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Comparative Study on Phytoremediation of Synthetic and Industrial Effluent

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Abstract

The effectiveness of Eichhornea Crassipes in removing metal ions was investigated. Results obtained indicate that plant was very effective in removing Cu^{+2} and Ni^{+} ions. After one week, the percentage removal efficiency of copper and Nickel in industrial effluent was 14.4% and 13.5% respectively, which increased to 73.5% for copper and 92.2% for Nickel. After five weeks, the plant was able to remove the metal successfully without any physical sign of being affected by it. Results showed that conductance, total dissolved solids, dissolved oxygen and CO_2 values have decreased after phytoremediation. Whereas relative growth was increased after phytoremediation. The value of total suspended solids in effluent, after first week was 1990mg/l and in last week it was reduced to 1940mg/l while pH of effluent was increased from 6.85- 7.01. Overall results indicate that Eichhornea Crassipes can be used for phytoremediation of industrial effluent.

Keywords: pH, EC, TDS, TSS, DO etc.

Introduction

The 20th century can be characterized as a time of increasing environmental awareness. Phytoremediation is an emerging technology that uses various plants to degrade, extract and immobilize contaminants from soil and water. This technology has been receiving attention lately as an innovative, cost-effective alternative to the more established treatment methods used at hazardous waste sites[1, 2].

Many hazardous waste sites are contaminated with salts, organics, heavy metals, trace elements, and radioactive compounds[3-5]. The simultaneous clean-up of multiple, mixed contaminants using conventional chemical and thermal methods are both technically difficult and expensive; these methods also destroy the biotic component of soils. Phytoremediation of a site contaminated with heavy metals or radionuclides involves "farming" the soil with selected plants to "biomine" the inorganic contaminants, which are concentrated in the plant biomass[6,7]. For soils contaminated with toxic organics, the approach is similar, but the plant may take up or assist in the degradation of the organic compounds[8.] Phytoremediation actually benefits the soil, leaving an improved, functional, soil ecosystem at costs estimated at approximately one-tenth of those currently adopted technologies.

Phytoremediation includes Rhizofiltration[9,10], Phytostabilization[11,12], Phytovolatization[13-15], and Phytodegredation[16-18].

In this study aquatic plant, water hyacinth (*Eichhornia crassipes*) was employed as a plant model for the removal of heavy metals from industrial effluent.

Material and methods

Plant materials: Eichhornia crassipes were collected from a pond, near M.M. University Mullana. This aquatic plant was put in hydroponic system containing tap water, for a two–week acclimatization period, before being exposed to heavy metal contaminants.

Preparation of copper and nickel contaminated solution: Synthetic solution of nickel and copper of 2.0 ppm and 4.0 ppm were prepared using copper and nickel standard solution of 1000ppm using deionised water.

Industrial Effluent: Industrial effluent was collected from electroplating waste water industry, Karnal.

Experimental Set up: Approximately 10 liters of raw effluent from factory was brought to the laboratory and experiment was set up in plastic craits. Industrial effluent was diluted 50, 40 and 30 times and then transferred to the plastic craits. For each experiment set up, three controls were maintained with 5.0 litres each of effluent, tap water, Cu^{2+} and nickel synthetic solutions [19]. Approximately 500g of Eichhornia crassipes was used for study. 500ml of each of effluent and synthetic solutions were collected periodically for analyzing the physico-chemical characteristics subsequently with an interval of 7 days up to 35 days.

Estimation of physico-chemical parameters: Major parameters analyzed include pH, total solid, TDS, TSS, free CO_2, Salinity, Cu^{2+}, Ni^{2+}, DO and conductivity.

Relative Growth: Relative growth of control and treated plant was calculated as follows; Relative growth = Final weight /

Initial fresh weight

Metal remained in residual solution: The quantification of the metal ions in the industrial effluent has been performed on AAS (AAS, 630, shimadzu, Japan). Results are given in table no. (a).

Estimation of nickel ions: In 2 ml of the sample slight excess of 0.1M EDTA solution was added. Solution was diluted by adding 20ml distilled water and 1ml of buffer of pH 10 was added to the solution. Few drops of Eriochrome Black T were added as an indicator. Excess of EDTAwas titrated with 0.1 M $ZnSO_4$ solution until colour changes from blue to wine red.

