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Effect of Biomass Power Plant Effluent on *Arachius hypogaea* L.

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Groundnut plants were grown in pots for a period of 30 d where the soils were treated with different effluent concentrations (25, 50, 75, 100 %) collected near industrial area. The distribution of metals in the soils and corresponding accumulations in the experimental crop was investigated on different experimental days 10, 15, 20, 25 and 30th day. The metals Cr, Cu, Mn, Fe, Co, Ni, Pb, Cd and Zn in plants and soil samples were analyzed using AAS technique. The pot treated with 50 % effluent has shown an increase of all the metals on 20th day whereas in the plants the metal accumulation has increased with 100 % effluent concentration on 25th day. The study could pave the way to draw attention phytoremidiation.

Key Words: Metal, Accumulation, Effluent, *Arachius hypogaea*.

INTRODUCTION

In the future, one key problem for foodstuff production and growth of renewable resources will be the climatic changes in areas of intensive agriculture. These changes will lead to the necessity of cultivating crops on polluted ground, because of decreasing amounts of agricultural arable land generated by the expansion of arid areas. Industrial wastes are a major source of soil pollution and originate from mining industries, chemical industries, metal processing industries and others. These wastes include a variety of chemicals like heavy metals, phenolics, *etc.*[1,2]. Use of industrial effluent and sewage sludge on agricultural land has become a common practice in India as a result of which these toxic metals can be transferred and concentrated into plant tissues from the soil. Accumulation and exclusion were two basic strategies by which plants respond to elevated concentration of heavy metals[3]. Hyper accumulators respond to heavy metals by employing the strategy of accumulation and sequestration of metals. Plants have an

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extremely high capacity to take up metals by roots and translocate and store them in the shoot[4-6].

These metals have damaging effects on the plants themselves and may become a health hazard to man and animals. Above certain concentrations and over a narrow range, the heavy metals turn into toxins[7,8]. As most studies are based on the work done in laboratory conditions, information is scantily on status of heavy metals in soils and standing plants receiving industrial effluents[9-11]. In this paper, the effect of an industrial effluent on both soil and plant of *Arachius* during the crop growth period is studied.

EXPERIMENTAL

An effluent sample was collected during March, 2006 from outlets of (biomass power plant) Rithwik energy systems situated at Rachagunneri, Chittoor district, India. Effluent sample was collected in well cleaned polythene bottle. Before collection each bottle was thoroughly washed with distilled water. After filtering the pH, electrical conductivity (EC) of the sample was immediately measured in the laboratory and afterwards the samples were stored at 4 °C for physico-chemical analysis[12]. Sandy clay loam soil near Rithwik power plant collected and used for pot culture. The seeds of *Arachis hypogaea* var TCGS 320 were obtained from Agriculture College, Tirupati and treated with 0.2 N mercuric chloride for 2 min and washed with running water to remove contamination of seed coat. This experiment carried out with *Arachis hypogaea* as a test crop using different concentrations of effluent 25, 50, 75, 100 % and distilled water which served as control. Each treatment including control was performed in triplicate and in every pot 10 seeds were used.

Soil analysis: Soil samples were air dried at 70 °C in the laboratory oven, then grinds into fine powder and sieved through 0.25 mm nylon mesh. To 1 g soil sample, 8 mL conc. HCl and 2 mL conc. HNO_3 were added and kept for over night. Digestion was done according to the method of McGrath and Cunliffe[13]. After digestion and filtration the digested solution was analyzed for determination of Cr, Cu, Mn, Fe, Co, Ni, Cd, Pb and Zn by atomic absorption spectroscopy.

Plant analysis: The plants were carefully washed with deionized water and oven-dried at 70 °C in the laboratory then grinds into fine powder, sieved through 1 mm nylon sieve. 1 g Plant samples were digested with 5 mL diacid mixture, nitric acid (HNO_3):perchloric acid ($HClO_4$) in the ratio of 3:2 at 110 °C for 8 h. Then distilled water was added to the digested samples to make up the volume to 50 mL and then filtered by Whatmann 42 filter paper[14]. The samples were ready for elemental analysis by AAS.

