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Are indigenous sedges useful for phytoremediation and wetland rehabilitation?

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INTRODUCTION

Toxic metal pollution is a side effect associated with mining (van der Merwe *et al.*, 1990), sewage pollution (Muchuweti *et al.*, 2006) and agricultural practices (Jadia and Fulekar, 2009). South Africa, a rapidly developing country, increasingly faces this kind of pollution in catchments such as the Olifants River (Dabrowski *et al.*, 2010). Future development plans of the mining industry, such as in the Waterberg area (Schachtschneider *et al.*, 2010), will put additional catchments at risk of metal contamination.

It is necessary to investigate options for remediation in already polluted catchments, and to properly plan for future developments. Phytoextraction is emerging as a cost-effective and long-term method of removing metal pollutants from soil, especially in widespread areas with low to medium contamination levels (US EPA, 2000; Singh and Jain, 2003; Paquin *et al.*, 2004; Jadia and Fulekar, 2009). In phytoextraction, selected plants accumulate and stabilise metals in their tissue, making it possible to harvest and sometimes even use them as a metal resource (USEPA, 2000; O'Niell and Nzengung, 2004). Plants are reported to accumulate up to 5% of their dry weight in nickel (Baker, 1995). Shoot accumulators are favoured for harvesting and removal from site (USEPA, 2000).

Several wetland plant species have been investigated internationally for their accumulative properties, including *Lemna minor, Eichhornia crassipes, Typha latifolia* and *Typha capensis, Juncus effusus, Cladium mariscus, Arundo donax* and *Phragmites australis* (van der Merwe *et al.*, 1990; USEPA, 2000; Deng *et al.*, 2004; Komosa *et al.*, 2006). Their introduction into catchments for phytoextraction purposes may however pose a whole set of alien invasive problems. Hence it is valuable to investigate the accumulation capacity of species indigenous to contaminated areas. Sedges (*Cyperaceae*) are typical wetland plants that are still understudied in South Africa, and hence their potential as phytoextractors is unestablished.

The aim of this brief, ongoing study is to determine whether sedges and other wetland graminoid species, common to the wider Limpopo catchment, accumulate the metals Al, Fe, Mg and Mn – which are common wetland pollutants in north-eastern parts of South Africa. Plant specimens were selected from the relatively pristine Mokolo and Lephalale rivers as well as the heavily polluted Olifants catchment. The sedges *Schoenoplectus corymbosus* and *Cyperus haspan* were collected, as well as *Phragmites australis* and *Juncus effusus*. The latter two species have previously shown to accumulate metals (Pb, Zn, Cu) (Deng *et al.*, 2004) and also occur naturally in the area.

METHODS

Sampling procedure

Vegetation species *S. corymbosus, C. haspan* and *P. australis* occurred in the middle reaches of both the impacted Olifants River and the reference Waterberg sites. Species *J. effusus* only occurred in the Olifants catchment. Samples were taken in June 2009 and in May 2010.

Specimens were sampled in the riparian zone, pressed, dried and frozen for 48 hours at - 25°C. Subsequently at least 5grams of above-ground material per sample were cut and placed into labelled HDPE sample tubes (Remon *et al.*, 2005).

Spectrophotometric analysis of samples

Samples were oven-dried for 24hrs and homogenised with a ball mill. Ground samples were microwave digested to dissociate metals from the sample matrix. The acid mixture was diluted and filtered as described in Ip et al. (2007). The modified XP1500 Method and inductively coupled atomic emission spectrometry were used to quantitatively analyse for metals (Fe, Al, Mg and Mn). Data are reported as mg/kg dry weight (mg/kg d.wt).