Estimation of copper ions: 2.0ml of sample was diluted by adding 3.0ml of distilled water. 3 ml of buffer of pH 10 was added followed by 2 drops of Eriochrome black T as an indicator. This solution was titrated against standard EDTA solution until colour changes from red to blue.

pH measurement: pH of each sample was noted after every seven days by pH meter (pH-microprocessor based, the EE-013 series, Tanko).

Conductance Measurement*:* Conductance was measured by using conductometer (Digital conductometer, the EE-014 series, Tanko).

Dissolved oxygen: Dissolved oxygen was measured using Winkler's Method.

Dissolved carbon di-oxide: 2-3 drops of phenolphthalein was added to each 100 ml of sample. Sample was titrated against NaOH, pink colour appeared, indicates the presence of CO_2.
CO_2, mg/l = Ax N_{NaOH} x1000 x 44/2x Vc.c., A= Volume of NaOH used, V= Volume of sample taken

Suspended impurities: 3ml of filtered water sample was kept in oven set at temperature 600^0C for the evaporation of water sample. After evaporation, crucible was kept in desiccators for a while to prevent impurities, and then weighed. Same procedure was repeated with unfiltered water sample. The process was repeated with each sample.

Results and Discussion

In the present study an attempt has been made to have a comparative assessment of the efficiency of aquatic plant like Eichhornea Crassipes to treat the industrial effluent and synthetic solution. The effluent sample and the synthetic solution were analyzed periodically with a view to find out the changes in physiochemical properties brought about by the Eichhornea Crassipes. It was observed that plants survive only in 50% effluent; therefore, the further studies were carried out only with this concentration.

Metal Removal Efficiency: It was calculated as $(C_i\text{-}C_f/C_i) \times 100$ % where C_i is the initial concentration and C_f is the remaining heavy metal concentration in the solution. Figure-1 and table-1 shows percentage removal efficiency of copper and nickel ions in effluent and synthetic solution. After one week, the percentage removal of copper in effluent was 14.4% and it and after last week percentage suddenly increased to 73.5%. The percentage removal of nickel in effluent after one week was 13.5% and in last week percentage removal nickel has greatly increased to 92.2%. This result shows that phytoremidiation has occurred in the effluent. The percentage removal of copper in synthetic solution was 12.5% during first week and in last week its value was reached to 31%. Same result was observed in case of nickel synthetic solution. Its value was 25% after one week and in last day it was increased up to 57.1%. It is clear from the trend that after certain time period the saturation point is reached, this is due to the loading effect where sorption sites were saturated by copper and nickel ions. The removal efficiency was also due to the utilization of Cu and Ni for the development of the plant. A similar trend was reported by Felix and Mokhtar[20,21], where the Pistia stratiotes, Asiattica and Spirodela polyrrhiza performed extremely well in removing the chromium and zinc from their solution and was capable of removing zinc, Copper and chromium during 12 days incubation period.

pH: pH of effluent was noted 6.85- 7.01 after phytoremediation. pH of the synthetic solution was also increased after the culture ***(t***able-2). Das had also recorded increase in pH of municipal sewage on exposure of macrophytes after seven days. Percentage increase in pH value was 0.72-2.28% in the effluent, Cu^{2+} solution and in Ni^{2+} solution. An increase in pH value supports the growth of aquatic plant[22].

Conductance: EC value had ranged from 2.51 -0.49 mho/cm in industrial effluent. Results are given in ***f***ig***ure***-2 and ***t***able-3. In the synthetic Ni^{2+} solution and in Cu^{2+}solution, EC values are 1.25-0.13 mho/cm and 1.21 -0.158 mho/cm respectively. EC value was lowered after the culture due to absorption of dissolved solids by E. Crassipes during Phytoremediation. Moorheed (1986)[23] recorded 48% reduction in EC value during 22 days of culture of aquatic plant.

