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Studies on the Effect of an Electroplating Factory Effluent on the Germination and Growth of Tomato (*Lycopersicum esculentum*) & Egg-plant (*Solanum melongena*)

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Abstract: The effect of electroplating factory effluent at different dilutions (such as 0.0, 0.10, 0.25, 0.50, 1.00, 1.50, 2.00, 2.50, 3.00, 3.50 and 4.00%) on the germination, growth and nutrient concentration in Tomato (*Lycopersicum esculentum*) and Egg-plant (*Solanum melongena*) was studied in an urban soil of Aligarh District of Uttar Pradesh. The results indicated that the germination of both the plant was delayed with increase of effluent concentration. The effluent tolerance limit of tomato and Egg-plant was found to be 2.50 and 3.00 % respectively beyond which the germination was not occurred under the experimental conditions of the study. The major nutrient concentration in both the plants decreases with increase in effluent concentration except in the case of Na in tomato and K in Egg-plants where it was found to be increased. The micronutrients concentration was increased at initial increase in effluent concentration up to 1.00% and then decreases except in the case of Cu and Mn in tomato and Mn in egg-plant. The dry matter yield of tomato and egg-plant was found to be steadily decreases with increase in effluent concentration. The heavy metals such as Pb, Cd, As and Co were not detectable in both the plants.

Keywords: Dry matter yield, Effluent, Electroplating factory, Germination, Growth, Heavy metals, Major-nutrients, Micro-nutrients

I. Introduction

The environmental pollution caused by inorganic [1] and organic [2] substances has been recognized to increase with increase in the usage of chemicals in industries and agriculture [3], [4]. Such pollution is apparent in the form of heavy metals, persistent organics and phenols etc in different environmental segments as soil, water and air [5]-[7]. The stream, lake and ground water which is replenished directly from ground water is more vulnerable to be contaminated with inorganic as well as organic pollutant depending upon the kind of sources. The waste water released from various industrial establishments (Effluent) contributes a major share to the environmental pollution and have different set of pollutants including mineral matters with some nutritional values for the plant growth [8] [9]. The Morris Bajaj Electroplating Factory (MBEF) which works as small to medium level factory around the residential areas of Aligarh city, discharges the waste water into the municipal drainage system knowingly or unknowingly without treating it at par with the guidelines of state pollution control board. The electroplating factories are generally considered as major contributors of heavy metals such as Ni and Cr along with Pb, Cd, Cu, Zn and Fe. The presence of different ions such as Cl^- , SO_4^{2-} , PO_4^{3-} , Ca^{2+} , Mg^{2+} , K^+ , and Na^+ etc which are essential for plant growth, when accumulated in higher concentrations, induce morphological and physiological disorders in plant [10], [11]. The present study was undertaken to observe the effects of MBEF effluent in different concentrations on the growth and nutrient concentration of the two vegetable plants which are generally grown in most of the urban kitchen gardens.

II. Materials and Methods

A. The Soil:

The surface soil samples (depth 0 – 25cm) were taken from the open field of the city areas with the help of the soil sampler. The soil was an illitic fine sandy loam. It was air dried and ground to pass through 5mm sieves (BSS) before use. The physico-chemical properties were determined by standard methods [12] and given in Table.1.

B. The Effluents:

The effluent of the Morris-Bajaj Electroplating Factory, a subsidiary industry of the Morris-Bajaj Group of Industries located in the city industrial area of Aligarh District, Uttar Pradesh (India), was collected from the outlet of the factory. It was analyzed for its physic-chemical properties by standard methods of Analysis as per the *Guidelines of American Public Health Association* [13]. The Physico-chemical properties of the Effluent is given in Table.2.