RESULTS AND DISCUSSION

The physicochemical characteristics of effluent are presented in Table-1. Effluent is colour is white and odourless. pH is 8.5 ± 0.23 this value is compared to Indian Standard Institution (ISI) standards[15] recommended for disposal of effluent on land for irrigation purpose. Electrical conductivity value is 11.5 ± 0.11 μmos/cm. Total suspended solids (Table-1.1), total dissolved solids values are 611 ± 11.79, 651.33 ± 3.28. Biological oxygen demand value is 53.6 ± 0.28; chemical oxygen demand value is 128.66 ± 0.28. Chromium is 0.071 ± 0.0.003, copper 0.014 ± 0.0.002, manganese 0.035 ± 0.002, iron 0.050 ± 0.001, cobalt 0.311 ± 0.02, nickel 0.041 ± 0.0.004, cadmium 0.028 ± 0.002, lead 0.108 ± 0.002, zinc 6.73 ± 0.120. Copper, manganese, iron, nickel these are metal concentrations in effluent below limits compared to ISI standards[15]. Remaining metals like chromium, cobalt, cadmium, lead and zinc these metals values are compared to ISI standards not suitable for irrigation.

TABLE-1
PHYSICO-CHEMICAL CHARACTERISTICS OF BIOMASS POWER PLANT EFFLUENT (mg/L)

Parameters	Values	Parameters	Values
Colour	White	Copper	0.014 ± 0.002
Odour	Odourless	Manganese	0.036 ± 0.002
pH	8.500 ± 0.230	Iron	0.050 ± 0.001
EC (μmhos/cm)	11.500 ± 0.110	Cobalt	0.311 ± 0.020
Dissolved solids	611.000 ± 11.790	Nickel	0.041 ± 0.004
Suspended solids	651.330 ± 3.280	Cadmium	0.028 ± 0.002
Biological oxygen demand	53.600 ± 0.280	Lead	0.108 ± 0.002
Chemical oxygen demand	128.660 ± 0.250	Zinc	6.730 ± 0.120
Chromium	0.071 ± 0.003	–	–

Values are arithmetic mean ± SEM of three replicates.

TABLE-1.1
ISI STANDARDS FOR IRRIGATION AND POTABLE WATER IS:10500 [Ref. 15]

Test	Unit	Standards irrigation waters ISI
pH		6.5-8.5
EC	μmos/cm	2.25
Total dissolved salts	mg L^{-1}	500.00
Cu	mg L^{-1}	0.05
Fe	mg L^{-1}	0.30
Mn	mg L^{-1}	0.10
Zn	mg L^{-1}	5.00
Cd	mg L^{-1}	0.01
Pb	mg L^{-1}	0.10
Cr	mg L^{-1}	0.05
Ni	mg L^{-1}	0.20
Co	mg L^{-1}	0.05

Metals in *Arachis hypogaea* soils: Co, Ni, Pb and Zn (8.123 ± 0.003, 8.123 ± 0.003, 4.868 ± 0.003, 6.132 ± 0.005) were high in 100 % effluent at 10th day, in 15th day Cu and Zn (4.816 ± 0.002, 2.015 ± 0.001) were high. 30th day Cu, Fe, Co, Ni, Cd, Pb and Zn (2.885 ± 0.001, 8.239 ± 0.001, 11.311 ± 0.024, 1.030 ± 0.003, 1.138 ± 0.002, 1.099 ± 0.001, 4.129 ± 0.0008, 2.020 ± 0.002 in 100 % effluent. On 20th day Cr, Cu, Fe, Co, Ni, Cd and Pb (1.082 ± 0.002, 3.141 ± 0.001, 31.031 ± 0.001, 1.906 ± 0.003, 2.011 ± 0.001, 1.127 ± 0.002, 2.994 ± 0.002) were high in 50 % effluent. On 25th day, Cr, Cu, Mn and Zn (0.299 ± 0.002, 2.827 ± 0.002, 6.603 ± 0.001, 0.192 ± 0.001) were high in 50 % effluent (Table-2).

Metals in plants: Fe was high in 10th and 15th days in 100 % effluent (937.32 ± 0.106, 780 ± 47 ± 0.270), On 20th day Cr, Mn, Fe and Pb (11.872 ± 0.173, 99.601 ± 0.295, 899.81 ± 0.291 and 110.36 ± 0.292) were high in 100 % effluent. On 25th day, all metals increased with 100 % effluent (Table-3) Cr and Pb were (56.241 ± 0.419, 1.071 ± 0.015) high in 100 % effluent at 30th day.

Accumulation of metals in root from soil and subsequent translocation to other parts of plants like stem, leaves and fruits is important for the selection of plant specially crops and vegetables. Plant accumulating least quantity of metals in edible parts, with the concentration within the permissible limit than the verity of species can be selected for the cultivation on the field having high level of metal contamination[16].