TDS: TDS value was observed to be decreasing after phytoremediation with Eichhornea Crassipes TDS and EC were closely related hence, exhibits the same trend of variation in value i.e 1377-1161mg/l in effluent. Values of TDS in copper synthetic solution vary from 1209-507mg/l and that nickel synthetic solution is 1013-304 mg/l. Reduction in the values is due to evaporation and absorption of dissolved solids by the plant.

Dissolved Oxygen: Dissolved oxygen values were recorded 6.8-5.7 ppm during phytoremediation of the effluent. The value of D.O. was found to be 6.9-4.7 ppm in Ni^{+2} solution and in case of Cu^{+2} synthetic solution it was 7.9 -5.9 ppm. From the observations, it was concluded that demand of oxygen has greatly increased in each plant for growth and phytoremediation has occurred in each plant. Results are given in figure-3 and figure-4. Patel and Kanungo also observed the decrease in DO after the culture of aquatic plant[24].

Suspended solid: The value of suspended impurities has decreasing trend shown in figure-4. The value of TSS in effluent after first week was 1990mg/l and in last week, it was reduced to 1940mg/l. similar trend was observed in synthetic solution of Cu^{+2}, it was 1400mg/l, after first week and in last week, it was reduced to 1355mg/l (figure-6). Similarly in case of Ni^{+2} synthetic solutions, its value was 1255mg/l after first week and in last week; it was reduced to 1220mg/l (figure-5). Highest reduction value was observed in last week. Phytoremediation generally reduced turbidity.

Relative Growth: The effect of Cu^{2+} and Ni^{2+} on the relative growth of Eichhornea Crassipes was shown in Figure 7. The relative growth of plants grown in the effluent as well as synthetic solution significantly increased with the passage of time. Highest value of relative growth was observed in effluent i.e. 1.21591%. In case of Cu and Ni synthetic solution value of relative growth was 1.21311% and 1.07229 % respectively.

Dissolved CO_2: The value of total CO_2 was ranging from 150.0 -79.0 ppm in the effluent during the phytoremedation. Dissolved CO_2 value was significantly reduced because of successful photosynthetic activity by the aquatic plant

Conclusion

Results obtained indicate that plant was very effective in removing Cu^{+2} and Ni^{2+} ions. After one week, the percentage removal efficiency of copper and Nickel in industrial effluent was 14.4% and 13.5% respectively, which increased to 73.5% for copper and 92.2% for Nickel. It is clear from the trend that after certain time period the saturation point is reached, this is due to the loading effect where sorption sites were saturated by copper and nickel ions. The removal efficiency was also due to the utilization of Cu and Ni for the development of the plant. Dissolved oxygen and CO_2 values have decreased after phytoremediation. It was concluded that demand of oxygen has greatly increased in each plant for growth. Dissolved CO_2 value was significantly reduced because of successful photosynthetic activity by the aquatic plant. The relative growth of plants, grown in the effluent as well as synthetic solution significantly increased with the passage of time which indicates that plant was very effective in removing Cu^{+2} and Ni^{2+} ions without any physical sign of being affected by it. EC value was lowered after the culture due to absorption of dissolved solids by E. Crassipes during Phytoremediation. Highest reduction value of the turbidity was observed in last week because phytoremediation generally reduces turbidity. All results indicate that Eichhornea Crassipes can be used for phytoremediation of industrial effluent.

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Table-a
Concentaration of Cu^{2+}, Ni^{2+} and Fe^{2+} ions in industrial effluent

S.No.	Metal ion	Concentration (ppm)
1.	Cu^{2+}	115.52
2.	Ni^{2+}	135.40
3.	Fe^{2+}	90.23

Table-1
Variation in percentage removal efficiency of metal ions in synthetic solution and effluent during Phytoremediation

Time Period (days)	% removal of Cu^{2+} in effluent	% removal of Ni^{2+} in effluent	% removal of Ni^{2+} in synthetic sol	% removal of Cu^{2+} in synthetic sol
7th	14.43	13.59	25.0	12.50
14th	39.08	50.60	37.5	18.75
21th	49.64	75.57	45.0	25.00
28th	52.64	91.65	51.25	28.12
35th	73.59	92.20.	57.12	31.00