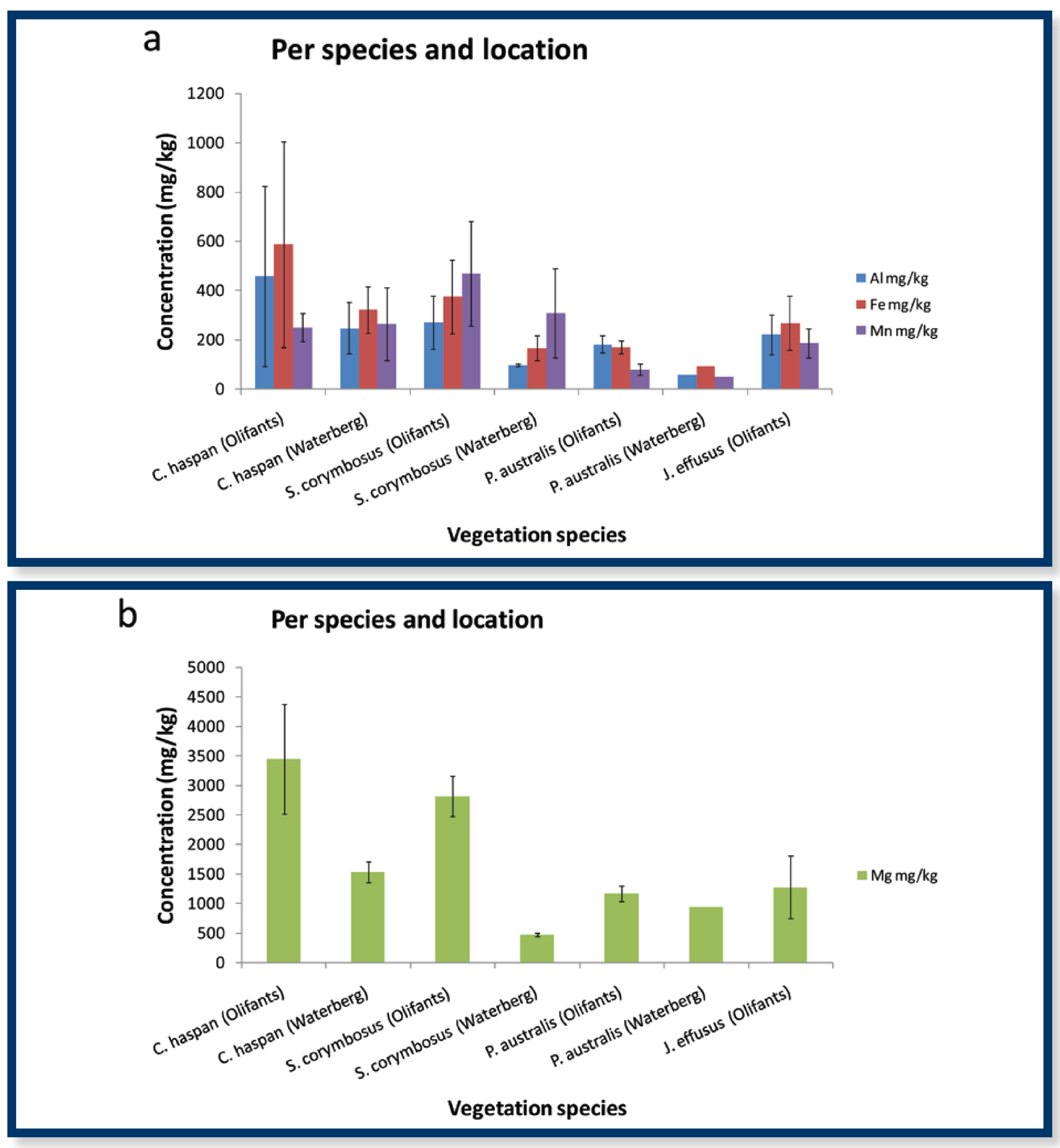

Figure 1: Results for the (a) Al, Fe, Mn and (b) Mg metal concentrations in the Olifants and Waterberg vegetation species of *C. haspan* (OL, n=3; WB, n=4), *S. corymbosus* (OL, n=4; WB, n=2), *P. australis* (OL, n=8; WB, n=1) and *J. effusus* (OL n=3) collected from different sampling locations.

RESULTS AND DISCUSSION

Metal concentrations were higher in the polluted Olifants than in the Waterberg (**Figure 1a**) samples. Comparatively higher metal concentrations were found in *C. haspan* at both locations, with highest values for Al and Fe. Manganese concentrations were highest in *S. corymbosus* at the Olifants, followed by *S. corymbosus* at Waterberg as well as *C. haspan* at both sites.

Mg concentrations in **Figure 1b** were higher compared to the Al, Fe and Mn concentrations. The sedges *C. haspan* and *S. corymbosus* again show good potential for above-ground accumulation of Mg.

