International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2013): 4.438

Effect of Textile Waste Water on *Vigna unguiculata* var. RC-101(cow pea) in a Pot Experiment with Reference of Heavy Metal Bioaccumulation

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Abstract: ***The plants of Vigna unguiculata var. RC-101 (cow pea) treated with different level of waste water and analyzed for metal accumulation, growth and biochemical parameters at pre, peak and post flowering stages. Findings of the study revealed that chlorophyll content was most severely affected with the increase in metal concentration. Total chlorophyll content showed a reduction of 56.55percent while carbohydrate, protein and nitrogen content showed a reduction of 47.83 percent, 55.31 percent and 55.40 percent respectively. With the increase in wastewater treatment the root and shoot length, root and shoot dry weight were reduced to 45.43 percent, 29.48 percent, 61.97 percent, 53.11 percent respectively. After crop harvesting, the fruit samples of the plants treated with highest concentration of textile waste(50 percent waste water mixed with 50 percent of distilled water) water contained 5.257 mg g -1 d.wt. of Zn, 2.518 mg g -1 d.wt. Cu, 1.276 mg g -1 d.wt. Ni, 1.895 mg g -1 d.wt. Cd, 4.893 mg -1 d.wt. Cr , 1.897 mg g -1 d.wt. Pb and 1.854 mg g -1 d.wt. Co.***

Keywords: Textile waste water, Heavy metals, *Vigna unguiculata*, Sanganer town

1. Introduction

Industrial progress and development of global population have led to an excessive contamination of ecosystems, particularly marine environment, by metals over the last three decades (Franca et al., 2005). Environmental pollution has become a worldwide phenomenon. Pollution of water bodies is a phenomenon of concern in the developing countries of the world including India (Awomeso et al., 2010). Industrial effluents urban runoff, direct disposal of wastes into the water bodies agricultural fertilizer and animal wastes remain the major water contaminants. It is also reported that textile and dyeing industry pose a major environmental threat because of the large amounts of water and dyes involved in the manufacturing process.

Large amount of chemically different dyes are employed for various industrial applications including textile dyeing (Pal and Brijmohan1990). Textile industry is considered to be one of water polluters. Water pollution due to textile industry is a topic of major concern as they discharge large quantity of effluent into nearby water bodies. Textile wastewater is a mixture of colorants (dyes and pigments) and various organic compounds used as cleaning solvents, plasticizers, etc. It also contains high concentrations of heavy metals, total dissolved solids, and has high chemical and biological oxygen demand. The major metal pollutants such as copper, zinc, chromium, etc. come mainly from the metal complex dyes and chromium salts used in wool dyeing or as oxidizing agents in sulfur dyeing (Chavan 2001). The dye effluent contains certain chemicals that could be toxic, carcinogenic or mutagenic to living organisms (Suzuki et al., 2001) Crops and vegetables grown in the agricultural fields irrigated by textile effluent are adversely affected both qualitatively and quantitatively. Impact of textile waste water on agricultural crops has been studied earlier by several workers (Khan and Jain, 1995; Jain and Khan, 1996; Sharma and Rao, 1996;Tomar et al., 2000).

Considering the high potential of pollution by textile waste water an experiment has been conducted. The study was to find out the adverse impacts on Vigna unguiculata and its tendency to biologically accumulating heavy metals.

2. Materials and Methods

Experimental Setup

For the experimental study *Vigna unguiculata* Var. RC-101 was selected as test plant. *Vigna unguiculata* (cow pea) belongs to family *Fabaceae*. It is a commonly used green pods as a vegetable and seeds as a pulses. The plants were grown in the earthen pots and the population of five plants per pot was maintained for experiment. Waste water was collected from Sanganer, Jaipur where large number of textile industries are located. These industries discharge huge quantity of untreated waste water in a dry river popularly known as Amanishah nala the erstwhile Drawyawati River. In this experiment six levels maintained containing different proportion of textile waste water and distilled water as follows:-

Level 1 - Controlled condition (Pure Double Distilled water)-(Control)
Level 2 - DW:WW:: 90:10
Level 3 - DW:WW:: 80:20
Level 4 - DW:WW:: 70:30
Level 5 - DW:WW:: 60:40
Level 6 - DW:WW:: 50:50

Growth Parameters

The plants were harvested at pre-flowering, peak-flowering and post-flowering stages for studying different growth parameters (root and shoot length, dry weight of root and shoot). For dry weight determination roots and shoots were separated and dried in hot air oven at 80ºC for 72 hr before determining biomass in gms.

