Effects of PBDEs on Enzymatic and Non-enzymatic Antioxidants in Seedlings of Kandelia obovata

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Introduction

- Due to anthropogenic activities, polybrominated diphenyl ethers (PBDEs) are emerging global environmental pollutants. Mangrove ecosystems closed to human settlements are often used as environmental waste/disposal areas and dumping sites.
- PBDEs are toxic to organisms as they induce oxidative stress through the over-production of reactive oxygen species (ROS). To combat such stress, many organisms develop antioxidative defense systems.
- Mangrove plants are well-known to have high content of tannins and have special adaptations to stressed environment, such as saline and anoxic conditions. Whether mangrove plants also possess defense systems to minimize the harmful effect of ROS caused by PBDEs have seldom been reported.

Kandelia obovata Sheue, Liu & Yang (Ko) is the most common mangrove plant species in Hong Kong and distributes at all tidal levels (Fig. 1). It is a good model plant to determine the response to PBDEs.

Objectives

- To investigate the effects of BDE-47, a typical congener of PBDEs, at different contamination levels on the antioxidative defense system of the seedlings of Kandelia obovata in hypoxic culture.
- To compare the sensitivity of the antioxidative enzymes, including superoxide dismutase (SOD), peroxidase (POD) and catalase (CAT) with the non-enzymatic antioxidants, including total polyphenols (TP), extractable condensed tannins (ECT), protein-bound condensed tannins (PBCT) and fibre-bound condensed tannins (FBCT), in roots and leaves, aiming to identify the potential indicator to PBDE oxidative stress.

Materials & Methods

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Results & Discussion

Antioxidative enzymes

- SOD: The changes of SOD in roots and leaves due to BDE-47 were similar. At high and very high levels of BDE-47, SOD activities were significantly higher than that at medium and low levels which were comparable to the controls in week 1. Such increases was still observed in week 4 but significantly declined in week 8 at a high BDE level, while decreases were found in SOD at very high BDE level from week 4 onwards (Fig. 3A and 3B). These results indicated that the SOD defense system might have been destroyed by long-term exposure to high level of BDE contamination.
- POD: Similar trends as SOD but more sensitive, as significant increases in POD were found in seedlings received even at low level of BDE-47 in week 1. The increase carried on to week 4 and week 8 under low and medium BDE contamination although at a lesser extent, while significant decreases were detected under very high and very high contamination levels in week 8 (Fig. 3C and 3D).
- CAT: The changes due to BDE contamination were similar to that of POD, except increases of CAT under different BDE levels lasted till week 8 although the increases became less and less as exposure time (Fig. 3E and 3F). The effects of BDE-47 levels and time were significant according to two-way ANOVA, especially POD activity in roots, indicating POD was a more sensitive response than the other two enzymes (Table 1). The interactions of BDE levels and time were also significant, suggesting that the enzymatic responses were both time- and contamination level-specific.

Non-enzymatic Antioxidants

- TP: TP in roots only showed significant decreases at very high BDE levels in weeks 4 and 8 but decline was found in leaves at both high and very high BDE levels (Fig. 4A and 4B). The decrease in leaves at same BDE level was also more than that in root, indicating that TP was more sensitive than TP.
- ECT: Same as TP, ECT also decreased at high and very high BDE levels (Fig. 4C and 4D). The decrease in leaves at same BDE level was also more than that in root, indicating that TP was more sensitive than TP.
- CAT: The changes of CAT in roots were similar to that of POD, except increases of CAT under different BDE levels lasted till week 8 although the increases became less and less as exposure time (Fig. 3E and 3F). The effects of BDE-47 levels and time were significant according to two-way ANOVA, especially POD activity in roots, indicating POD was a more sensitive response than the other two enzymes (Table 1). The interactions of BDE levels and time were also significant, suggesting that the enzymatic responses were both time- and contamination level-specific.

Conclusions

- For all types of tannins, the effects of BDE-47, irrespective to the contamination levels, were not significant in both roots and leaves, suggesting that non-enzymatic antioxidants were less sensitive to BDE-47 than antioxidative enzymes.
- TP: TP in roots only showed significant decreases at very high BDE levels in weeks 4 and 8 but decline was found in leaves at both high and very high BDE levels (Fig. 4A and 4B). The decrease in leaves at same BDE level was also more than that in root, indicating that TP was more sensitive than TP.
- CAT: The changes of CAT in roots were similar to that of POD, except increases of CAT under different BDE levels lasted till week 8 although the increases became less and less as exposure time (Fig. 3E and 3F). The effects of BDE-47 levels and time were significant according to two-way ANOVA, especially POD activity in roots, indicating POD was a more sensitive response than the other two enzymes (Table 1). The interactions of BDE levels and time were also significant, suggesting that the enzymatic responses were both time- and contamination level-specific.

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Fig. 1. The location of eight different mangrove species in a mangrove nursery in Ting Chau, Hong Kong (Yang et al., 2010). Acanthus and mangrove (Ko) are anemone macrophyte, Bg: Bambusa gymnorrhiza, Sh: Syringa oblata, Kl: Kandelia obovata, Ln: Lasius camerunensis, Pl: Plantago hirta, rivulus (from face of China, DEDC).

Fig. 2. Hydroponic set-up

Fig. 3. Acanthus

Fig. 4. Comparison of antioxidative enzymes (SOD, TP, and CAT activities (μg mg−1prot) in roots and leaves of the Acanthus and mangrove (Ko) control, treated at 0, 5, 10, 5, 100, and 10, 000 mg g−1 FW. (Control, 0 mg g−1 FW, root and leaf samples were not treated with different BDE concentrations due to a very high antioxidant activity and standard deviation of three replicates are shown).