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## Evaluation of lead and chromium tolerance and accumulation level in *Gomphrena celosoides*: a novel metal accumulator from lead acid battery waste contaminated site in Nigeria

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### ABSTRACT

Biology, tolerance, and metal (Pb and Cr) accumulating ability of *Gomphrena celosoides* were studied under hydroponic conditions. The seedlings were raised in Hoagland's solution containing different concentrations of Pb (0, 500, 1000, 1500, 2000, 3000, 4000, and 5000 mg l<sup>-1</sup>) and Cr (0, 50, 100, 150, 200, 300, and 400 mg l<sup>-1</sup>). Biomass and metal accumulation in different plant parts were determined at seven (7) and fourteen (14) days after stress. Antioxidant enzyme activities, protein, and proline contents were estimated in stressed and unstressed plants. *Gomphrena celosoides* was able to tolerate Pb and Cr concentrations up to 4000 and 100 mg l<sup>-1</sup>, respectively in hydroponic solution. Metal accumulation was concentration and duration dependent with the highest Pb (21,127.90 and 117,985.29 mg kg<sup>-1</sup>) and Cr (3130.85 and 2428.90 mg kg<sup>-1</sup>) in shoot and root, respectively found in the plants exposed to 5000 mg l<sup>-1</sup> Pb and 400 mg l<sup>-1</sup> Cr for 14 days. Proline, antioxidant enzyme activities, and protein contents were the highest in plant exposed to higher Pb and Cr concentrations for 7 and 14 days. *Gomphrena celosoides* could be considered as Pb and Cr accumulator with proline and increase in antioxidant enzyme activities being the tolerance mechanisms.

### KEYWORDS

Tolerance; hyperaccumulation; osmolytes; abiotic stress; metallophytes; heavy metals; antioxidants

### Introduction

Increase in industrialization and urbanization has been blamed for the contamination of the environment with toxic heavy metals like Pb, Cr, As, Cd, and Cr (Peterson and Girling 1981; Zayed and Terry 2003; Morsy et al. 2012). The most worrisome of this is the contamination of agricultural land with heavy metals. It reduces the size of arable lands, reduces crop yield by disrupting the physiological and biochemical processes and it poses threats to human health through food poisoning (Shanker et al. 2005; Rizwan et al. 2018). To restore contaminated soil and enhance crop yield, different methods have been proposed for the remediation of metal contaminated soil; chemo-remediation (Ogundiran 2007), excavation and landfilling, compost remediation (Rennevan et al. 2007; Bolan et al. 2010; Adejumo et al. 2011), soil washing and flushing (Iturbe et al. 2003; Udovic and Lestan 2009; Moon et al. 2012), and phytoremediation (Brooks 1998; Li et al. 2003; Shah and Nongkynrih 2007). Among these, phytoremediation approach is currently gaining much attention because of its eco-friendliness and cost effectiveness (Cunningham and Berti 2000; Reeves 2006). It is a green technology that is self-sustainable compared to the conventional physical and chemical remediation procedures (USEPA 2000; Pokhrel and Dubey 2012).

Phytoremediation comprises of phytoextraction, phytostabilization, rhizofiltration, and phytovolatilization (Pulford

and Watson 2003; LeDuc et al. 2004; Padmavathiamma and Li 2007). The phytoextraction process which involves the use of plants to absorb metals from contaminated matrices is commonly employed (Brooks 1998; Li et al. 2003; Shah and Nongkynrih 2007). The plants for phytoextraction process must, however, be tolerant and be able to accumulate high concentration of metals in their above-ground tissue (Clemens 2006). These plant species are called metal accumulators or hyperaccumulators (Brooks et al. 1977; Kramer 2010) and are categorized as plants that can accumulate metals in the shoot from 100 to 1000 fold compared to non-accumulators without showing any toxicity symptom (Baker 1987; McGrath et al. 2002; van der Ent et al. 2013). They achieve this through the help of several stress tolerance markers which could be enzymatic or non-enzymatic strategies (Clemens 2001). The non-enzymatic include, production of stress-related osmolytes and amino-acids like proline, glutathione, phytochelatin, glycine betaine, cysteine, etc.), while, the enzymatic strategy involves the up or down regulation in the activities of the enzymes associated with stress such as aminotransferases or ureases, superoxide dismutase and catalase (Clemens 2001; Candan and Tarhan 2003; Hossain et al. 2012). The enzymatic and non-enzymatic strategies help in increasing stress tolerance and preventing oxidative stress by scavenging the reactive oxygen species