C. The Germination:

The term germination refers to the initial appearance of the radical by visual observations, for which, the seeds of tomato (*Lycopersicum esculentum*) and egg-plant (*Solanum melongena*) were soaked in distilled water and then with different concentrations of effluents (such as 0.0, 0.25, 0.50, 1.00, 1.50, 2.00, 2.50, 3.00, 3.50, 4.00, 4.50, 5.00%) for six hours after surface sterilization by alcohol. Then, 25 seeds were randomly chosen and kept in each of the Petri dish (Size:12 cm dia) containing a pre-sterilized filter papers. The seeds were at the uniform distances with each other and treated with distilled water (Control) and corresponding effluent concentration as above. Each set was replicated three times. The number of seeds germinated in each Petri dish at 12-hour intervals was counted and the total percentage of germination was calculated after 120 hours of treatments.

D. The Plant Growth:

For the measurement of plant growth, a greenhouse experiment was conducted simultaneously in glazed earthenware pots filled with two kg of the soil. They were irrigated with distilled water (*Control*) and corresponding effluent concentrations as and when required to maintain the WHC at 50%. All the treatments were replicated three times. The Plant shoots and roots were harvested before the flowering stage and immediately washed with distilled water, acidified de-ionized water and de-ionized water sequentially. The Dry matter yield was recorded after drying the sample in an oven at 70° C for a constant weight [10].

E. Analytical Methods:

For the determination of nutrient and other metal concentration in plant materials, each plant sample was digested in an acid mixture of 3 and 4 in HNO₃ and HClO₄ should be in its subscript forms (4:1 v/v) and analyzed for nutrient and heavy metals by Atomic Absorption Spectrophotometer (GBX Make) following the method of David [14]. All the chemicals and reagents used in the above experiments were of Analytical Reagent Grade of BDH. Statistical Analysis of Variance was made on all data and critical difference (CD5%) was calculated using the value of t at 5% confidence level of significance.

III. Results and Discussion

Table.1 shows the physico-chemical properties of soil samples used in these experiments. The soil sample used in these studies was an illitic fine sandy loam having 14% swelling clay in the form of illite along with only 0.41% organic matter. It suggest that the soil is an average fertile soil which has average amount of nutrients and shows a cation exchange capacity of 16.8 meq/100g soil.

Table 2 shows the physico-chemical properties of the effluent. It indicates that the effluent was deficient of dissolved oxygen, highly acidic with a pH of 1.08 and has a large amount of solids, total acidity, total phosphate, nitrate-N, Chloride, and sulphate. The nutrient and heavy metals such as Cr, Ni, Pb, Cu, Zn, Mn, and Co were also present in appreciable amounts while ammonium and nitrite nitrogen could not be detected and cyanide test was found to be positive.

Table 1 Physico-chemical properties of Soil

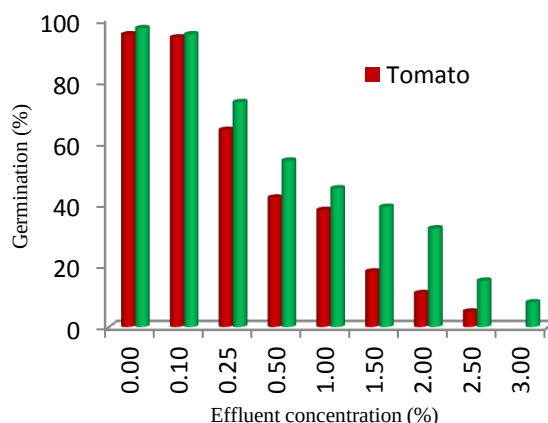
S. No.	Parameter	Values	S. No.	Parameter	Values
1	Sand (%)	61	11	Mg (meq/100g)	1.3
2	Silt (%)	25	12	Mn (ppm)	1.36
3	Clay (%)	14	13	Zn (ppm)	0.35
4	Org. Matter (%)	0.41	14	Cu (ppm)	1.86
5	pH	8.78	15	Fe (ppm)	12.6
6	EC dms ⁻¹	4.8	16	Cr (ppm)	4.32
7	CEC (meq/100g)	16.8	17	Ni (ppm)	ND
8	Na (meq/100g)	1.5	18	Pb (ppm)	0.98
9	K (meq/100g)	0.8	19	Cd (ppm)	0.83
10	Ca (meq/100g)	4.5	20	Co (ppm)	ND

Table 2 Physico-chemical properties of Effluent:

