© 2016 IJSRSET | Volume 2 | Issue 2 | Print ISSN: 2395-1990 | Online ISSN : 2394-4099

Impact of Various Concentrations of Electroplating Industry Effluent on Growth and Metabolism of Rice (*Oryza sativa* L.) Plants

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Abstract

A significant reduction was observed in seed germination, plant growth, yield (total fresh weight and dry weight), protein concentration and amylase activity in rice plants. The chlorophyll and carotenoid content showed variable results with increasing concentrations of effluent. At lower concentration of effluent plant showed a significant stimulation in sugar content, while it was inhibited at 50, 75 and 100% concentration of effluent. Activity of enzyme catalase and peroxidase was found to be significantly increased with increasing supply of industry effluent in rice plants. Chemical properties of soil analysis showed that pH adversely affected with variable results, while calcium carbonate % and organic carbon % was increased with increasing concentrations of effluent.

Keywords: Electroplating Industry Effluent, Rice, Germination, Growth, Pigments, Sugar , Protein, Catalase, Peroxidase, Amylase and Soil chemical changes

I. INTRODUCTION

Pollution is one of the biggest challenges that are faced by the human being in the current scenario. Various pollutants from innumerable sources have caused a gradual decline in this ecosystem's health and apparently in the quality of human life also. This degradation, being very slow in nature has failed to gain our attention and thus we have constantly neglected this fatal improvement around ourselves. One another reason for this widespread ignorance is also the materialistic pursuit in human beings which prevents them from going beyond the limits of their pleasures to look in to the problem which will eventually lead to the doom of this whole mankind and the plant earth itself. A major source which eats up our nature in exchange of monitory wealth is the number of exponentially increasing industries. Though, industries are important for development and are an integral part of it but the way we neglect their negative aspects is very harmful for the nature and for us too. The chemical wastes that these industries produce cause huge damage to our ecosystem by destroying the land and water bodies by injecting poisonous substances which are gradually eating up the minerals in soil and water. This not only degrades the quality of the soil but also causes illness and death of flora and fauna. This act of defilement makes these elements unsuitable for any kind of human consumption, which when consumed by humans , lead them to their ill fate, for which as we know, they themselves are responsible.

II. MATERIALS AND METHODS

Experiment was carried out in soil as pot culture under controlled glass house conditions. The tap water washed soil was filled in medium size earthen pots provided with a central drainage hole. The soil pH was maintained by repeatedly flushing with distilled water. The glass distilled water was used for all metabolic and analytical work. The basal nutrient solution was prepared by method given by Hewitt (1966).When plants were raised basal nutrition solution were supplied. The plants were treated with different concentrations (25, 50, 75 and 100%) of effluent on alternate days. Germination studies were conducted under lab conditions. Activities of enzymes catalase and peroxidase was assayed by the modified methods of Bisht (1972) and Luck (1963) respectively. Amylase activity was assayed by the method of Katsuni and Frekuhara (1969). Chlorophyll, total sugars , proteins were measured by the methods of Petering et al.(1940), Dubias et al.(1956) and Lowry et al.(1951) respectively. The soil sample were collected after harvest and allowed to dry in shade. The dried soil sample were powdered and sieved through a 1 mm sieve. Processed samples were analyzed for different chemical characteristics. The soil pH was determined in 1:2 soil water ratio (Jackson,1973). Calcium carbonate in the soil was determined by the rapid titration method of Piper (1942). The organic carbon in the soil was determined by Walkley and Black's (1934) rapid titration method.

