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PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet

Asian Network for Scientific Information

308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences, 1 (4): 332-334, 1998 Research Article

Aquatic Macrophytes as Biological Indicators for Pollution Management Studies. IV: Effect of Salts present in Factory Effluent Water on Chemical and Biochemical Composition of *Eichhornia crassipes* and *Pistia stratioites*

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Abstract

The experiments were conducted in artificially constructed water ponds during the months of May-July, 1994. Both the macrophytes were treated with different concentrations of salts commonly used in textile processing units. Chemical and biochemical analyses were made at the end of the experiment. Na^+ concentration of the aqueous medium was more crucial. Which also interfered with the Ca^{2+}, Mg^{2+} and K^+ percentage of the plant. There was a positive correlation of concentrations in the aqueous medium and their accumulation in the case of Na^+ and Cl^- . Nitrogen in aqueous medium increased the crude protein status at lower levels of treatment.

Key words: *Eichhornia crassipes, Pistia stratioites,* Factory effluents, Chemical analysis, water hyacinth, water lettuce

Introduction

Indiscriminate use of various inorganic salts during different industrial processes at manufacturing/processing units has posed a serious threat to our water flora, as majority of the units dispose off untreated effluents. These injurious factors have played havoc with phytoplankton in water pools, which, in turn, have interfered with all natural food chains and food webs. Original landscape of this region had been changed drastically during the last few decades. The situation is so grave that population of even large hydrophytes have now become affected due to the presence of deleterious salts in the effluent water.

The response of various species to stressed conditions varies greatly and is specific to a particular index of disturbance in environment (Hanif and Davies, 1998).

Eichhornia crassipes (water hyacinth) and *Pistia stratioites* (water lettuce) are aquatic weeds. The cover of both these plants took up metabolic ions from rooting medium (Foster and Warshall 1991). Studies on the accumulation of ions within their bodies can depict the extent of pollution in vicinity of rooting medium (Ashraf and O'Leary, 1997).

The differential responses of *E. crassipes* and *P. stratioites* to various salts make them suitable candidates under various polluted aquatic ecosystem, i.e., according to the chemical nature of the affluents contributing to the water body.

The situation is still rectifiable but an exhaustive study covering all the aspects of this toxicity exudation and its control is a pre-requisite. For proper toxicity management of our water bodies both conventional and non-conventional approaches have to be adopted. The present study is an attempt to adopt a non-conventional approach by studying the ionic interference of rooting medium with chemical and biochemical status of plants.

Materials and Methods

Experiments were performed at Botanical Gardens, University of Agriculture, Faisalabad. Plants were grown in artificially constructed polyethylene lined ponds (2 ft x 2 ft with uniform depth of 9 inches). Each ponds was filled with 35 liters of solution having 0, 100, 500 and 1000 ppm concentration of NaCl, NH_4Cl, $NaHCO_3$, Na_2CO_3, $CaOCl_2$ and NH_4NO_3. Plants were harvested after period of three months and dried to determine their chemical composition for Na^+, K^+, Mg^{2+}, Ca^{2+}, Cl^- and total-N.

The N_a^+ and K^+ were determined with flame photometer, Ca^{2+} and Mg^{2+} with atomic absorption spectrophotometer. While Cl^- with chloride analyzer (Yoshida *et al.,* 1976) the total-N was determined using microkjeldahl method (Jackson, 1962). The data were subjected to statistical treatment using Minitab package programme (Minitab, 1989) and treatment means were compared using Duncan's Multiple Range Test.

Results

Data regarding the effect of various salts with varying concentrations on the chemical composition of *E. crassipes* and *P.stratioites* have been given in Table 1. There were statistically significant differences among the ionic concentrations in both the plant species, under different salt treatments. Calcium composition was adversely affected by the application of all the salts. With the increasing concentrations of salts, Ca (%) in the plant tissues followed a decreasing order in NaCl or NH_4NO_3 treatments. Whereas the reverse effect was observed in NH_4Cl treatment, though more percentage of calcium was observed in control. The composition of Mg^{2+} and K^+ was affected likewise due to the competition of these cations with Na^+.

Table 1: Chemical composition of whole plants (%age on dry weight basis) under varying concentration of salts.

