Original Research Article

Characterization of Polyphenols and Mineral Contents in Three Medicinal Weeds

ABSTRACT

Aims: Common weeds *Rorippa palustris* (L.) Besser, *Euphorbia rothiana* Spreng. and *Schoenoplectiella articulata* (L.) Lye are used for food, medicinal, green biofertilizer and bio-sorbent applications. In this work, their polyphenol and mineral contents have been characterized.

Methodology: Samples from aforementioned three plants were manually collected in Raipur city (CG, India) and processed for the analyses. Folin-Ciocalteu and aluminum chloride were used for the spectrophotometric determination of polyphenols. The mineral contents were quantified by X-ray fluorescence.

Results: The total concentration of 20 elements (viz. P, S, Cl, As, Se, K, Rb, Mg, Ca, Sr, Ba, Al, Ti, Cr, Mn, Fe, Co, Zn, Mo and Pb), total polyphenol and flavonoid contents in the leaves ranged from 46372 to 71501, from 47877 to 73791 and from 1950 to 9400 mg/kg, respectively. Remarkable concentrations of several nutrients (P, S, Cl, K, Mg, Ca and Fe) were observed.

Conclusion: The biomass from medicinal weeds *R. palustris*, *E. rothiana* and *S. articulata* featured very high K, Ca and Fe contents. Other nutrients (polyphenols, flavonoids, P, S, Cl and Mg) were identified at moderate levels. These species may hold promise as bioindicators.

Keywords: weeds; XRF; flavonoid; phenolic; mineral elements.

1. INTRODUCTION

Aquatic plants not only provide food and habitat for many animals such as fish and waterfowl, but also are potential bio-sorbents for the accumulation of trace elements [**1**], and may be used as green manure to restore soil fertility [**2**]. Moreover, some wetland plants have medicinal value, and are frequently used in Ayurveda and folk medicine [**3**].

Rorippa palustris (bog yellowcress or marsh yellowcress) grows in many types of damp, wet, and aquatic habitats. It has antiscorbutic properties; its roots are diuretic and it is used in the treatment of measles [**4**].

Euphorbia rothiana (white latex; in India: Chagul putputi, Merashupal chedi, and Palootti chedi) is an annual erect, glabrous, profusely branched subshrub of ≈1-m height, widely distributed in India, Sri Lanka, China and Indonesia. The leaves of *E. rothiana* (*Rubus elipticus* Sm. and *Rubus racemosus* Roxb.) are chewed together to relieve symptoms of sudden sickness and giddiness thought to be caused by evil spirits. Further, its biomass is used as a medicine for cattle. Its latex is externally applied for healing sores, it is also believed to promote hair growth, and the whole plant is used for household insect repellent [**5-6**].

Schoenoplectiella articulata (in India: Chichora, Ciccodaka, Gaichira, Laghukaseruka, Pappati Chickha, Tan-pokli, and Tsjeli) is an aquatic annual herb distributed through Indo-China to Malaysia regions. Its tubers are effective for against diarrhea and vomiting, and its fruits and leaves in bodyache, pain and fevers. It has been reported to have anthelmintic, antibacterial, antiemetic, antifungal, carminative, contraceptive, digestive, febrifuge and sedative properties [**7**].

Similar species, e.g., *Schoenoplectus lacustris* (L.) Palla*, Rorippa globosa* (Turcz.) Hayek and *Euphorbia macroclada* Boiss. have been applied in the accumulation and phytoremediation of heavy metals in contaminated soils [**8-10**]. The bioaccumulation of various elements (P, K, Mg, Ca, Cr, Mn, Fe, Co, Zn, Pb, Cu and Cd) in macrophytes (e.g., *Azolla pinnata* R.Br.*, Pistia stratiotes* L.*, Solvinia molesta* D.Mitch.*, Trapa natans* L.*, Persicaria maculosa* Gray and *Nelumbo nucifera* Gaertn.) has also been reported in the literature [**11-22**].

In this work, the total polyphenols, flavonoids, and trace element (P, S, Cl, As, Se, K, Rb, Mg, Ca, Sr, Ba, Al, Ti, Cr, Mn, Fe, Co, Zn, Mo and Pb) contents in the biomass from these three weeds (*R. palustris, E. rothiana* and *S. articulata*) are described.

2. **MATERIALS AND METHODS**

R. palustris (RP), *E. rothiana* (ER) and *S. articulata* (SA), shown in **Fig. 1**, were botanically recognized [**23**]. Samples were collected from a municipal waste dumping area in Raipur city, CG, India (21.25°N 81.63°E) in March-June 2017. The plants biomass (including leaves, stems and fruits) was washed thrice with deionized water and sun-dried in a glass room for one week. The crushed samples were sieved out to separate particles of mesh size ≤ 0.1 mm, they were further dried at 50 °C overnight, and they were finally stored in a deep freezer at –4 °C till the analyses were conducted.

Fig. 1. (*From left to right*) Photographs of biomass from *Rorippa palustris*, *Euphorbia rothiana* and *Schoenoplectus articulata*.