III. RESULTS AND DISCUSSION

Growth parameters

Germination percentage was found to be decreased at increasing concentration of effluent. It was 12.86, 21.43, 22.86 and 24.29% decrease at 25, 50, 75 and 100 % concentration respectively than the control (Table-1). Increasing concentration of effluent caused reduction in shoot length and root length. The result showed that the shoot length was significantly and root length was non- significantly decreased at increasing concentration of effluent. Percentage decrease in shoot length was 11.87, 17.35. 21.46 and 27.40 and root length was 10.99, 13.99, 18.00 and 22.99 at 25, 50, 75 and 100% concentration respectively than the control. Total Fresh weight and dry weight was significantly decreased at increasing concentration of effluent (Table-1). Based on the outcomes of the current study, it can be concluded that increasing doses of electroplating industry effluents caused reduction in germination percentage , it may be due to the decreased activity of enzyme dehydrogenase (Murkumar and Chavan (1987) and other possibility of reduction in the germination percentage and root and shoot length was due to high amount of total dissolved solids present in the effluent that disturbed the osmotic relation in a plants (Sahai et al. 1983). Ajmal and khan (1985) studied the effect of electroplating factory effluent in different concentrations on the germination and growth of hyacinth beans (*Dolichos lablab*) and mustard seeds (*Brassica compastris*) and they found that the germination of seeds was delayed with the increase of effluent concentration.

Metabolic activities

Chlorophyll: Chlorophyll a and total chlorophyll was found to be significantly decreased at increasing concentration of effluent. Chlorophyll b was found to be non-significantly decreased at 25, 50 and 100% concentration of effluent while similar increase was observed at 75% concentration (Table-2) . Reduction in pigment contents causes deficiency in light harvesting capacity and as a result decreased photosynthetic activity of the cells (Ouzounidou, 1996; Srivastava et al ., 2005). Heavy metals may also interrupt membrane of root tips and other cells that affect absorption and transport of some essential nutrients such as Fe, Mg (Bisht, 1972; Yang et al., 2001; Zornoza et al ., 2002; Larbi et al ., 2002). Carotenoid content was also found to be significantly decreased at 25, 50 and 100% concentration while significant increase was observed at 75% concentration of effluent (Table-2). Carotenoid is an antioxidant, which plays an important role in protection of chlorophyll pigment under stress conditions (Sinha and pandey, 2003). Kenneth et al. (2000) reported that, enhancement of carotenoid content under metal stress may be allocated to the strategy of plants to overcome the metal induced oxidative stress.

Sugar: Sugar concentration in rice plants showed variable results with increasing concentration of effluent . At lower concentration, this parameter was found to be increased significantly. It was 19.62% increase as compared to control. It may be due to the lack of proper translocation of sugar from leaf to root which cause excess sugar in leaf tissue while significant decrease was observed at 50, 75 and 100% concentration of effluent (Table-3). Reduction at higher concentration may be due to the heavy metal toxicity that may inhibit the membrane transport system mechanism, which transport sugar to the phloem (Rauser, 1978).

Protein: It was found to be significantly decreased at increasing concentration of effluent. It was 6.91, 20.69, 45.20 and 56.89% decrease at 25, 50, 75 and 100% concentration respectively than the control (Table-3). Singh et al. (2005) reported that decrease in protein content may be due to the breakdown of soluble protein or due to the increased activity of protease or other catabolic enzymes which might have activated and destroyed the protein.

Enzymes activity

Catalase: The Catalase activity was significantly increased at increasing concentration of effluent. It was 30.99, 66.95, 173.33 and 284.23% increase at 25, 50, 75 and 100% concentration respectively than the control (Table-4). The antioxidant enzyme, catalase (CAT) plays a very key role in preventing oxidative stress by catalyzing the reduction of H_2O_2 (Weckx and Clijsters, 1996; Devi and Prasad ,1998) and activity of this antioxidant enzyme generally increased in plants when exposed to stressful conditions (Allen, 1995, Stevens et al., 1997, Schutzendubel et al., 2001).

Peroxidase: The peroxidase activity was found to be significantly increased. It was 62.14, 84.18, 152.43 and 226.89% increase at 25, 50, 75 and 100% concentration respectively than the control (Table-4). This may be due to the fact that effluents contain toxic metals which may cause enhancement of peroxidase generation in plants. Enhanced peroxidase activity in plants has been used as a stress bioindicator under various contaminant stresses (Markkola et al., 2002; Rottio et al ., 1999).The other possibility of enhancement of peroxidase may be due to the effluents having large amounts of various cations and anions (Behera and Mishra, 1982).

Amylase: The amylase activity was found to be significantly decreased. It was 26.42, 50.02, 58.84 and 70.58% decrease at 25, 50, 75 and 100% concentration respectively than the control (Table-4). Heavy metal toxicity can also cause a reduction in the hydrolysis products and these heavy metals can also interfere in the enzyme action by replacing metal ions from the metaloenzymes and suppress different physiological processes of plants (Agarwal 1999).

