Development of Environmental Biosensors for Endocrine Disrupters

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RESEARCH OBJECTIVES

Water recycling is an important strategy for management of this scarce resource, but concerns about residual contamination in recycled water remain a limiting barrier in implementing water conservation through water recycling. Concerns have developed around endocrine disrupting compounds (EDCs) in recycled water because of their ability to mimic hormones involved in many biological processes, including immune function, reproduction, growth, and control of other hormones. EDCs are hormonally active at small concentrations (parts per billion or trillion). The list of EDCs found in water is steadily growing and includes many common agricultural, industrial, and household chemicals and their degradation products. Significant sources of EDCs include both synthetic chemicals like pesticides and those produced naturally by plants and animals. The objective of this work is to develop analytical capabilities to characterize the diverse sources of EDCs in urban and agricultural sources to evaluate the connection between EDCs and pesticides, and to develop biosensors to detect EDC activity in natural sources.

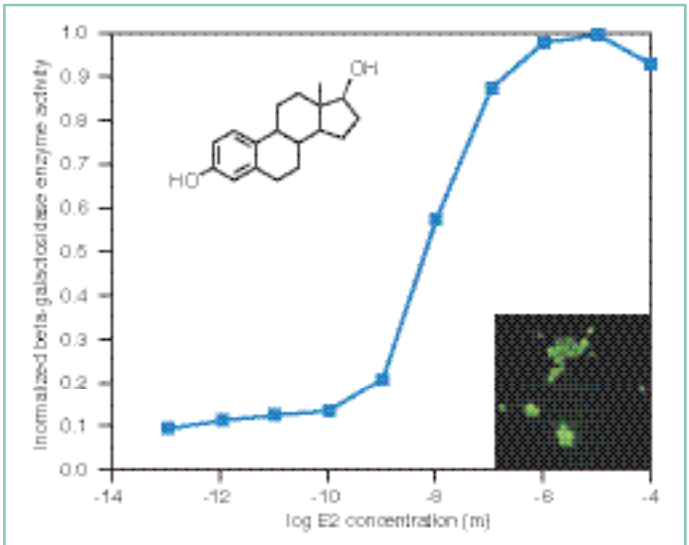

Figure 1. Dose-response of β-galactosidase enzyme production when the estrogen-responsive yeast strain RMY/ER-ERE is exposed to the hormonal estrogen 17β-estradiol (E2). Inset is the chemical structure of E2 and the fluorescent response of live yeast cells to E2. Other estrogenic compounds, including some EDCs, may behave in a similar manner, eliciting a similar response.

APPROACH

Traditional analytical techniques (gas chromatography, gas chromatography/mass spectrometry, high-pressure liquid chromatography) were used for calibration and verification of bioassays. Analytic capabilities were developed for hormones in both sediment and water to improve sensitivity and modify the techniques for use in an automated system. Enzyme-linked immunosorbent assay (ELISA) kits were used for analysis of estrogenic chemicals in water, wastewater, wastewater solids, and sediment. Chromogenic and fluorescent bioassays were developed to monitor estrogenic activity in water samples, and the response was studied using microscopy and spectroscopy to evaluate cell structural changes, viability, and response (Figure 1).

ACCOMPLISHMENTS

A prototype biosensor system was developed to measure the cellular response of luminescent microbes, providing the hardware necessary to use a luminescent EDC biosensor using fluorescence. Extensive bioassay development was performed on time-lapsed EDC activity response in live estrogen-sensitive yeast cells. This fluorescence assay was used in conjunction with Fourier-transform infrared (FTIR) spectromicroscopy, a noninvasive technique used for collecting real-time data on live cells. Employing these methods, we collected dose-response and abundant complementary data on multiple intercellular mechanisms (Figure 1).

SIGNIFICANCE OF FINDINGS

The biosensors developed provide a novel tool for assessing estrogenic compounds and surfactants. We have applied the biosensors to waters from agricultural systems and will apply them to water from the San Joaquin River Basin, and various wastewater treatment systems. Additionally, the sensors will be applied in wastewater treatment plants to demonstrate their usefulness for management of EDC degradation in wastewater treatment processes.

RELATED PUBLICATIONS

Campbell, C.G., S.E. Borglin, W.T. Stringfellow, F.B.Green, and A. Grayson, Review of bioassays for monitoring fate and transport of estrogenic endocrine disrupting compounds in water. Critical Reviews in Environmental Science and Technology (submitted), 2005.

Campbell, C.G., S.E. Borglin, W.T. Stringfellow, F.B.Green, and A. Grayson, Biologically based sensors for endocrine disrupting compounds in water. Conference Paper, American Society of Civil Engineers, Alaska, May 15–20, 2005.

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