S. No.	Parameter	Values	S. No.	Parameter	Values
1	Color	Dark Brown	13	SO ₄ ²⁻ (ppm)	5864
2	pH	1.08	14	Total Acidity (ppm)	975
3	Turbidity (FTU)	1550	15	Total PO ₄ ³⁻ (ppm)	348
4	Suspended Solids (ppm)	1354	16	Mn (ppm)	52.60
5	Dissolved Solids (ppm)	16359	17	Zn (ppm)	91.00
6	Volatile Solids (ppm)	1024	18	Cu (ppm)	371.50
7	Total Solids (ppm)	21628	19	Fe (ppm)	205.75
8	Dissolved Oxygen	Nil	20	Cd (ppm)	2.50
9	Ammonium -N (ppm)	Nil	21	Cr (ppm)	11365.50
10	Nitrate-N (ppm)	2352	22	Ni (ppm)	768.35
11	Nitrite-N (ppm)	Nil	23	Pb (ppm)	234.85
12	Chloride as Cl ⁻ (ppm)	509	24	Co (ppm)	11.55

A. The Germination of Plants:

It has been found (Fig.1) that the germination of tomato (*Lycopersicum esculentum*) was inhibited from 95 to 5% at 2.5% effluent concentration and egg-plant (*Solanum melongena*) from 97 to 8% at 3% effluent concentration. The tomato seeds were germinated only up to 2.50% effluent concentration beyond which the germination was stopped while in the case of egg-plant, seeds germination was found to tolerate 3% effluent concentration. It may be due to the fact that the tomato plant has higher toxicity index for Ni and Cr in comparison to the egg-plant [11].

Figure 1 Effect of Effluent on the germination of plants

B. *The Nutrient and heavy metal Status of Plants:*

Table.3 shows the amount of nutrients and heavy metals in tomato plants. It shows that the major nutrients viz. K, Ca, and Mg were decreased in tomato while sodium increases from 0.14 to 0.53%. The micronutrients concentration in the plant show a variable patterns as Mn and Cu decreases 26.5 and 24.9% respectively, Zn & Fe content increases up to the effluent concentration of 1.00% and then decreases below the control. The Heavy metal Cr & Ni content of the tomato plant was found to show different increasing patterns as Cr increases abruptly in the plant from 15.5 to 3852.9 ppm while Ni content was increased steadily. The abrupt increase in Cr content of the tomato plant could be explained on the basis of its very high concentration in the effluent (Table.2) in comparison of the other metal ions.

Table 3 Effects of effluent water on the nutrients and heavy metals in Tomato.

Effluent Conc.	Major Nutrients (%)				Micronutrients (ppm)				Heavy Metals (ppm)	
	Na	K	Ca	Mg	Mn	Zn	Cu	Fe	Ni	Cr
Control	0.14	5.14	4.75	0.24	16.80	69.00	20.85	110.00	0.05	15.5
0.10	0.17	4.92	4.58	0.22	16.21	133.00	19.62	128.00	0.08	186.5
0.25	0.21	4.21	3.95	0.19	15.75	140.00	19.15	135.00	0.11	315.4
0.50	0.27	3.45	3.21	0.18	15.05	145.00	18.52	141.00	0.13	785.3
1.00	0.33	2.85	2.65	0.16	14.68	151.00	17.32	158.00	0.13	1040.6
1.50	0.41	2.15	2.01	0.14	14.08	89.00	16.85	145.00	0.15	1256.9
2.00	0.48	1.69	1.98	0.11	13.65	61.00	16.10	139.00	0.16	2335.4
2.50	0.53	1.15	1.82	0.08	12.35	43.00	15.65	108.00	0.21	3852.9
CD _{5%}	0.02	0.04	0.10	0.01	0.50	3.50	0.21	4.52	0.02	45.8

Table 4 shows the values of the nutrients & heavy metals in egg-plant grown in effluent treated soil. It shows that the major nutrients viz. Na, Ca & Mg decreases in the egg-plants while K increases unlike the tomato from 2.25 to 5.90%. The micronutrients in egg-plant were observed to increase initially up to the effluent treatment level of 1.00% and then decrease below the control level. However, the exception was only Mn which was decreases from 27.5 (control) to 16.3 (3.00% effluent).