Soil chemical changes: The soil pH showed variable results with increasing concentration of effluent. It was significantly increased at 25% concentration while significant decrease was observed at 50, 75, 100% of effluent. Calcium carbonate was significantly decreased at 25% concentration of effluent while significant increase was observed at 50, 75, 100% of effluent. Organic carbon was found to be non significantly increased at 25% concentration of effluent while similar increase was observed at 50,75 and 100% concentration of effluent (Table-5). In our result decrease in pH was found at higher concentrations of effluent similar finding is reported by Malarkodi et al. (2007). In general electroplating industry using nitric , sulphuric and hydrochloric acid during stripping process, which results in more free acids in the effluent which extends the effluent by decreasing the values of pH (Manivasakam,1987). Calcium carbonate was also found increased at higher concentrations of effluents in the soil. Similar results of increased soil calcium carbonate content was reported by Ajmal and Khan (1983). The increased organic carbon was also a result of high total solid present in the effluent (Osaigbovo and Orhue, 2006).

Table 1. Effect of different concentrations of Electroplating industry effluent on germination percentage, growth and yield of rice (*Oryza sativa* L.) plants.

S. No.	Effluent Concentration (%)	Germination (%)	Shoot Length(cm)	Root Length(cm)	Total fresh weight (g)	Total dry weight(g)
1.	Control	93.333[a] ±2.667	73.000[a] ±0.577	33.333 ±1.667	25.625[a] ±1.166	7.812[a] ±0.414
2.	25	81.333[a] ±1.333 (-12.86%)	64.333[ab] ±0.333 (-11.87%)	29.667[NS] ±2.603 (-10.99%)	13.523[ab] ±1.726 (-47.23%)	4.018[ab] ±0.534 (-48.57%)
3.	50	73.333[a] ±1.333 (-21.43%)	60.333[abc] ±0.882 (-17.35%)	28.667[NS] ±1.202 (-13.99%)	11.452[a] ±0.681 (-55.31%)	3.547[a] ±0.020 (-54.60%)
4.	75	72.000[a] ±2.309 (-22.86%)	57.333[abcd] ±0.882 (-21.46%)	27.333[NS] ±1.764 (-18.00%)	9.495[a] ±1.158 (-62.95%)	3.125[a] ±0.390 (-59.997%)
5.	100	70.667[a] ±4.807 (-24.29%)	53.000[abcd] ±0.577 (-27.40%)	25.667[NS] ±2.963 (-22.99%)	6.945[ab] ±0.903 (-72.90%)	2.117[ab] ±0.387 (-72.90%)

All values are means of triplicates ±S.E. Identical superscripts on values denote significant difference ($p<0.05$) between means of different treatments according to Duncan's multiple range test. NS=non significant The values given in the bracket shows the percent increase or decrease as compared to control.

Table 2. Effect of different concentrations of Electroplating industry effluent on pigment contents of rice (*Oryza sativa* L.)plants.

S.No.	Effluent concentration (%)	Chlorophyll a (mg/g FW)	Chlorophyll b (mg/g FW)	Total chlorophyll (mg/g FW)	Carotenoid (mg/g FW)
1.	Control	2.251^{a} ±0.020	1.594 ±0.006	3.845^{a} ±0.025	1.638^{b} ±0.005
2.	25	2.201^{b} ±0.017 (-2.22%)	1.287^{NS} ±0.017 (-19.26%)	3.487^{ab} ±0.034 (-9.31%)	1.329^{abcd} ±0.010 (-18.87%)
3.	50	1.775^{abc} ±0.006 (-21.15%)	1.355^{NS} ±0.021 (-14.99%)	3.130^{ad} ±0.026 (-18.60%)	1.545^{c} ±0.011 (-5.68%)
4.	75	1.442^{abcd} ±0.042 (-35.94%)	1.705^{NS} ±0.248 (+6.96%)	3.147^{abc} ±0.207 (-18.15%)	1.711^{a} ±0.108 (+4.46%)
5.	100	1.255^{abcd} ±0.008 (-44.25%)	1.248^{NS} ±0.030 (-21.71%)	2.503^{abcd} ±0.030 (-34.90%)	0.872^{abcd} ±0.016 (-46.76%)

All values are means of triplicates ±S.E. Identical superscripts on values denote significant difference ($p<0.05$) between means of different treatments according to Duncan's multiple range test. NS=non significant. The values given in the bracket shows the percent increase or decrease as compared to control.

