Enzyme activities and glyphosate biodegradation in a riparian soil affected by simulated saltwater incursion

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◆Introduction

As an interface and transition zone between terrestrial and aquatic ecosystems, riparian wetlands and associated microbial, plant and fauna processes have multiple ecological and environmental functions such as riverside protection, water purification and herbicide non-point pollution control. Soil salinization due to saltwater incursion, is a major threat to biochemical activities and thus strongly alters biogeochemical processes in a freshwater riparian of coastal estuary region. A pot incubation experiment was conducted to investigate the effects of simulated saltwater incursion on some key enzymatic activities and biodegradation dynamics of herbicide glyphosate in a riparian soil in Chongming Island located in the Yangtze River estuary, China.

◆Materials and Method

A pot incubation experiment was conducted. Non-contaminated soil was obtained from the 0-30 cm depth of a riparian wetland (121.26° E, 31.55° N) in the Southwest of Chongming Island, where soil salinity is relatively slight due to receieving less seawater incursion. 200g dry weight equivalent BSM-contaminated riparian soil was weighed into a 500-ml flask and statically incubated at 30 ºC in an incubator without illumination.The saltwater additions with 0%, 10%, 20%, and 50% seawater were made once per day for 10 d. The incubation experiment ran for 50 d. Soil sampling was carried out at intervals of 1, 7, 14, 21, 28, 35, 42, 50 d of incubation period.

◆Results and Discussion

(1) Biodegradation dynamics of glyphosate in riparian soils

saltwater addition with 10% artificial seawater significantly increased the biodegradation efficiency of glyphosate with the lowest residual concentration among all the treatments. This was attributed to increased substrate availability with relatively high salt concentrations through either increased dispersion of soil aggregates or dissolution or hydrolysis of soil organic matter. However, glyphosate degradation was markedly decreased in the riparian soil with high levels of saltwater treatment. As compared with no saltwater treatment, the half-lives for 20% and 50% seawater treatments were prolonged by 4.9% and 21.1%, respectively.

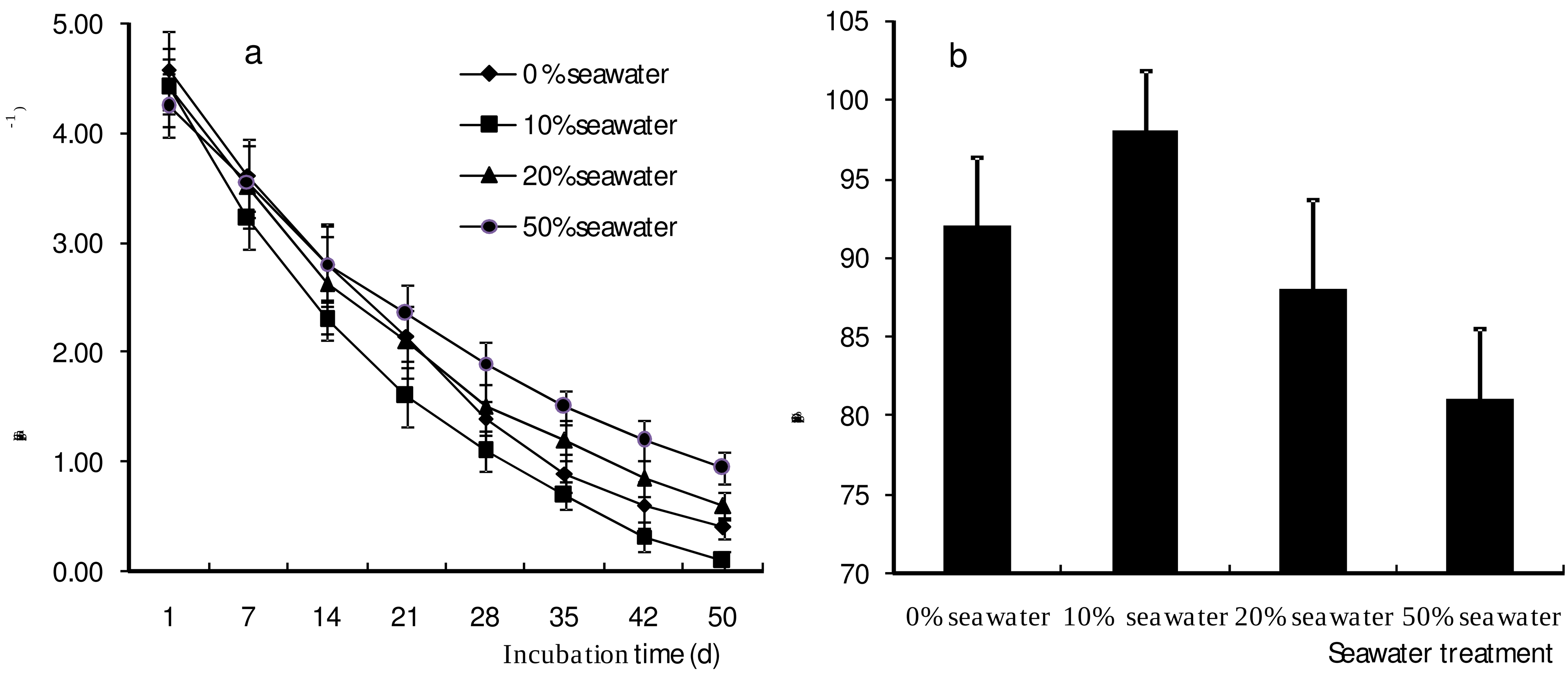

Fig.1 Biodegradation dynamics (a) and degradation percentage (b) of glyphosate in riparian soils affected by saltwater treatments.