Biochemical Analysis

Chlorophyll a, b and total chlorophyll content in leaves were estimated by employing method suggested by Arnon (1949). Carbohydrate content was estimated by employing the Anthrone method .Protein content was determined by employing the method suggested by Lowry *et al*. (1951) while nitrogen content was estimated by microkjeldhal's method (Allen, 1931). Heavy metals in the soil and crop plant samples were estimated using Atomic Absorption Spectrophotometer (AAS Model GBC 932 place).

3. Results and Discussion

The plants of *Vigna unguiculata* (cow pea) treated with waste water (Level -6) effluent showed a root length 12.07 (45.43%), shoot length 45.3cm (29.48%), Root dry weight was 0.305gm (61.97%) and shoot dry weight was 2.223 (53.11%) (Table 1a and 1b) at post flowering stage as compared to control condition. The amount of total chlorophyll was 0.791mg/gm at treatment level six with a reduction of 56.34 percent as compared to controlled conditions at peak flowering stage .(Table 1c). while a maximum reduction in carbohydrate 32.1mg/gm (47.83%),phosphorous 3.118 (11.39%) nitrogen 0.953percent (55.40%) and protein 5.977percent (55.31%) content was found at treatment level six as compared to control condition at post flowering stage. (Table 1d and 1e).

The results of heavy metal analyzed in different plant parts samples of *Vigna unguiculata* (cow pea) at pre-flowering, peak-flowering and post-flowering stages are given in table . The concentration of Zn increased with increase in waste water treatment. At six level treatment the plants accumulated Zn concentration 1.204mg/gm d.wt.,0.577mg/gm and 0.722mg/gm in root ,stem and leaves respectively at pre flowering stage. Cu concentration was 0.552mg/gm ,0.370mg/gm and 1.254mg/gm ,Ni concentration was 0.191mg/gm,0.311mg/gm and 0.326mg/gm ,Cd was 0.171mg/gm,0.271mg/gm and 0.282mg/gm, Cr was 0.207mg/gm ,0.196mg/gm and 0.442mg/gm, Pb was 0.428mg/gm, 0.227mg/gm and 0.214mg/gm , and Co concentration was 0.327g/gm,0.226mg/gm and 0.314mg/gm in root ,stem and leaves respectively at pre-flowering stage. The Zn concentration was increased in peak flowering stage. At six treatment level the plants accumulated Zn concentration was 1.454mg/gm ,0.724mg/gm and 1.468mg/gm , Cu was 0.719mg/gm,0.643mg/gm and 1.747mg/gm, Ni was 0.256mg/gm ,0.469mg/gm and 0.458mg/gm, Cd was 0.219mg/gm,0.348mg/gm and 0.428mg/gm , Cr concentration was measured 0.306mg/gm,0.362mg/gm and 0.743g/gm ,Pb was 0.552mg/gm, 0.339mg/gm and 0.276mg/gm, Co was 0.422mg/gm, 0.363mg/gm and 0.481mg/gm in root ,stem and leaves respectively at peak flowering stage.

Similarly the heavy metals concentration was increased at post flowering stage at treatment level six effluent or waste water Zn concentration was 1.639mg/gm ,0.928mg/gm and 2.224mg/gm , Cu was 0.669mg/gm,0.730mg/gm and 0.378mg/gm ,Ni was 0.333mg/gm,0.589mg/gm and 0.572mg/gm, Cd was 0.272mg/gm, 0.514mg/gm and 0.532mg/gm, Cr concentration was 0.404mg/gm,0.430mg/gm and 0.951mg/gm, Pb was 0.633mg/gm, 0.428mg/gm and 0.633mg/gm, Co was 0.524mg/gm, 0.483mg/gm and 0.679mg/gm in root ,stem and leaves respectively at post flowering stage.