Table 3. Effect of different concentrations of Electroplating industry effluent on the concentrations of sugar and protein of rice (*Oryza sativa* L.) plants.

S.No.	Effluent concentration (%)	Sugar Concentration (mg/g FW)	Protein Concentration(%FW)
1.	Control	3.400^{ab} ±0.115	2.301^{a} ±0.159
2.	25	4.067^{a} ±0.073 (+19.62%)	2.142^{b} ±0.000 (-6.91%)
3.	50	3.200^{ac} ±0.029 (-5.88%)	1.825^{ac} ±0.079 (-20.69%)
4.	75	1.950^{abcd} ±0.058 (-42.65%)	1.261^{abc} ±0.084 (-45.20%)
5.	100	1.700^{abcd} ±0.087 (-50.00%)	0.992^{abc} ±0.173 (-56.89%)

All values are means of triplicates ±S.E. Identical superscripts on values denote significant difference ($p<0.05$) between means of different treatments according to Duncan's multiple range test. The values given in the bracket shows the percent increase or decrease as compared to control.

Table 4. Effect of different concentrations of Electroplating industry effluent on the activity of different enzymes in rice (*Oryza sativa* L.) plants.

S.No.	Effluent concentration (%)	Catalase activity (µ moles H_2O_2 decomposed/min/mg Protein)	Peroxidase activity(ΔOD/mg protein)	Amylase activity(starch hydrolyzed in mg/gm FW)
1.	Control	51.087^{ab} ±1.753	1.030^{ab} ±0.095	2.267^{a} ±0.176
2.	25	66.917^{ab} ±2.057 (+30.99%)	1.670^{a} ±0.006 (+62.14%)	1.600^{ab} ±0.231 (-26.42%)
3.	50	85.287^{a} ±3.877 (+66.95%)	1.897^{a} ±0.068 (+84.18%)	1.133^{a} ±0.176 (-50.02%)
4.	75	139.637^{ab} ±6.803 (+173.33%)	2.600^{b} ±0.152 (+152.43%)	0.933^{a} ±0.133 (-58.84%)
5.	100	196.293^{a} ±38.396 (+284.23%)	3.367^{a} ±0.569 (+226.89%)	0.667^{ab} ±0.267 (-70.58%)

All values are means of triplicates ±S.E. Identical superscripts on values denote significant difference ($p<0.05$) between means of different treatments according to Duncan's multiple range test. NS=non significant. The values given in the bracket shows the percent increase or decrease as compared to control.

Table 5. Chemical properties of Electroplating industry effluent irrigated soils after harvesting of rice (*Oryza sativa* L.) Plants.

S.No.	Effluent concentration(%)	pH (1:2 soil water)	Calcium carbonate(%)	Organic carbon(%)
1.	Control	7.200^{b} ±0.058	2.250^{abc} ±0.144	0.381 ±0.046
2.	25	7.333^{a} ±0.088 (+1.85%)	2.500^{a} ±0.144 (+11.11%)	0.419^{NS} ±0.012 (+9.97%)
3.	50	6.500^{abc}	3.083^{c}	0.355^{NS}

		±0.000 (-9.72%)	±0.083 (+37.02%)	±0.009 (-6.82%)
4.	75	6.033^{abcd} ±0.033 (-16.21%)	3.250^{b} ±0.382 (+44.44%)	0.359^{NS} ±0.021 (-5.77%)
5.	100	5.533^{abcd} ±0.033 (-23.15%)	3.417^{a} ±0.083 (+51.87%)	0.321^{NS} ±0.023 (-15.75%)

All values are means of triplicates ±S.E. Identical superscripts on values denote significant difference ($p<0.05$) between means of different treatments according to Duncan's multiple range test. NS=non significant. The values given in the bracket shows the percent increase or decrease as compared to control.

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