The polyphenol content in the samples in powder form was determined by extraction in an acetone:water mixture (7:3, v/v), equilibrating 0.1 g of sample with the solvent, as indicated by Bertaud et al. [**24**]. For the analysis of the total polyphenol content, an aliquot of the extract was treated with Folin-Ciocalteu reagent (Sigma-Alrich, F9252) to form a blue colored polyacid [**25**]. A standard calibration curve was prepared by using tanning acid (Sigma-Alrich, 403040) as the reference material. The flavonoid content was determined by reacting an aliquot of the extract with aluminum chloride (Sigma-Alrich, 563919), as described in the literature [**26**], using quercetin (Sigma-Alrich, Q4951) as the reference material.

A Bruker Tracer 5i portable X-Ray Fluorescence (pXRF) instrument with a Rhodium tube was used for the analysis of trace elements, following the empirical calibrations described by Towett et al. [**27**].

All measurements were performed in triplicate, and their mean values were reported.

3. RESULTS AND DISCUSSION

3.1. Polyphenol Contents

The chemical characteristics of the biomass of RP, ER and SA are summarized in **Table 1**. The total phenolic content (TPh) and the flavonoid content (Fla), expressed in tannic acid and quercetin equivalents, ranged from 47877 to 73791 and from 1950 to 9400 mg/kg, respectively. The mass concentration ratio of {[Fla]/[TPh]} varied from 0.04 to 0.13. The maximum concentration of polyphenols was found in ER biomass.

The polyphenol contents in the examined weeds were lower than or comparable to the phenolic contents reported by Březinová et al. [**28**] in other macrophytes (*Phragmites australis* Trin. ex Steud., *Phalaris arundinacea* L., *Typha latifolia* L., *Glyceria maxima* Holmb., *Scirpus sylvaticus* L., *Carex nigra* Reich. and *Juncus effusus* L.), in the 9020-28390 mg/kg interval. For comparison purposes, the concentrations of total polyphenols and flavonoids in another set of macrophytes (*A. pinnata, P. stratiotes, S. molesta, T. natans, P. maculosa* and *N. nucifera*) were found to vary from 750 to 20800 and from 2420 to 11760 mg/kg, respectively [**22**].

Table 1. Concentration of polyphenols and trace elements in the three weeds under study, expressed in mg/kg (dw).

Weed	***Rorippa palustris***	***Euphorbia rothiana***	***Schoenoplectus articulata***
TPh	69623	73791	47877
Fla	5150	9400	1950
Mg	2286	2309	1550
Al	9319	1018	1123
P	1431	2321	1642
S	5129	3142	1672

Cl	2279	1725	9532
K	13038	17573	16537
Ca	13072	13086	3727
Rb	8	14	36
Ti	143	227	308
Cr	27	40	18
Mn	680	421	1452
Fe	19632	29486	8719
Co	67	44	1
Zn	30	37	5
As	3.5	1	1.5
Se	1	1	1
Sr	108	46	29
Mo	14	3	10
Ba	60	2	2
Pb	18	5	6

3.2. Trace Element Concentrations

The total concentration of 20 elements (P, S, Cl, As, Se, K, Rb, Mg, Ca, Sr, Ba, Al, Ti, Cr, Mn, Fe, Co, Zn, Mo and Pb), Σn_{20}, ranged from 46372 to 71501 mg/kg (**Table 1**). The maximum concentration corresponded to ER biomass.

The concentrations of P, K, Mg, Ca, Cr, Fe and Zn were in the 1431 to 2321, 13038 to 17573, 1550 to 2309, 3727 to 13086, 18 to 40, 8719 to 29486 and 5 to 37 mg/kg range, respectively. The maximum concentration of these elements was again observed in ER.

Contents of Cl, Rb, Ti and Mn varied from 1725 to 9532 mg/kg, from 8 to 36 mg/kg, from 143 to 308 mg/kg, and from 421 to 1452 mg/kg, respectively. Remarkable high concentrations of these elements were detected in SA biomass, suggesting their bioaccumulation as chlorine complexes.

The maximum concentration of the other elements: S, Al, As, Sr, Ba, Co, Pb and Mo was detected in RP biomass, probably due to their accumulation as sulfur compounds. The concentration of Se in the biomass of the three weeds was only detectable at trace levels (<1.0 mg/kg).

Similar bioaccumulation patterns have been reported for other macrophytes [**11-22**].

3.3. Toxicity

These weeds are used as food as well as in traditional medicine. Heavy metals were found to be bio-accumulated in the weeds. The permissible limits of As, Pb, Cr and Zn in medicinal plants are 1.0, 5.0, 2.3 and 20 mg/kg, respectively [**29-30**]. The concentrations of As and Pb were higher than the prescribed values in the biomass from two of the weeds (RP and SA), chromium concentration was above the prescribed limit in all weeds, and concentrations of Zn above 30 mg/kg were accumulated in RP and ER.