Table-2
Variation in pH value of synthetic solution and industrial effluent during Phytoremidiation

Time Period (days)	pH of Effluent (50%)	pH of Tap Water	pH of Ni^{2+} synthetic Solution	pH of Cu^{2+} synthetic Solution
1st	6.85	7.0	6.90	6.02
7th	6.90	7.0	6.93	6.94
14th	6.93	7.0	6.95	6.96
21th	6.95	7.0	6.97	6.97
28th	6.98	7.0	6.99	7.02
35th	7.01	7.0	7.05	7.04

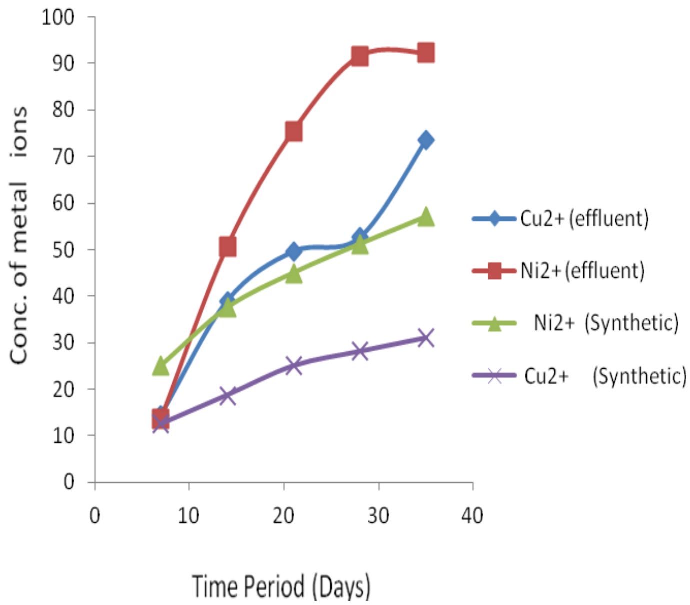

Figure-1

Percentage removal efficiency of metal ions in synthetic solution and industrial effluent during Phytoremediation

Table-3

Variation in conductance values of synthetic solution and industrial effluent during phytoremediation

Time Period (days)	Effluent (50%)(mhos/cm)	Ni^{2+} synthetic Solution(mhos/cm)	Cu^{2+} synthetic Solution (mhos/cm)
1st	2.51	1.25	1.21
7th	2.49	1.17	1.15
14th	2.47	1.15	1.30
21th	0.845	0.360	0.336
28th	0.525	0.350	0.178
35th	0.490	0.139	0.158

Table- 4

Variation in dissolved oxygen of synthetic solution and industrial Effluent during phytoremediation

Time Period (days)	Effluent (50%) ppm	Ni^{2+} synthetic solution (ppm)	Cu^{2+} synthetic solution (ppm)	Tap Water (ppm)
1st	6.8	6.9	7.9	6.7
7th	7.4	5.9	6.9	6.5
14th	5.6	4.8	5.8	6.4
21th	5.9	4.3	5.5	5.8
28th	5.3	4.6	5.7	5.4
35th	5.7	4.7	5.9	5.9

Table-5

Variation in total suspended solids in synthetic solution and industrial effluent during Phytoremediation

Time Period	Effluent (50%)	Ni^{2+} synthetic solution	Cu^{2+} synthetic solution	Tap Water
1st	1990	1255	1400	1600
7th	1982	1250	1390	1590
14th	1974	1240	1381	1589
21th	1964	1235	1372	1580
28th	1950	1230	1365	1570
35th	1940	1220	1355	1565