	Eichhornia crassipes						*Pistia stratioites*					
	NaCl	NH_4Cl	$NaHCO_3$	Na_2CO_3	$CaOCl_2$	NH_4NO_3	NaCl	NH_4Cl	$NaHCO_3$	Na_2CO_3	$CaOCl_2$	NH_4NO_3
Calcium (Ca)												
100 ppm	0.56	0.60	0.72	0.70	0.60	0.78	0.80	0.84	0.70	0.63	0.651	0.86
500 ppm	0.62	0.65	0.61	0.68	0.62	0.64	1.16	0.72	0.69	0.61	0.632	0.73
1000 ppm	0.53	0.72	0.60	0.63	0.59	0.60	0.96	0.65	0.67	0.60	0.591	0.67
Control	0.84	0.84	0.84	2.84	0.84	0.84	0.96	0.96	0.96	0.96	0.960	0.96
Magnesium (Mg)												
100 ppm	2.714	2.616	2.60	2.38	2.712	2.66	2.640	2.08	2.18	2.1	2.152	2.0
500 ppm	2.592	2.623	2.61	2.39	2.832	2.64	2.712	2.12	2.054	2.0	2.122	2.1
1000 ppm	2.390	2.640	2.63	2.29	2.900	2.52	2.695	2.00	2.01	1.9	2.110	2.1
Control	2.808	2.808	2.81	2.81	2.808	2.81	2.544	2.54	2.544	2.544	2.544	2.544
Sodium (Na)												
100 ppm	1.300	1.288	1.30	1.38	1.184	1.294	1.213	1.580	1.084	1.13	1.294	1.12
500 ppm	1.388	1.191	1.39	1.39	1.201	1.146	1.291	1.291	1.271	1.24	1.382	1.11
1000 ppm	1.430	1.158	1.44	1.43	1.100	1.129	1.352	1.131	1.395	1.35	1.401	1.15
Control	1.288	1.288	1.29	1.29	1.288	1.288	1.158	1.158	1.158	1.158	1.158	1.58
Potassium (K)												
100 ppm	1.615	1.514	1.62	1.43	0.848	1.134	1.115	0.848	0.740	1.11	0.795	0.85
500 ppm	1.414	1.371	1.51	1.37	0.892	1.338	0.932	0.912	0.712	1.10	0.742	0.78
1000 ppm	1.230	1.100	1.21	1.26	0.730	1.232	0.763	0.700	0.709	0.90	0.734	0.75
Control	0.768	0.768	0.77	0.77	0.768	0.768	1.180	1.180	1.180	1.18	1.180	1.18
Chlorine (Cl)												
100 ppm	3.79	3.58	3.36	3.00	3.41	3.94	3.96	3.72	2.93	3.81	3.81	2.61
500 ppm	4.14	4.10	3.81	3.20	3.88	3.53	4.23	4.10	3.94	4.19	4.19	2.30
1000 ppm	4.23	5.39	3.90	3.00	3.60	2.94	4.59	4.20	4.05	3.91	3.91	2.10
Control	3.18	3.18	3.18	3.18	3.18	3.18	3.69	3.69	3.69	3.69	3.69	3.69

Table 2: Crude protein composition of whole plants (%age on dry weight basis) under varying concentration of salts.

	NaCl	NH_4Cl	$NaHCO_3$	Na_2CO_3	$CaOCl_2$	NH_4NO_3
			Eichhornia crassipes			
100 ppm	16.83	17.06	15.30	14.12	8.37	20.93
500 ppm	12.62	18.75	12.60	12.10	8.81	17.93
1000 ppm	11.12	21.00	10.33	10.23	6.61	19.62
Control	14.43	14.43	14.43	14.43	14.43	14.43
			Pistia stratioites			
100 ppm	10.50	12.60	16.08	15.56	11.43	14.76
500 ppm	21.00	23.36	15.75	13.75	7.23	18.33
1000 ppm	14.23	22.71	13.33	12.60	7.1	20.66
Control	15.31	15.31	15.31	15.31	15.31	15.31

Crude protein composition on whole plant basis was calculated for both the plants and is presented in Table 2. This biochemical parameter is an important indicator of any plant species for its nutritional value. An apparent look at these tables indicated that dry matter of *E. crassipes* had greater crude protein contents than *P. stratioites,* so was found to be better candidate species as far as its fodder value was concerned. $CaOCl_2$ showed a similar protein depleting trend in both the plants. While there was a positive correlation between nitrogen source and the crude protein values in *E. crassipes.* In case of *P. stratioites,* single N-source salt showed a similar trend as was found in *E. crassipes.* However, nitrogen contents did not increase when the plants were exposed to NH_4NO_3 and crude protein contents did not enhance appreciably.

Discussion

The aqueous solution around root zone was also found to have a major role in the distribution/presence of various ions within plant body. Ca^{2+} %age in plant body was adversely affected by the application of Na^+- salts especially at higher concentrations. Na^+ -salts also had an antagonistic relations with K^+ and Mg^{2+} %age in plants. The application of Cl^- was found to be proportional to the Cl^- (% age) of the plant material. However, Cl interfered with the NH_4^+ or NO_3 and NH_4Cl applications in both the plants. *P. stratioites* was found to be more tolerant of Na^+ as Ca^{2+} and Mg^{2+} contents were less affected in this hydrophyte.