The heavy metal concentration in the edible parts was recorded at post flowering stage. Zinc, Copper, Nickel, Cadmium, Chromium, Lead and Cobalt concentration was 5.257mg/gm, 2.518, 1.276 mg/gm, 1.895, 4.893, 1.897 and 1.854mg/gm respectively.

Earlier studies by Khan and Marwari (2002, 2003) and Khan et al. (2003 a, b) reported high concentration of heavy metal in vegetables grown in agricultural fields receiving textile waste water. Metal accumulation in vegetables may pose a direct threat to human health (Türkdogan *et al*., 2003)Heavy metals may enter the human body through inhalation of dust, direct ingestion of soil, and consumption of food plants grown in metal-contaminated soil. Crop plants growing on heavy metal contaminated medium can accumulate high concentrations of trace elements to cause serious health risk to consumers. Long *et al*., (2003) studied the effects of excess zinc on plant growth of three selected vegetables i.e. Chinese cabbage, celery and pakchoi. They found that excess Zn in growth media caused toxicity to all three vegetable crops and showed symptoms like chlorosis in young leaves, browning of coralloid roots, and serious inhibition on plant growth. Singh and Agarwal (2006) reported that cowpea, okra raddish, spinach, chickpea, pea and wheat grown in heavy metals contaminated soils affected biomass, yield and metal distribution in different parts of crop plants. Among the heavy metals, Zn showed highest tissue concentration followed by Cu, Pb and Cd. The concentration of metals was higher in edible parts of leafy vegetables such as spinach and radish than in the edible parts of fruit type of vegetables and field crops. Among the crops, wheat showed maximum uptake of Cu and Zn, while spinach and okra manifested maximum uptake of Pb and Cd respectively. Althoug maximum proportion of heavy metals absorbed by the crops accumulated in their vegetative shoots (leaves, stem and root), but substantial proportion of metals transported to seeds and fruits as well. Athar and Ahmad (2002) conducted a study by pot experiment to investigate the toxic effects of certain heavy metals on the plant growth and grain yield of wheat (*Triticum aestivum L*.). Present study was also conducted through a laboratory pot experiment to ascertain the bioaccumulation of heavy metals. Higher the amount of textile wastewater addition more was the bioaccumulation. The results revealed that heavy metals brought about significant reductions in both parameters, Cd being the most toxic metal followed by Cu,Ni, Zn, Pb , Cr and Co. There is also a reduction in plant protein and nitrogen content was recorded with the increasing concentration of heavy metals. Metal uptake by grains was directly related to the applied heavy metal with greater concentrations of metals found in cases where metals were added separately rather than in combinations. The toxic effects on the plant growth, nitrogen content in plant parts, and protein content in grains, exerted by two metals in combination were not additive, but rather only as severe as for the most toxic metal alone. Thus, the practice of growing vegetables using waste water(textile waste) should be checked in order to reduce biomagnifications of metals via food chain. Waste water should be used only after adequate treatment.

4. Acknowledgement

The authors are thankful to the Director, Indira Gandhi Centre for Human Ecology, Environment and Population Studies and Dean Faculty of Science, University of Rajasthan for providing necessary facilities. One of the authors (Jaishree) is thankful to University Grant Commission New Delhi for providing financial assistance as Rajiv Gandhi Senior Research Fellowship.