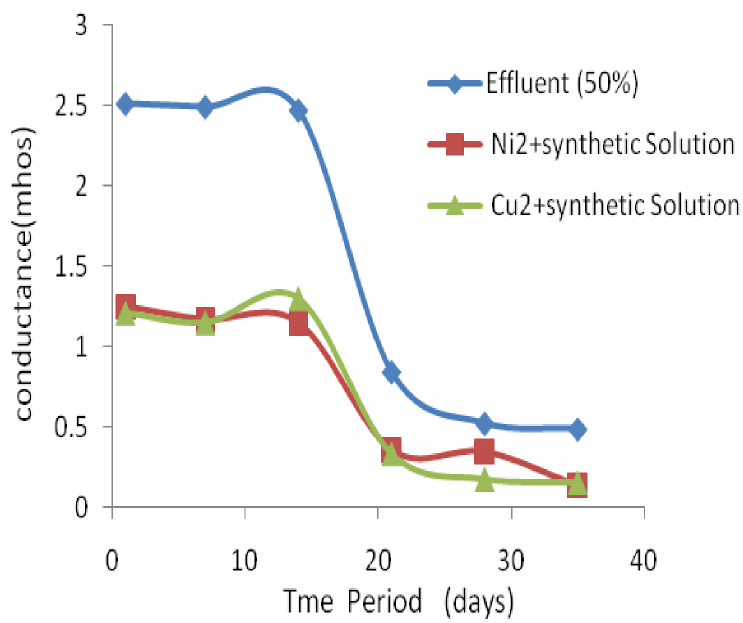

Figure-2

Variation in conductance values of synthetic solution and industrial effluent during phytoremediation

Table-6

Variation in relative growth of the plants in synthetic solution and industrial effluent during phytoremediation

Time Period	Relative growth in effluent	Plant Control	Cu^{2+} synthetic solution	Ni^{2+} synthetic solution
7th	1.06818	1.01282	1.01667	1.01205
14th	1.09091	1.02564	1.03279	1.02413
21th	1.13636	1.05128	1.09836	1.04217
28th	1.18182	1.06838	1.18033	1.05422
35th	1.21591	1.09402	1.21311	1.07229

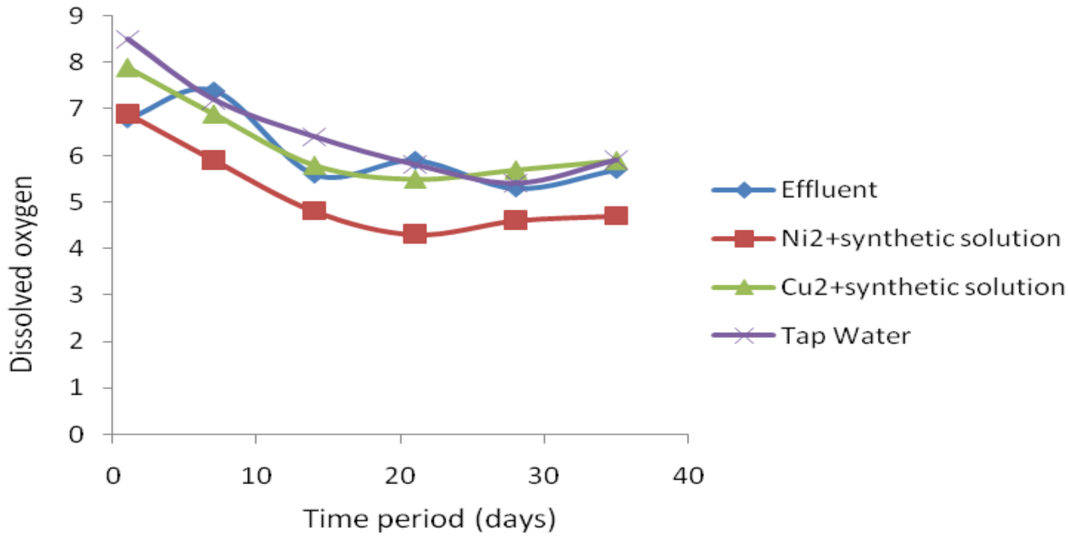

Figure-3

Variation in values of dissolved oxygen of synthetic solution and effluent during phytoremediation