3.4. Correlation Coefficients

The correlation coefficients (r) matrix between the polyphenol contents and the studied trace elements (for average values across the three weeds) is shown in **Table 2**. The TPh and Fla contents showed a good correlation with K, Ti, Mn and Co, probably due to formation of complexes. The elements: S, Mg, Ca, Cr, Fe, Co and Zn had also high correlation, pointing to their accumulation as sulfur compounds. Similarly, a group of elements: Al, As, Sr, Mo, Ba and Pb showed good correlation, expecting their accumulation as aluminum compounds. Elements: Cl, Rb, Ti and Mn showed good correlations, indicating their absorption as chloride complexes. Phosphorous showed good correlations with K, Cr and Fe, hinting at its role as a co-factor element.

Table 2. Correlation coefficients among the total polyphenol (TPh), flavonoid (Fla) and trace element content present in the biomass from *R. palustris*, *E. rothiana* and *S. articulata*.

	Mg	**Al**	**P**	**S**	**Cl**	**K**	**Ca**	**Rb**	**Ti**	**Cr**	**Mn**	**Fe**	**Co**	**Zn**	**As**	**Sr**	**Mo**	**Ba**	**Pb**	**TPh**	**Fla**
Mg	1.00																				
Al	0.47	1.00																			
P	0.32	-0.69	1.00																		
S	0.80	0.90	-0.31	1.00																	
Cl	-1.00	-0.43	-0.35	-0.78	1.00																
K	-0.27	-0.98	0.83	-0.79	0.24	1.00															
Ca	1.00	0.49	0.29	0.82	-1.00	-0.30	1.00														
Rb	-0.97	-0.66	-0.09	-0.92	0.96	0.49	-0.98	1.00													
Ti	-0.85	-0.87	0.24	-1.00	0.83	0.74	-0.86	0.95	1.00												
Cr	0.82	-0.12	0.80	0.33	-0.84	0.32	0.81	-0.67	-0.40	1.00											
Mn	-0.98	-0.27	-0.51	-0.66	0.98	0.06	-0.97	0.90	0.71	-0.93	1.00										
Fe	0.89	0.02	0.71	0.45	-0.91	0.19	0.88	-0.77	-0.52	0.99	-0.97	1.00									
Co	0.93	0.76	-0.06	0.97	-0.92	-0.61	0.94	-0.99	-0.98	0.56	-0.83	0.66	1.00								
Zn	0.98	0.30	0.48	0.68	-0.99	-0.09	0.98	-0.92	-0.74	0.91	-1.00	0.96	0.85	1.00							
As	0.30	0.98	-0.81	0.81	-0.27	-1.00	0.33	-0.51	-0.76	-0.29	-0.09	-0.16	0.63	0.12	1.00						
Sr	0.65	0.98	-0.52	0.97	-0.62	-0.91	0.67	-0.80	-0.95	0.10	-0.47	0.23	0.88	0.50	0.92	1.00					

Mo	-0.18	0.78	-0.99	0.44	0.22	-0.90	-0.16	-0.05	-0.37	-0.71	0.39	-0.61	0.19	-0.36	0.88	0.63	1.00				
Ba	0.48	1.00	-0.68	0.91	-0.44	-0.98	0.50	-0.67	-0.87	-0.10	-0.28	0.03	0.77	0.31	0.98	0.98	0.78	1.00			
Pb	0.41	1.00	-0.73	0.87	-0.38	-0.99	0.44	-0.61	-0.84	-0.17	-0.21	-0.04	0.72	0.24	0.99	0.96	0.82	1.00	1.00		
TPh	0.99	0.35	0.43	0.72	-1.00	-0.15	0.99	-0.94	-0.77	0.89	-1.00	0.94	0.88	1.00	0.18	0.55	-0.30	0.36	0.30	1.00	
Fla	0.84	-0.09	0.78	0.35	-0.86	0.30	0.82	-0.69	-0.42	1.00	-0.94	0.99	0.58	0.92	-0.27	0.12	-0.69	-0.08	-0.15	0.90	1.00

4. CONCLUSIONS

The polyphenols and mineral contents of three weeds that grow in wetlands in India (*Euphorbia rothiana, Rorippa palustris* and *Schoenoplectus articulata*) were characterized. Total polyphenol and flavonoid contents ranged from 47877 to 73791 and from 1950 to 9400 mg/kg, respectively, lower than (or comparable to) those reported for other macrophytes. Although the three species were found to feature high contents of nutrients along with Cl and Al, the concentrations of heavy metals beyond safety limits advice against their use for food purposes. Nonetheless, these species may hold promise to control water and soil alkalinity, hardness and metal toxicity. The biomass from *R. palustris* for Ca, Mg, Al, S, Co, As and Pb; that of *E. rothiana* for P, K, Cr, Fe and Zn; and the *S. articulata* for Cl, Rb, Ti and Mn can be used as a bioindicator for their contamination detection, respectively.

CONSENT

Not applicable.

ETHICAL APPROVAL

Not applicable.

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