(2) Key enzymatic activities in the glyphosate -spiked soil

Throughout the incubation period, saltwater addition with 10% seawater stimulated the enzymatic activities in the glyphosate-spiked riparian soil, as compared to the treatment with 0% seawater. Flourescein diacetate (FDA) hydrolysis rate, dehydrogenase activity (DHA), catalase activityin the glyphosate-spiked riparian soil treated with 10% seawater were 68.5%, 49.2%, 38.7%, and 28.6% higher than those for no saltwater treatment, respectively.

The effect of 20% seawater treatment on the glyphosate-spiked riparian soil enzymatic activities fluctuated between promotion and inhibition depending on the type of enzymes. Soil enzymatic activities were severely depressed by increasing salinity level with 50% seawater treatment, relative to no saltwater treatment. Especially, FDA hydrolysis rate and DHA were decreased by 73.8% and 64.8%, respectively, as compared to no saltwater treatment.

Glyphosate degradation percentages were strongly positively correlated to the FDA hydrolysis rate and DHA, indicating that as compared to the other enzymes, the two enzymes contributed more to the herbicide biodegradation in the salt-affected riparian soil.

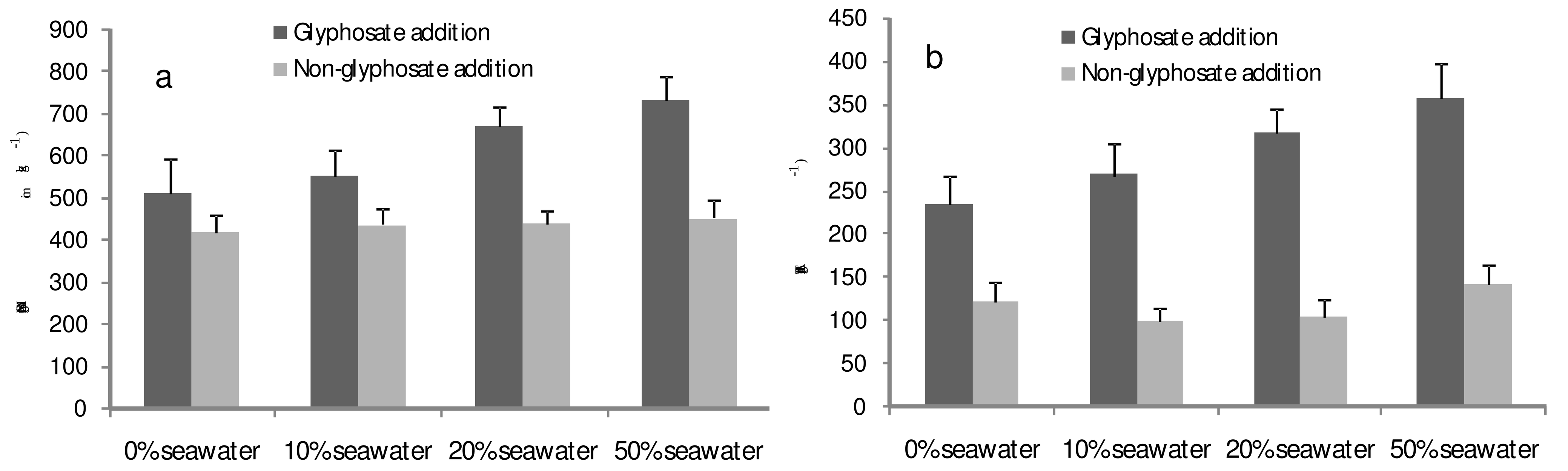

Fig.2 Soil microbial biomass C (MBC) (a) and microbial ATP content (b) in the glyphosate -spiked riparian soils affected by saltwater treatments.

Table 1 Variations of key enzymatic activities in the glyphosate -spiked riparian soils affected by saltwater treatments

Treatments	Dehydrogenase (μg TPF[1] g^{-1} soil 24 h^{-1}) 7d	21d	50d	FDA hydrolysis rate /(μg fluoreμscein g^{-1} soil) 7d	21d	50d	Catalase activity /(μmol $KMnO_4$ g $^{-1}$ soil min^{-1}) 7d	21d	50d
0% seawater		26.72 a	30.78 b	22.67 b	28.78 b	31.23 b	7.452 a	9.146 a	7.844 b
10% seawater	18.56 b [a]	27.22 a	35.41 a	26.74 a	32.75 a	38.34 a	8.021 a	12.78 a	17.56 a
20% seawater		19.34 b	15.23 c	17.15 c	19.12 c	13.78 c	7.121 a	9.123 a	6.341 c
50% seawater	3.12 a	11.34 c	11.87 d	13.34 d	8.453 d	8.125 d	4.789 b	3.112 a	2.784 d

2.12 a
7.45 b

◆Conclusion

Due to the inhibitory effects on key enzymatic activities, high level of saltwater treatment showed markedly lower degradation rates and prolonged half-life as compared to no saltwater treatment. Consequently, the riparian soil treated with 50% seawater showed the lowest degradation percentage and the highest BSM residual concentration after laboratory incubation for 50 days. However, low level of saltwater treatment with 10% seawater significantly enhanced the BSM degradation in the riparian soil.

◆Acknowledgement

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Thank s for your attention!