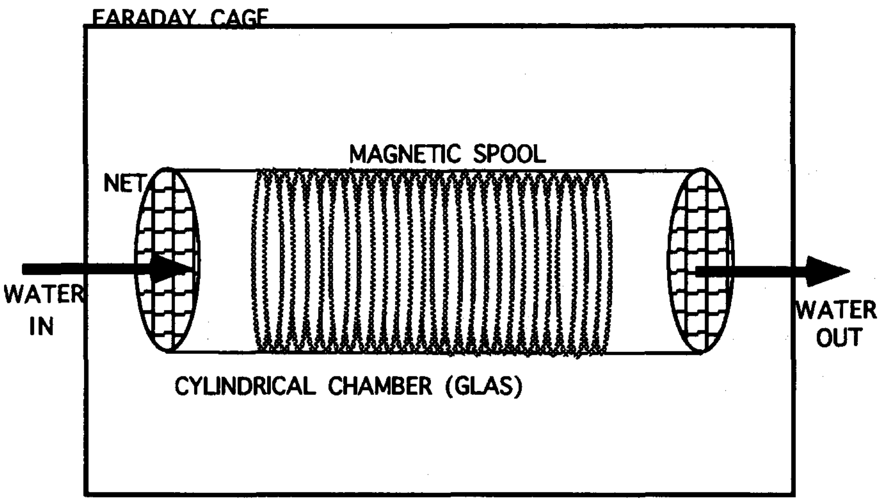

Fig. 1. Test chamber of the inductivity converter.

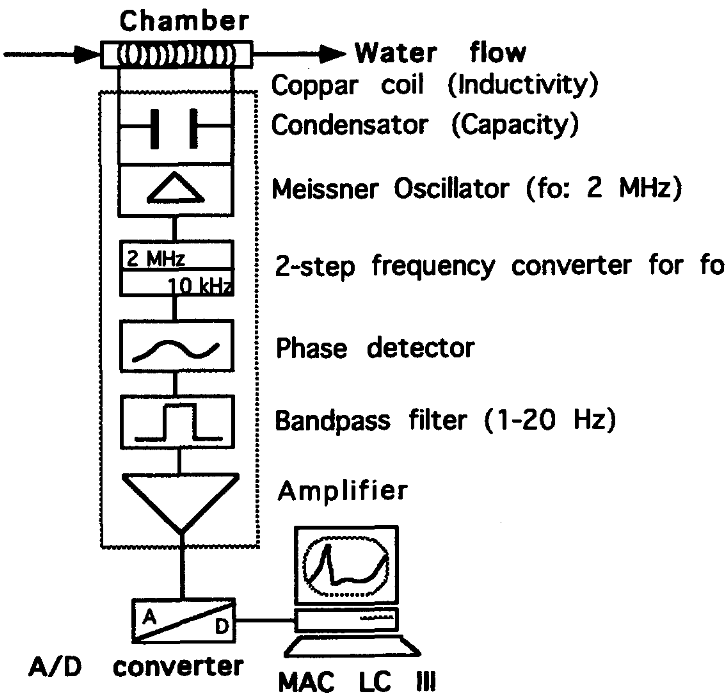

Fig. 2. Components of the inductivity converter.

METHOD

Inductivity measurements

The principle of the method is that a test organism is part of an oscillator resonance circuit. The organism provokes changes in the resonance circuit, which affect the intrinsic frequency of the Meissner oscillator, fo, which is, in this case, 2 MHz. These changes in frequency are then transformed to variations in voltage, which are proportional to the organism's movements.