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Table 1a: Effects of Textile Waste Water on Root and Shoot Lengths (cm) of Vigna unguiculata var RC-101 (Cow pea) through pot experiment

Treatment Levels (DW:WW)	*Pre-Flowering Stage*		*Peak-Flowering Stage*		*Post-Flowering Stage*	
	Root Length (cm)	*Shoot Length (cm)*	*Root Length (cm)*	*Shoot Length (cm)*	*Root Length (cm)*	*Shoot Length (cm)*
Level 1 Control (D.W)	15.62 ± 1.22	50.3 ± 3.33	21.34 ±0.766	63.58 ±0.858	22.12 ±1.262	64.24 ±1.137
Level 2 (90:10)	13.30 ± 0.95 (14.85)	48.36 ± 1.34 (3.85)	18.42 ±0.819 (13.68)	60.04 ±2.912 (5.56)	19.16 ±1.139 (13.38)	61.4 ± 1.394 (4.42)
Level 3 (80:20)	12.84 ± 0.74 (17.79)	47.04 ± 0.88 (6.48)	15.94 ± 0.76 (25.30)	57.9 ± 1.222 (8.93)	16.23 ±1.028 (26.62)	58.3 ± 1.339 (9.24)
Level 4 (70:30)	11.8 ± 0.69 (24.45)	43.12 ± 0.84 (14.27)	14.36 ±0.776 (32.70)	56.26 ±1.099 (11.51)	15.1± 0.781 (31.73)	57.12 ±1.019 (11.08)
Level 5 (60:40)	10.5 ± 0.75 (32.77)	39.66 ± 0.95 (21.15)	12.88 ±0.746 (39.64)	52.76 ±2.357 (17.01)	13.25 ±0.791 (40.09)	53.1 ± 0.953 (17.34)
Level 6 (50:50)	9.24 ±0.90 (40.84)	36.24 ± 0.40 (27.95)	11.64 ±0.856 (45.45)	44.78 ±1.266 (29.56)	12.07 ±1.094 (45.43)	45.3 ± 2.745 (29.48)

Table 1b: Effects of Textile Waste Water on Root and Shoot Weight (gm) of Vigna unguiculata var RC-101 (Cow pea) through pot experiment

Treatment Levels (DW:WW)	**Pre-Flowering Stage**		**Peak-Flowering Stage**		**Post-Flowering Stage**	
	Root Weight (gm)	**Shoot Weight (gm)**	**Root Weight (gm)**	**Shoot Weight (gm)**	**Root Weight (gm)**	**Shoot Weight (gm)**
Level 1 Control (D.W)	0.452 ±0.027	2.595 ±0.044	0.714 ±0.019	4.486 ±0.114	0.802±0.022	4.741 ±0.036

Level 2 (90:10)	0.400 ±0.015 (11.50)	2.169 ±0.043 (16.41)	0.652 ±0.019 (8.68)	3.984 ±0.054 (11.19)	0.712 ±0.02 (11.22)	4.318 ±0.037 (8.92)
Level 3 (80:20)	0.349 ±0.019 (22.78)	1.938 ±0.065 (25.31)	0.570 ±0.019 (20.16)	3.611 ±0.058 (19.50)	0.618± 0.019 (22.94)	4.102 ±0.059 (13.47)
Level 4 (70:30)	0.280 ±0.016 (38.05)	1.705 ±0.077 (34.29)	0.434 ±0.019 (39.21)	3.323 ±0.098 (25.92)	0.498 ±0.026 (37.90)	3.521 ±0.066 (25.73)
Level 5 (60:40)	0.218 ±0.017 (51.76)	1.321 ± 0.05 (49.09)	0.343 ±0.027 (51.96)	2.204 ± 0.06 (50.86)	0.375 ±0.028 (53.24)	2.613 ±0.172 (44.88)
Level 6 (50:50)	0.181 ±0.014 (59.95)	1.066 ± 0.24 (58.92)	0.275 ±0.021 (61.48)	1.910 ±0.045 (57.42)	0.305 ± 0.03 (61.97)	2.223 ±0.101 (53.11)

Table 1c: Effects of Textile Waste Water on Chlorophyll (mg/gm) in Vigna unguiculata var RC-101 (Cow pea) through pot experiment

