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# Evaluation on potential for assessing indoor formaldehyde using biosensor system based on swimming behavior of Japanese medaka (*oryzias latipes*)

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ABSTRACT

In order to develop an early-warning biosensor system for predicting the impact on health of long-term and low-level exposure to indoor chemical compounds, e.g. volatile organic compounds (VOCs), we evaluated the potential for assessing indoor air quality using the biosensor system based on the swimming behavior of Japanese medaka (*oryzias latipes*) as an indicator of indoor air quality in the beginning. As a technology to dissolve chemical compounds into water efficiently, a micro bubble generator was introduced. The test chemical was formaldehyde which is a representative of chemical compounds existing indoors. The result of the measuring solubility of formaldehyde was that formaldehyde concentration in water was raised to 0.12 mg/L when 1.0 mg/m$^3$ of formaldehyde in air was bubbled for approximately 44 h. The correlation between the 0.1 mg/L of formaldehyde in water, which is roughly equivalent to 0.83 mg/m$^3$ of formaldehyde in air, and the swimming activities of medaka was investigated. The fish showed abnormal behavior compared to one under a control treatment, e.g. the body movement distance decreased and the duration time near the upper water column increased significantly. It was verified that it is possible to detect concentrations of formaldehyde of 0.83 mg/m$^3$ in indoor air using this proposed biosensor system.



## 1. Introduction

Increasing environmental awareness has led to interest in indoor air quality, on which many studies have been conducted. Especially, some studies have shown that that long-term and low-level exposure to volatile organic compounds (VOCs) is responsible for several health-related ailments [5–7,15,16,21,22,24,27,28,35,38,42]. Therefore, it is requested to detect these chemical substances and predict their concentration levels over prolonged periods. Furthermore, it is necessary to investigate whether they have the potential to affect health even at low concentrations, e.g. below established guidelines for VOCs, in order to create healthy indoor environments. Generally, in order to measure the concentration of formaldehyde and toluene, which are typical indoor chemical compounds considered responsible for affecting residents' health, indoor air contaminated with them is sampled using a 2, 4-Dinitrophenylhydrazine (DNPH) cartridge and Tenax TA, a porous polymer resin based on 2, 6-diphenylene-oxide. Then, they are identified and quantified using a high performance liquid chromatography (HPLC) system and a gas chromatography/mass spectrometry (GC/MS) system. However, it is difficult to predict the health impact of unknown chemical substances contained in indoor air by using such analysis systems even though it is possible to exactly quantify concentration levels. On the other hand, several studies have shown that some residents suffer from symptoms such as headaches, dizziness and fatigue, similar to symptoms for sick house syndrome, in Japan, even though the concentrations of the 13 substances designated by the Ministry of Health, Labor and Welfare are lower than guidelines for indoor concentrations [12,37]. This suggests that those symptoms are triggered by exposure to chemical compounds not being addressed and toxic materials generated from reactions between chemical substances. Therefore, it would be useful not only to measure the concentration of chemical compounds designated as major indoor chemical substances, but also to carry out comprehensive evaluations of long-term exposure to indoor airborne substances considered responsible for affecting residents' health.

In recent years, simple measuring instruments based on chemical and physical principles have been designed to measure airborne chemical substances in indoor air, but they need to be regularly calibrated by precise measuring instruments [36,41]. Furthermore,

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