The oscillator has a constant amplitude (200 mV). The resonance circuit consists of an inductivity (L) connected in parallel with a capacity (C). The intrinsic frequency of the oscillator, fo, is defined as:

$$fo = \frac{1}{2\pi (LC)^{\frac{1}{2}}}$$

As C is constant, only changes of the inductivity L have an influence on the resonance frequency fo. The inductivity is realized as a copper-coil, wired around a glass tube (1.5 cm diameter), in which the test organism is placed (Fig. 1). The inductivity depends on the number of windings, the diameter of the coil, and the magnetic permeability of the core. The core of the coil consists of the test water and the organism. As the permeability of the organism differs from that of the test water, the movements of the organism change the inductivity of the coil and, with that, the intrinsic resonance frequency of the oscillator varies up to values of fo delta-f. The sensitivity of the system can be described as delta-f/fo. In order to increase the sensitivity, a two-step frequency-conversion of fo is performed from 2 MHz to 10 kHz; however, delta-f is not affected. The output voltage is modified by a bandpass filter (1-20 Hz) to get a signal in which voltage changes are proportional to the movements of the test organism (Fig. 2).

The behavioural biomonitoring system

The test organism moves freely in its cylindrical chamber (1.5 cm in diameter, 6 cm long) in the core of the magnetic spool. The water is pumped through the chamber and nylon nets (500 µm) prevent the organism from escaping. Each chamber has to be placed in a Faraday cage to shield magnetic disturbances from outside. The electrical signals are transformed by an A/D converter and processed in a MAC LC 3 computer using Super Scope Software (GW Instruments) or the programmes written for the Multispecies Freshwater Biomonitor (Gerhardt et al. 1998). The first tests with 1 cm long insect larvae revealed a signal-to-noise ratio of 10:1 in freshwater and 5:1 in saturated saltwater (NaC1).

OUTLOOK

The described method of inductivity conversion allows the measurement of movements of aquatic organisms in freshwater and saltwater. In combination with the software of the Multispecies Freshwater Biomonitor, this system can be used as an online biological early warning system to detect changes in behaviour of sensitive test organisms due to pollution peaks. However, a series of different freshwater and marine test species must be measured first in order to calibrate this new biomonitor for its specific application. The size and construction of the test chambers must be optimized for each species. Recommended organisms are freshwater and marine amphipods, marine polychaeta, and freshwater insect larvae. The system could be used to survey water quality in harbours, at industrial effluents in the sea, and at oil platforms.

REFERENCES

Gerhardt, A.; Clostermann, M.; Fridlund, B.; Svensson, E. Monitoring of behavioural patterns of aquatic organisms with an impedance conversion technique. Environ. Int. 20(2): 209-219; 1994.

Gerhardt, A. Monitoring behavioural responses to metals in *Gammarus pulex* (L.) (Crustacea) with impedance conversion. Environ. Sci. Pollut. Res. 2(1): 15-23; 1995.

Gerhardt, A.; Janssens de Bisthoven, L. Behavioural, developmental and morphological responses of *Chironomus* gr. *thummi* larvae (Diptera, Nematocera) to aquatic pollution. J. Aquat. Ecosystems Health 4: 205-214; 1995.

Gerhardt, A. Behavioural early warning responses to polluted water – Performance of *Gammarus pulex* (L.) (Crustacea) and *Hydropsyche angustipennis* (Curtis) (Insecta) to a complex industrial effluent. Environ. Sci. Pollut. Res. 3(2): 63-69; 1996.

Gerhardt, A.; Carlsson, A.; Ressemann, C.; Stich, K.P. New online biomonitoring system for *Gammarus pulex* (L.) (Crustacea): *In situ* test below a copper effluent in South Sweden. Environ. Sci. Technol. 32: 150-156; 1998.

Gunkel, G. Bioindikation in aquatischen Ökosystemen (Bioindication in aquatic ecosystems). Stuttgart, Germany: Gustav Fischer Verlag Jena; 1994: 356-364.

Lagadic, L.; Caquet, T.; Ramade, F. The role of biomarkers in environmental assessment (5). Invertebrate populations and communities. Ecotoxicology 3: 193-208; 1994.

Warner, R.E. Bioassays for microchemical environmental contaminants with special reference to water supplies. Bull. W.H.O. 36: 181-207; 1967.