Treatment Levels (DW:WW)	**Pre-Flowering Stage**			**Peak-Flowering Stage**			**Post-Flowering Stage**		
	Chl-a (mg/gm)	**Chl-b (mg/gm)**	**Total Chl (a+b) (mg/gm)**	**Chl-a (mg/gm)**	**Chl-b (mg/gm)**	**Total Chl (a+b) (mg/gm)**	**Chl-a (mg/gm)**	**Chl-b (mg/gm)**	**Total Chl (a+b) (mg/gm)**
Level 1 Control (D.W)	0.780±0.512	0.456±0.24	1.236±0.56	1.145±0.25	0.656±0.14	1.812±0.40	1.121±0.95	0.633±0.35	1.754±0.99
Level 2 (90:10)	0.701±0.379 (10.12)	0.382±0.206 (16.22)	1.083±0.586 (12.37)	0.896±0.85 (21.74)	0.475±0.26 (27.59)	1.353±0.67 (25.33)	0.842±0.27 (24.88)	0.459±0.14 (27.48)	1.302±0.42 (25.76)
Level 3 (80:20)	0.642±0.26 (17.69)	0.350±0.14 (23.24)	0.992±0.404 (19.74)	0.776±0.30 (32.22)	0.436±0.16 (33.53)	1.203±0.61 (33.60)	0.766±0.27 (31.66)	0.418±0.15 (33.96)	1.184±0.43 (32.49)
Level 4 (70:30)	0.533±0.32 (31.66)	0.291±0.17 (36.18)	0.824±0.49 (33.33)	0.681±0.31 (40.52)	0.361±0.16 (44.96)	1.042±0.47 (42.49)	0.647±0.33 (42.28)	0.353±0.17 (44.23)	1.001±0.51 (42.93)
Level 5 (60:40)	0.465±0.61 (40.38)	0.264±0.11 (42.10)	0.734±0.73 (40.61)	0.583±0.28 (49.08)	0.323±0.15 (50.76)	0.918±0.43 (49.33)	0.580±0.40 (48.26)	0.316±0.22 (50.07)	0.896±0.63 (48.91)
Level 6 (50:50)	0.386±0.60 (50.51)	0.21±0.33 (53.94)	0.596±0.94 (51.77)	0.522±0.29 (54.41)	0.285±0.15 (56.55)	0.791±0.44 (56.34)	0.495±0.47 (55.84)	0.266±0.19 (57.97)	0.762±0.65 (56.55)

Table 1d: Effects of Textile Waste Water on Carbohydrate and Phosphorous (mg/gm) in Vigna unguiculata var RC-101 (Cow pea) through pot experiment.

Treatment Levels (DW:WW)	**Pre-Flowering Stage**		**Peak-Flowering Stage**		**Post-Flowering Stage**	
	Carbohydrate (mg/gm)	**Phosphorous (mg/gm)**	**Carbohydrate (mg/gm)**	**Phosphorous (mg/gm)**	**Carbohydrate (mg/gm)**	**Phosphorous (mg/gm)**
Level 1 Control (D.W)	41.56±0.864	3.29±0.282	60.22±0.944	3.396±0.182	61.54±1.327	3.51±0.205
Level 2 (90:10)	37.3±1.004 (10.25)	3.22±0.215 (2.12))	55±0.894 (8.66)	3.346±0.191 (1.47)	56.2±0.604 (8.67)	3.42±0.184 (2.56)
Level 3 (80:20)	33.68±0.676 (18.96)	3.16±0.228 (3.95)	50.62±1.202 (15.94)	3.21±0.281 (5.30)	51.26±1.359 (16.70)	3.32±0.166 (5.41)
Level 4 (70:30)	29.57±0.522 (28.84)	3.05±0.16 (7.29)	46.04±0.829 (23.54)	3.19±0.215 (5.89)	47.12±1.593 (23.43)	3.24±0.177 (7.69)
Level 5 (60:40)	27.36±0.698 (34.16)	2.93±0.163 (10.94)	40±1.106 (33.57)	3.136±0.151 (7.66)	41.1±0.968 (33.21)	3.19±0.215 (9.11)
Level 6 (50:50)	23.1±0.777 (44.41)	2.876±0.221 (12.76)	30.88±1.098 (48.72)	3.05±0.16 (10.02)	32.1±1.08 (47.83)	3.118±0.17 (11.39)