In soil metal concentration on 10th day Cr, Co, Ni, Pb and Zn were high in 100 % effluent, Cu is high in 50 %, Co is high in 75 % and Cd is high in 25 % effluent concentrations. Cu and Zn were high in 100 %, Mn, Ni, Cd and Pb were high in 25 % and Co is high in 50 % effluent concentrations on 15th day. On 20th day all metals increased with 50 % effluent. Cr, Cu, Mn, Fe and Zn were high in 50 % effluent, Co and Cd high in 75 % effluent on 25th day. Cu, Fe, Co, Ni, Cd, Pb and Zn were high in 100 %, Mn is high in 25 % effluent concentrations on 30th day.

In plants Fe was high in 100 % effluent at 10, 15, 20, 25th days except 30th day. Cr, Cu, Co, Ni, Pb and Cd were high in 50 % effluent, Mn and Zn were high in 75 % effluent at 10th day. Cr, Cu, Mn, Co, Ni, Cd and Pb were high in 75 % effluent concentration Zn is high in 50 % effluent concentration at 15th day. On 20th day Cr, Mn and Fe were high in 100 % effluent. Metal accumulation (Cr, Cu, Mn, Fe, Co, Ni, Cd, Pb and Zn) increasing 100 % effluent concentration at 25th day. Cr and Pb in 100 % effluent Cu, Co, Ni and Zn were high in 50 % effluent Mn is high in 75 % effluent concentrations on 30th day.

In contrast, plants accumulating high concentration of heavy metals from contaminated soil can be used for detoxification phytoremediation of metals from soil or growing medium.

TABLE-2
GROUNDNUT SOILS

	Cr	Cu	Mn	Fe	Co	Ni	Cd	Pb	Zn
					10th day				
Control	3.110±0.011	2.946±0.025	8.041±0.035	12.619±0.249	1.847±0.032	2.002±0.005	1.239±0.001	1.096±0.008	0.296±0.002
25 %	1.908±0.003	1.977±0.002	3.817±0.002	42.574±0.007	0.099±0.001	0.979±0.004	2.822±0.005	1.097±0.002	0.687±0.002
50 %	9.475±0.582	3.129±0.004	4.128±0.002	14.513±0.008	1.889±0.001	1.889±0.001	0.727±0.002	0.286±0.002	3.928±0.002
75 %	0.693±0.002	1.630±0.004	0.890±0.004	0.980±0.001	2.031±0.020	2.031±0.020	1.038±0.027	3.923±0.006	0.987±0.002
100 %	4.127±0.002	2.023±0.0009	7.448±0.166	0.618±0.003	8.123±0.003	8.123±0.003	0.385±0.007	4.868±0.003	6.132±0.005
					15th day				
Control	2.870±0.003	4.132±0.003	11.812±0.003	11.890±0.001	2.034±0.002	1.983±0.001	1.125±0.002	4.890±0.002	0.318±0.005
25 %	1.025±0.002	3.256±0.002	19.807±0.003	10.1±0.002	2.013±0.002	2.913±0.001	3.982±0.002	6.122±0.002	0.167±0.002
50 %	1.891±0.001	1.933±0.002	6.107±0.002	11.018±0.003	3.118±0.004	1.089±0.002	1.118±0.001	3.117±0.004	0.160±0.001
75 %	0.903±0.002	1.104±0.002	1.924±0.002	9.808±0.002	0.981±0.001	0.449±0.268	1.005±0.001	1.982±0.002	0.173±0.002
100 %	0.987±0.003	4.816±0.002	6.026±0.004	8.004±0.004	0.093±0.002	0.954±0.001	1.108±0.003	0.988±0.002	2.015±0.001
					20th day				
Control	0.984±0.002	2.980±0.001	5.840±0.0008	28.131±0.002	1.313±0.002	1.868±0.001	1.024±0.002	2.254±0.001	2.322±0.005
25 %	0.920±0.001	1.891±0.002	4.618±0.001	22.1±0.001	1.208±0.002	1.737±0.002	1.016±0.002	2.433±0.002	0.1±0.001
50 %	1.082±0.002	3.141±0.001	5.629±0.002	31.031±0.001	1.906±0.003	2.011±0.001	1.127±0.002	2.994±0.002	2.320±0.0008
75 %	0.623±0.002	0.918±0.003	5.435±0.002	22.201±0.003	1.016±0.001	1.103±0.002	0.998±0.005	1.973±0.002	1.007±0.002
100 %	0.564±0.027	1.085±0.001	4.910±0.001	17.131±0.002	1.082±0.002	1.008±0.003	1.025±0.002	1.827±0.003	1.181±0.002
					25th day				
Control	0.098±0.001	1.936±0.002	6.733±0.003	26.828±0.002	0.314±0.002	0.657±0.001	0.120±0.001	0.321±0.002	0.104±0.003
25 %	0.294±0.002	2.139±0.001	5.814±0.002	19.128±0.002	0.292±0.001	0.435±0.001	0.079±0.002	1.818±0.001	0.124±0.001
50 %	0.299±0.002	2.827±0.002	6.603±0.001	24.858±0.002	0.323±0.002	0.632±0.0008	0.098±0.003	1.921±0.001	0.192±0.001
75 %	0.105±0.001	2.673±0.001	5.985±0.002	20.377±0.002	0.362±0.001	0.630±0.001	0.121±0.001	2.443±0.002	0.103±0.002
100 %	0.093±0.002	2.100±0.001	4.029±0.003	16.178±0.002	0.194±0.002	0.403±0.002	0.071±0.001	2.393±0.0008	0.096±0.001
					30th day				
Control	0.123±0.002	2.428±0.001	9.687±0.002	11.189±0.001	0.998±0.001	0.992±0.003	0.127±0.002	4.026±0.001	1.936±0.002
25 %	0.093±0.002	2.487±0.001	10.104±0.001	10.827±0.002	0.535±0.001	1.098±0.001	0.124±0.002	3.985±0.005	1.001±0.001
50 %	0.073±0.002	1.977±0.002	8.098±0.003	9.814±0.012	0.402±0.002	0.868±0.002	0.101±0.0008	3.699±0.001	1.984±0.001
75 %	0.115±0.001	2.1±0.001	7.124±0.002	10.106±0.002	0.933±0.002	1.037±0.002	0.100±0.001	3.230±0.003	0.03±0.001
100 %	0.047±0.0008	2.885±0.001	8.239±0.001	11.311±0.024	1.030±0.003	1.138±0.002	1.099±0.001	4.129±0.0008	2.020±0.002

