Development of the Boron Concentration Measurement Device Using Neutrons and Evaluation of the Practical Utility

Background

Boron was added to wastewater regulations by Water Pollution Control Law revision of July, 2001. Therefore, the process monitor that can measure boron concentration quickly is necessary in precise waste-water management. We applied for the patent of the boron concentration measurement device, based on high thermal neutron capture ability of boron in 2001 *1. This device requires no maintenance cost after the setting, and can measure boron concentration in real time. This is completely different from the conventional measurement techniques.

Objectives

The purpose of this study is to confirm the performance of this boron concentration measurement device from nuclear physics theory and experiments, and to demonstrate experimental proof results in real plant wastewater.

Principal Results

1. Confirmation of measurement principle

Fast neutron released from ^{252}Cf becomes thermal neutron of 0.025eV in energy level by dispersion and collision with hydrogen atoms in waste-water. Boron has high ability to capture this thermal neutron in comparison with other elements. (Fig. 1)

(1) From diffusion calculation composed of fast and thermal neutron, clear corresponding relationship was obtained between boron concentration and thermal neutron counting rate. (Fig. 2)

(2) This was confirmed by the laboratory experiment that inserted the sensor which attached neutron source and thermal neutron detector in a water tank which controlled boron concentration.

2. Evaluation of measurement precision

In consideration of current waste-water regulations, the measurement precision of this measurement method was compared with ICP analysis that is the official analysis in Japan for boron concentration in the range of 10-500mg/L.

(1) Relative error lowers so that boron concentration is high. (Fig. 3)

(2) In the range with more than 50mg/L of boron concentration, this device has precision at the same level as ICP analysis by the measurement time of minutes. (Fig. 3)

3. Result of proof experiment

The following were confirmed by one-month performance test for real plant waste-water. (Fig. 4)

(1) Stable measurement of boron concentration was possible without preprocessing waste-water, under the condition to exceed water temperature 40℃ in suspended matter density 2,000mg/L or more. (Fig. 5)

(2) Measurement precision was obtained at the same level as ICP analysis.

Thus, this device was shown to be of practical use as a process monitor of the real-time measurement. This boron concentration measurement device was released as “a boron concentration online monitoring meter” in April, 2009.

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Reference

H. Shimogaki, et al., 2009, “Development of the boron concentration measurement device using neutron and evaluation of the practical utility”, CRIEPI Report V08060 (in Japanese)

*1 : Measurement principle of boron concentration, and measurement device which uses this principle, Patent application number 2001-161867, 2001 (in Japanese)

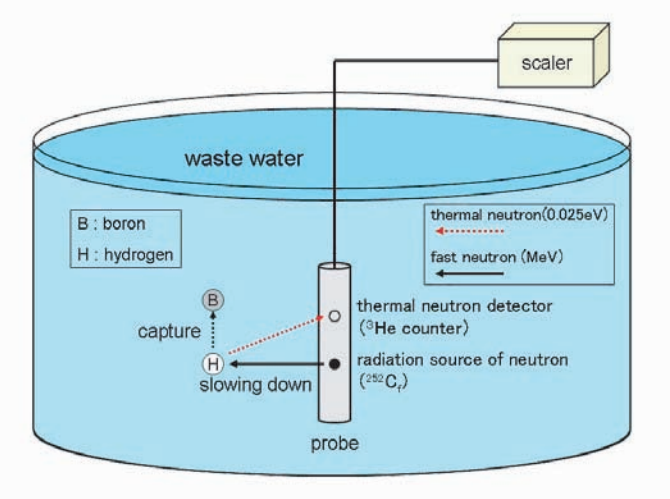

Fig.1 Fundamental principle using neutron for measuring boron concentration in waste-water