Table 1(e): Effects of Textile Waste Water on Nitrogen and Protein in Vigna unguiculata var RC-101 (Cow pea) through pot experiment

Treatment Levels (DW:WW)	**Pre-Flowering Stage**		**Peak-Flowering Stage**		**Post-Flowering Stage**	
	% Nitrogen	**% Protein**	**% Nitrogen**	**% Protein**	**% Nitrogen**	**% Protein**
Level 1 Control (D.W)	1.094±0.087	6.605±0.555	1.366±0.083	7.303±0.522	2.137±0.117	13.376±0.748
Level 2 (90:10)	0.933±0.07 (14.72)	5.84±0.530 (11.58)	1.047±0.091 (23.35)	6.397±0.786 (12.40)	1.944±0.13 (9.03)	12.172±0.816 (9)
Level 3 (80:20)	0.765±0.08 (30.08)	4.798±0.537 (27.35)	0.933±0.08 (31.69)	5.843±0.557 (19.99)	1.719±0.129 (19.56)	10.847±0.989 (18.90)
Level 4 (70:30)	0.681±0.08 (37.76)	4.266±0.527 (35.41)	0.812±0.075 (40.55)	5.089±0.55 (30.31)	1.451±0.124 (32.10)	9.085±0.78 (32.04)
Level 5 (60:40)	0.583±0.07 (46.71)	3.657±0.530 (44.63)	0.700±0.091 (48.75)	4.388±0.573 (39.91	1.171±0.142 (45.20)	7.342±0.894 (45.11)
Level 6 (50:50)	0.410±0.07 (62.53)	2.575±0.468 (61.01)	0.562±0.093 (58.85)	3.526±0.595 (51.71)	0.953±0.132 (55.40)	5.977±0.833 (55.31)

Table 1(f): Heavy metal analysis of Vigna unguiculata var RC-101 (Cow pea) through pot experiment at Pre-Flowering Stage

Heavy Metals (mg/g)	Plant Parts	Treatment Levels (DW:WW)					
		100:00	90:10	80:20	70:30	60:40	50:50
Zn	Root	0.000	1.004	1.039	1.125	1.148	1.204
	Stem	0.000	0.342	0.389	0.453	0.504	0.577
	Leaves	0.000	0.370	0.428	0.568	0.640	0.722
Cu	Root	0.000	0.433	0.457	0.486	0.509	0.552
	Stem	0.000	0.137	0.167	0.247	0.313	0.370
	Leaves	0.000	0.428	0.529	0.678	0.946	1.254
Ni	Root	0.000	0.107	0.128	0.150	0.171	0.191
	Stem	0.000	0.110	0.149	0.223	0.241	0.311
	Leaves	0.000	0.097	0.159	0.200	0.269	0.326
Cd	Root	0.000	0.069	0.100	0.122	0.140	0.171
	Stem	0.000	0.068	0.114	0.174	0.199	0.271
	Leaves	0.000	0.096	0.129	0.179	0.219	0.282
Cr	Root	0.000	0.127	0.148	0.166	0.183	0.207
	Stem	0.000	0.033	0.071	0.134	0.162	0.196
	Leaves	0.000	0.101	0.176	0.228	0.327	0.442
Pb	Root	0.000	0.318	0.350	0.378	0.408	0.428
	Stem	0.000	0.070	0.103	0.142	0.172	0.227
	Leaves	0.000	0.011	0.097	0.142	0.168	0.214
Co	Root	0.000	0.110	0.186	0.223	0.277	0.327
	Stem	0.000	0.048	0.060	0.139	0.182	0.226
	Leaves	0.000	0.148	0.177	0.228	0.262	0.314

Table 1(g): Heavy metal analysis of Vigna unguiculata var RC-101 (Cow pea) through pot experiment at Peak-Flowering Stage