Values are arithmetic mean ± SEM of three replicates.

TABLE-3

METAL ANALYSIS IN GROUNDNUT PLANT SAMPLES

	Cr	Cu	Mn	Fe	Co	Ni	Cd	Pb	Zn
					10th day				
Control	3.642±0.096	9.320±0.074	27.777±0.384	370.95±0.475	22.397±0.251	32.610±0.314	5.026±0.031	75.015±0.045	51.104±0.071
25 %	3.927±0.067	11.488±0.081	40.033±0.030	199.36±0.303	22.164±0.124	33.019±0.023	5.274±0.150	81.471±0.187	46.514±0.291
50 %	6.488±0.094	16.335±0.252	45.396±0.192	370.04±1.834	43.652±0.237	69.011±0.016	10.256±0.082	154.51±0.207	69.610±0.237
75 %	5.554±0.048	10.311±0.119	65.449±0.132	463.29±0.167	34.141±0.081	46.370±0.271	8.464±0.259	113.47±0.184	122.53±0.09
100 %	5.280±0.052	8.219±0.065	25.428±0.162	937.32±0.106	12.072±0.043	20.515±0.240	7.115±0.08	48.518±0.324	43.245±0.065
					15th day				
Control	3.781±0.113	4.067±0.017	11.515±0.150	255.93±0.054	22.402±0.292	29.538±0.156	5.501±0.218	74.538±0.343	109.42±0.24
25 %	4.756±0.134	17.682±0.321	24.022±0.058	391.66±0.224	0.999±0.032	3.441±0.184	0.213±0.034	0.095±0.005	239.54±0.233
50 %	7.656±0.186	11.874±0.359	25.655±0.234	435.22±0.496	23.354±0.292	34.379±0.305	5.383±0.283	87.776±1.704	297.08±0.077
75 %	7.704±0.360	17.972±0.086	47.361±0.069	521.23±0.475	40.459±0.312	47.425±0.255	9.394±0.272	143.32±0.667	263.37±0.263
100 %	6.815±0.115	11.660±0.086	43.969±0.078	780.47±0.270	26.575±0.292	41.518±0.239	6.024±0.039	89.428±0.256	186.15±0.114
					20th day				
Control	7.599±0.171	11.648±0.240	44.639±0.226	204.75±0.637	32.604±0.252	52.148±0.028	7.587±0.195	109.66±0.482	296.31±0.311
25 %	7.435±0.185	16.668±0.285	50.720±0.321	428.38±0.317	36.368±0.218	59.363±0.270	8.459±0.244	121.52±0.284	307.53±0.289
50 %	4.742±0.236	7.394±0.300	18.588±0.295	205.53±0.250	20.518±0.249	32.470±0.233	4.735±0.309	74.571±0.300	184.78±0.230
75 %	10.392±0.282	22.273±0.278	94.519±0.240	531.60±0.331	51.388±0.274	69.096±0.068	11.691±0.286	173.47±0.291	424.54±0.254
100 %	11.872±0.173	16.453±0.270	99.601±0.295	899.81±0.291	32.523±0.256	62.535±0.185	7.669±0.295	110.36±0.292	206.06±0.027
					25th day				
Control	5.309±0.226	16.657±0.356	24.391±0.235	298.69±0.230	12.170±0.069	23.725±0.314	2.636±0.208	42.023±0.079	167.57±0.173
25 %	8.736±0.342	11.692±0.295	35.567±0.247	452.21±0.257	35.464±0.231	45.649±0.274	8.263±0.096	110.05±0.077	167.28±0.089
50 %	4.459±0.254	10.430±0.272	25.768±0..102	242.75±0.616	18.505±0.240	29.560±0.255	4.200±0.067	66.764±0.371	144.11±0.046
75 %	6.348±0.218	13.303±0.251	33.616±0.257	378.58±0.257	11.587±0.257	24.499±0.257	2.550±0.208	45.195±0.136	196.55±0.301
100 %	10.390±0.233	23.727±0.135	61.308±0.259	697.21±0.090	44.641±0.272	74.125±0.080	8.695±0.254	161.38±0.282	270.30±0.065
					30th day				
Control	6.005±0.006	18.585±0.172	50.778±0.088	399.25±0.059	20.639±0.120	50.169±0.127	6.531±0.148	91.052±0.087	81.984±0.006