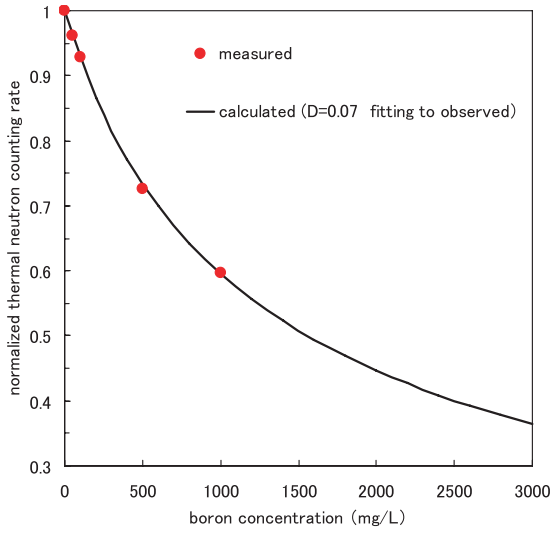

Fig.2 Comparison with measured and calculated for relationship of boron concentration and normalized thermal neutron counting rate

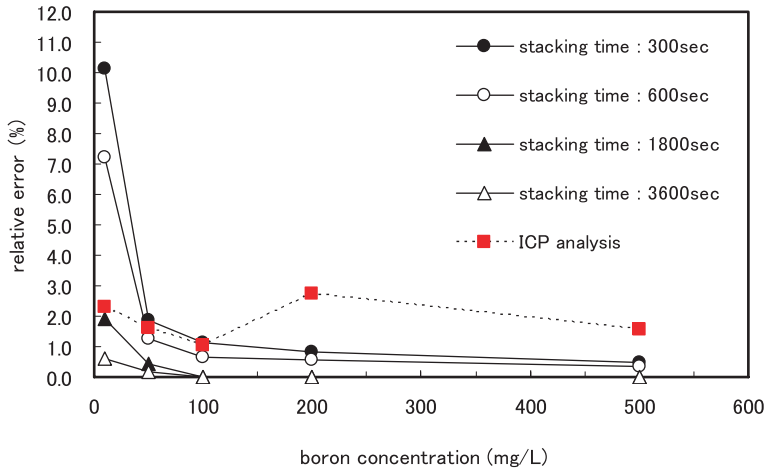

Fig.3 Precision of boron concentration measurement device

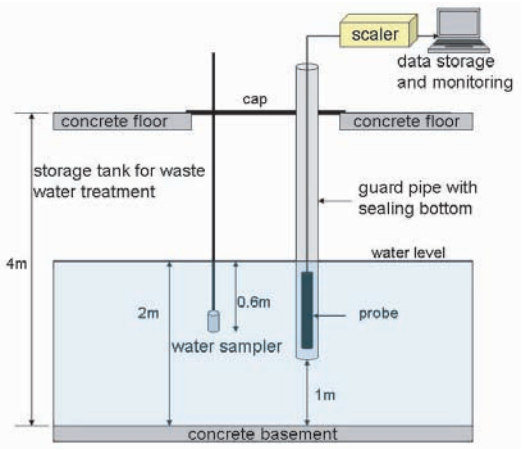

Fig.4 Outline of proof experiment in plant waste-water

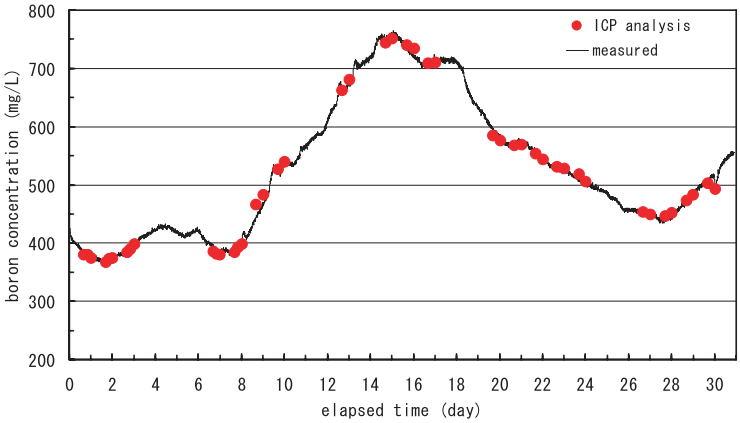

Fig.5 Result of measuring boron concentration for one-month proof experiment