Lynch and Lauchli (1985) proposed that Na^+ may inhibit the radial movement of Ca^{2+} from external solution to the root xylem by screening of cation exchange sites in the apoplast. Sodium induced Ca^{2+} deficiencies have also been observed by Grieve and Maas (1988) and Maas and Grieve (1987). As the activity of Na^+ in the substrate increases, the system becomes less discriminating and the selectivity for Ca^{2+} is impaired (Suarez and Grieve, 1988).

The composition of Mg^{2+} and K^+ was affected likewise due to the competition of these cations with N_a^+. Ashraf and O'Leary (1997) reported similar results and are of the opinion that uptake of cations in plant tissues is directly correlated with the concentration of the surrounding medium. Jung *et al.* (1987) reported inverse proportion of (K^+ percentage in plants and NH_4^+ nitrogen in the aqueous nedium around roots. Ashraf and O'Leary (1995) and (1997) reported and similar trend of anion and cation distribution after exposure to Na^+ salts.

The effects on total crude protein contents and the problems of growth suppression could he linked with the studies of Costa *et al.* (1992) and Varanasi *et al.* (1992). Sodium salt had reduced the N-uptake by the plants. So the crude protein contents decreased with these salts. These results are in line with the results of Jilani *et al.* (1992).

References

Ashraf, M. and J.W. O'Leary, 1995. Distribution of cations in leaves of salt tolerant and salt sensitive lines of sunflower under saline conditions. J. Plant Nutr., 18: 2379-2388.

Ashraf, M. and J.W. O'Leary, 1997. Ion distribution in leaves of salt-tolerant and salt-sensitive lines of spring wheat under salt stress. Acta Botanica Neerlandica, 46: 207-217.

Costa, J.E., B.L. Howe, A.E. Gibin and L. Valiela, 1992. Monitoring Nitrogen and Indicators of Nitrogen Loading to Support Management Action in Buzzards Bay. In: Ecological Indicators, Volume 1, McKenzie, D.H., D.E. Hyatt and V.J. McDonald (Eds.). Chapter 29, Springer, London, UK., ISBN: 978-1-4613-7108-3, pp: 499-531.

Foster, K.E. and P. Warshall, 1991. Water hyacinth wastewater treatment system design for arid/semiarid regions. Adv. Desert Arid Land Technol. Dev., 5: 129-138.

Grieve, C.M. and E.V. Maas, 1988. Differential effects of sodium/calcium ratio on Sorghum genotypes. Crop Sci., 28: 659-665.

Hanif, M. and M.S. Davies, 1998. Effects of NaCl on meristem size and proximity of root hairs to the root tips in *Triticum aestivum* (cvs. Lyallpur-73, Pak-81 and Lu-26-S). Pak. J. Biol. Sci., 1: 1-4.

Jackson, M.L., 1962. Soil Chemical Analysis. Constable and Co. Ltd., London, pp:183-192.

Jilani, G.M. Salahuddin, R.V. Rehman and M.A. Abbas, 1992. Effect of growth a some physiological aspects of tomato grown in solution culture. Pak. J. Agric., 1: 132-135.

Jung, Y.T., J.S. Lee, K.H. Park and J.H. Choi, 1987. Research and development of new forage green-manure crops, 2: Physio-ecological characteristics and the values of water hyacinth, *Eichhornia crassipes* Solms, as a forage or green-manure crop. Rural Dev. Admin., 29: 299-305.

Lynch, J. and A. Lauchli, 1985. Salt stress disturbs the calcium nutrition of barley (*Hordeum vulgare* L.). New Phytol., 99: 345-354.

Maas, E.V. and C.M. Grieve, 1987. Sodium-induced calcium deficiency in salt-stressed corn. Plant Cell Environ., 10: 559-564.

Minitab Inc., 1989. Minitab Statistical Software. Minitab Inc., State College, Pennsylvania, USA.

Suarez, D.L. and C.M. Grieve, 1988. Predicting cation ratios in corn from saline solution composition. J. Exp. Bot., 39: 605-612.

Varanasi, U., J.E. Stein, L.L. Johnson, T.K. Collier, E. Casillas and M.S. Myers, 1992. Evaluation of Bioindicators of Contaminant Exposure and Effects in Coastal Ecosystems. In: Ecological Indicators, Volume 1, McKenzie, D.H., D.E. Hyatt and V.J. McDonald (Eds.). Chapter 28, Springer, London, UK., ISBN: 978-1-4613-7108-3, pp: 461-498.

Yoshida, S., D.A. Forno, J.H. Cock and K.A. Gomez, 1976. Laboratory Manual for Physiological Studies of Rice. 3rd Edn., The International Rice Research Institute, Los Banos, Manila, Philippines, ISBN-13: 9789711040352, Pages: 83.