25 %	9.106±0.033	10.767±0.018	9.588±0.082	331.58±0.324	31.640±0.043	41.955±0.015	6.664±0.028	100.68±0.344	283.86±0.066
50 %	10.536±0.097	24.120±0.037	41.918±0.082	526.78±0.310	37.380±0.103	57.075±0.031	8.474±0.031	114.63±0.073	362.17±0.078
75 %	7.333±0.063	16.867±0.047	72.501±0.175	448.54±0.141	24.368±0.037	41.128±0.031	5.485±0.012	71.588±0.026	248.64±0.115
100 %	56.241±0.419	7.788±0.084	35.605±0.058	382.93±0.077	0.778±0.018	3.700±0.062	0.070±0.01	1,071±0.015	25.721±0.04

Values are arithmetic mean ± SEM of three replicates

The accumulation of heavy metal from soil to plant parts did not follow any particular pattern and varied with respect to metals, species and plant parts.

The metal content in the cultivated soil irrigated with contaminated water was found to be either below or with in the usual typical back ground values as suggested by[17] except for Cd, Pb and Ni.

The concentration of metals especially Cd, Pb, Cr and Ni are much higher in wheat and mustard and may exceed the average normal concentration reported by others and are beyond human consumption level. This may create health problems in the long run. The average normal concentration of Cd is 0.05 μg/g[18], Pb is 0.01 to 1.0 μg/g[19]. Cr and Ni are 60 and 250 μg/g, respectively[20].

The concentrations of nine metals in soils were the similar in plants, this result meant the concentrations of heavy metal in soils should have effect on the concentrations in plants. The reason maybe due to the fact that total concentrations of nine heavy metals in soils were affected by many factors and influenced the concentrations in plant indirectly. Selecting different extract solution to get different part concentrations of heavy metals necessary, which could find direct factor that affect the concentration of plant[21,22].

Plants maintain metals at relatively low concentrations with in plants by avoiding excessive metal uptake and transport[5,6]. The mechanisms include chelation, compartmentalization, biotransformation and cellular repair mechanisms[23,24].

Conclusion

The hyper accumulator chosen primarily, if further confirmed and optimized, could have impact on practical phytoremediation approaches and decrease ultimately the rick of heavy metals to human health[25]. This is an important work for phytoremediation of soil polluted by heavy metal. However, this work is complex and interdisciplinary, study on soil characteristic, the mechanism of plants to accumulate heavy metals, interaction between plant and soil, based on my results metal accumulation low compared than remaining effluent concentrations.

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