Table 1: Average metal concentrations (Al, Fe, Mn and Mg) in roots versus shoots, measured in *S. corymbosus* (n=2) and *P. australis* (n=8) from the Olifants River sites. Results in brackets indicate (± 1 SE)

Species	Al mg/kg	Fe mg/kg	Mn mg/kg	Mg mg/kg
S. corymbosus shoot	384 (166)	532 (251)	685 (405)	2405.5 (552.5)
S. corymbosus root	1888 (515)	3110.5 (68.5)	2002.5 (1561.5)	1991.5 (64.5)
P. australis shoot	225 (36.5)	188.4 (30.5)	80.25 (21.3)	1191.6 (120.2)
P. australis root	10733 (1371.4)	10824.3 (1436.2)	1652.1 (633.2)	1859.4 (298.3)

Initial screening of root versus shoot accumulation show that *P. australis* is an excellent accumulator of Al, Fe and Mn in roots, with a shoot to root uptake ratio of 1:48 for Al, 1: 57 for Fe and 1:21 for Mn. *S. corymbosus* is a better shoot accumulator, with a shoot to root accumulation ratio of 1:5 Al, 1:6 Fe and 1:3 Mn. Both species accumulated near-equal amounts of Mg in shoots versus roots (1:1.5 *P. australis*; 1:0.8 *S. corymbosus*).

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Figure 2: *Schoenoplectus corymbosus* stand in the Olifants River.

Figure 3: Pressed specimen of *Cyperus haspan*.

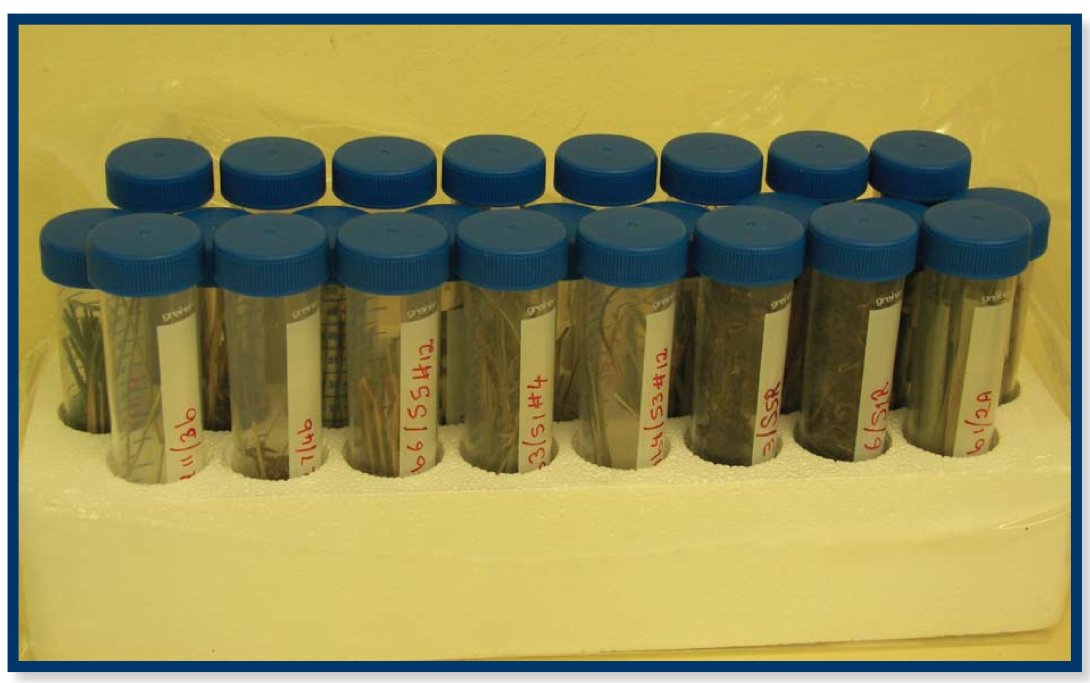

Figure 4: Sampled specimen ready for laboratory processing

Indigenous wetland plants are promising candidates to extract and accumulate heavy metals along freshwater ecosystems. The regular harvesting and disposal/ metal extraction of such plants could help to remediate the impacts along polluted river systems.

CONCLUSIONS

Both *C. haspan* and *S. corymbosus* show better shoot accumulation potential than *P. australis* and *J. effusus*. Initial root versus shoot accumulation suggest that *P. australis* is a better root accumulator than *S. corymbosus*. The three species occupy varying water depth/inundation regimes and vary in amount of biomass production in a year, and therefore have potential to be used for phytoextraction in wetlands of various wetland types.

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