Heavy Metals (mg/g)	Plant Parts	Treatment Levels (DW:WW)					
		100:00	90:10	80:20	70:30	60:40	50:50
Zn	Root	0.00	1.110	1.153	1.26	1.372	1.454
	Stem	0.00	0.455	0.525	0.619	0.636	0.724
	Leaves	0.00	0.681	0.848	0.959	1.066	1.468
Cu	Root	0.00	0.638	0.660	0.689	0.703	0.719
	Stem	0.00	0.239	0.303	0.378	0.458	0.643
	Leaves	0.00	0.734	0.975	1.358	1.581	1.747
Ni	Root	0.00	0.148	0.179	0.203	0.219	0.256
	Stem	0.00	0.198	0.258	0.352	0.381	0.469
	Leaves	0.00	0.168	0.228	0.291	0.399	0.458
Cd	Root	0.00	0.116	0.149	0.171	0.191	0.219
	Stem	0.00	0.149	0.172	0.264	0.304	0.348
	Leaves	0.00	0.148	0.214	0.269	0.337	0.428
Cr	Root	0.00	0.199	0.220	0.252	0.269	0.306
	Stem	0.00	0.110	0.130	0.246	0.288	0.362
	Leaves	0.00	0.160	0.289	0.369	0.535	0.743
Pb	Root	0.00	0.445	0.462	0.513	0.608	0.552
	Stem	0.00	0.128	0.149	0.251	0.281	0.339
	Leaves	0.00	0.058	0.124	0.169	0.198	0.276
Co	Root	0.00	0.131	0.228	0.317	0.391	0.422
	Stem	0.00	0.141	0.173	0.246	0.281	0.363
	Leaves	0.00	0.240	0.297	0.350	0.399	0.481

Table 1(h): Heavy metal analysis of Vigna unguiculata var RC-101 (Cow pea) through pot experiment at Post-Flowering Stage

Heavy Metals (mg/g)	Plant Parts	Treatment Levels (DW:WW)					
		100:00	90:10	80:20	70:30	60:40	50:50
Zn	Root	0.00	1.337	1.378	1.497	1.548	1.639
	Stem	0.00	0.588	0.706	0.778	0.835	0.928
	Leaves	0.00	0.910	1.143	1.360	1.649	2.224
	Fruit	0.096	2.278	2.89	3.386	4.223	5.257
Cu	Root	0.00	0.301	0.386	0.446	0.530	0.669
	Stem	0.00	0.328	0.363	0.459	0.527	0.730
	Leaves	0.00	0.218	0.253	0.257	0.278	0.378
	Fruit	0.076	0.65	0.768	0.984	1.884	2.518
Ni	Root	0.00	0.190	0.229	0.262	0.291	0.333
	Stem	0.00	0.248	0.314	0.442	0.432	0.589
	Leaves	0.00	0.229	0.318	0.388	0.490	0.572

	Fruit	0.033	0.371	0.676	0.807	0.965	1.276
Cd	**Root**	0.00	0.157	0.187	0.212	0.241	0.272
	Stem	0.00	0.234	0.294	0.359	0.418	0.514
	Leaves	0.00	0.215	0.261	0.345	0.436	0.532
	Fruit	0.057	0.567	0.876	1.047	1.583	1.895
Cr	**Root**	0.00	0.248	0.303	0.342	0.381	0.404
	Stem	0.00	0.154	0.204	0.338	0.370	0.430
	Leaves	0.00	0.240	0.383	0.539	0.781	0.951
	Fruit	0.063	0.833	1.108	1.776	3.069	4.893
Pb	**Root**	0.00	0.498	0.526	0.565	0.610	0.633
	Stem	0.00	0.172	0.203	0.319	0.342	0.428
	Leaves	0.00	0.098	0.163	0.216	0.300	0.352
	Fruit	0.023	0.409	0.670	1.307	1.549	1.897
Co	**Root**	0.00	0.171	0.311	0.388	0.423	0.524
	Stem	0.00	0.242	0.263	0.349	0.404	0.483
	Leaves	0.00	0.328	0.420	0.499	0.586	0.679
	Fruit	0.045	0.654	0.889	1.158	1.692	1.854