Table 4 Effects of effluent water on the nutrients and heavy metals in Egg-plant.

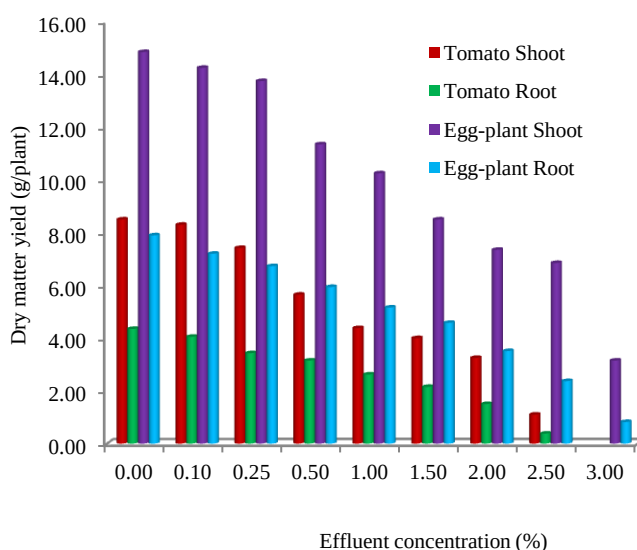
Effluent Conc.	Major Nutrients (%)				Micronutrients (ppm)				Heavy Metals (ppm)	
	Na	K	Ca	Mg	Mn	Zn	Cu	Fe	Ni	Cr
Control	0.91	2.25	3.56	0.71	27.50	115.00	9.91	178.00	0.08	16.8
0.10	0.86	2.31	3.18	0.63	26.40	138.00	12.38	469.00	0.12	155.3
0.25	0.79	2.69	2.64	0.58	25.80	156.00	14.58	649.00	0.15	298.7
0.50	0.64	3.05	1.98	0.53	24.70	189.00	18.32	921.00	0.19	665.8
1.00	0.60	3.71	1.85	0.49	21.50	193.00	23.45	1256.00	0.21	985.4
1.50	0.58	4.25	1.73	0.46	20.60	98.00	19.31	968.00	0.26	1154.8
2.00	0.53	4.85	1.15	0.40	19.80	59.00	15.25	634.00	0.29	1468.5
2.50	0.47	5.20	0.93	0.35	17.90	46.00	13.65	358.00	0.31	2134.6
3.00	0.41	5.90	0.74	0.31	16.30	16.00	12.86	212.40	0.36	2865.9
CD _{5%}	0.01	0.02	0.10	0.02	0.56	3.58	1.25	51.5	0.02	65.5

The results show that the movement of some of the heavy metals from soil to plant is easier in tomato than in the egg-plant. It also suggests that the egg-plant is more tolerant to survive in more concentration level of effluent treatment.

C. The Dry Matter Yield of the Plants:

The effect of MBEF effluent treatment on the dry matter yield of the two vegetable plants grown in soil is reported in Fig.2. It shows that the dry matter yield of both the plant was decreases uniformly with increase in the effluent treatments. It also shows that the dry matter yield of tomato was decreased 87 and 99% in terms of the plant shoot and root respectively. While egg-plant observed 78 and 90% decrease in the plant shoot and root respectively.

Figure 2 Effect of effluent concentration on the dry matter yield of plants



The dry matter yield in the form of shoot and root of tomato when compared with the egg-plant, it was observed that around 84% less growth was held in tomato shoot and root at the level of 2.50% effluent treatment. These results also substantiate the work done by various workers [15], [16]. They showed the reduction of Dry matter yield in terms of lesser plant length, branches and leaves of various crop plants. Fig.2 also indicates that tomato and egg-plant roots are more adversely affected by effluent treatment which can be attributed to the heavy metal competence with the nutrient metal ions for their movement through plant sap [17].

IV. Acknowledgement

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