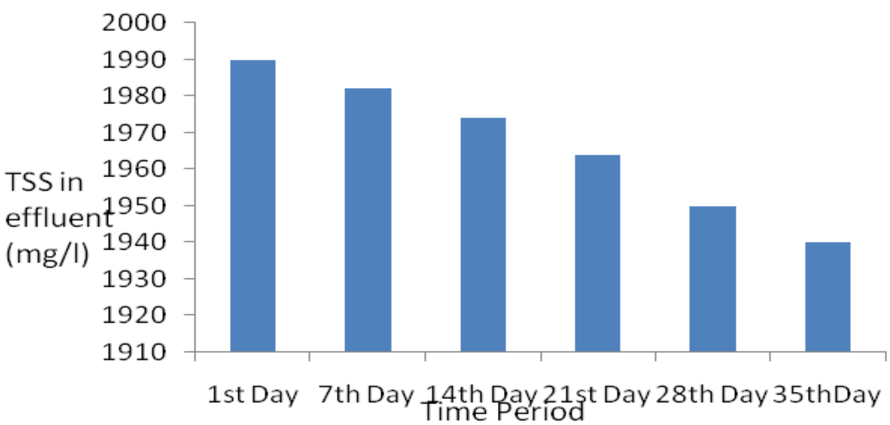

Figure-4

Variation in total suspended solids in industrial effluent during phytoremidiation

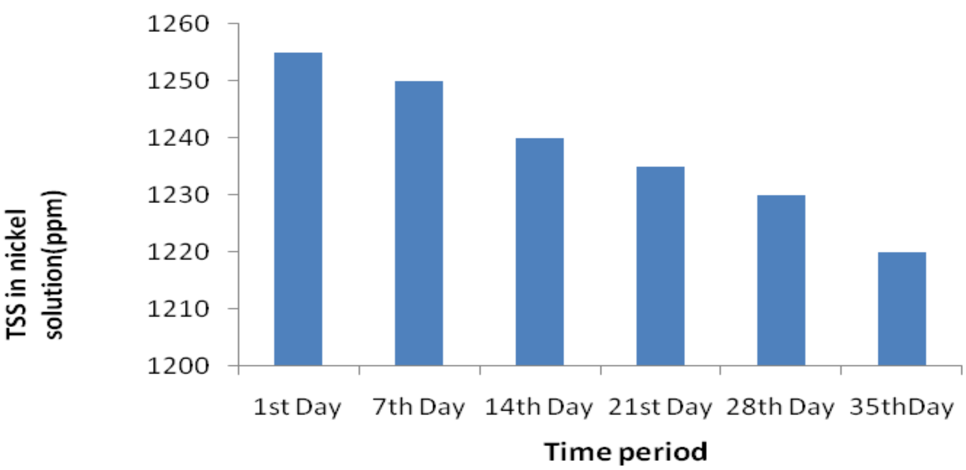

Figure-5

Variation in total suspended solids in nickel synthetic solution during phytoremediation

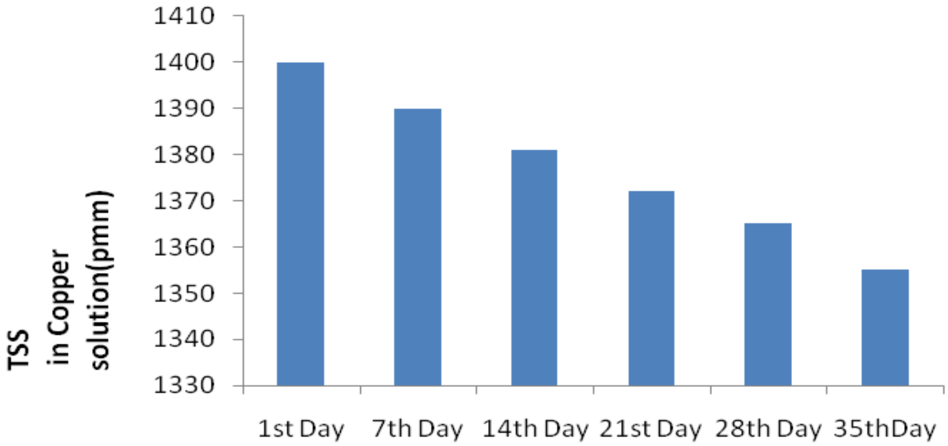

Figure-6
Variation in total suspended solids in copper synthetic solution after phytoremediation

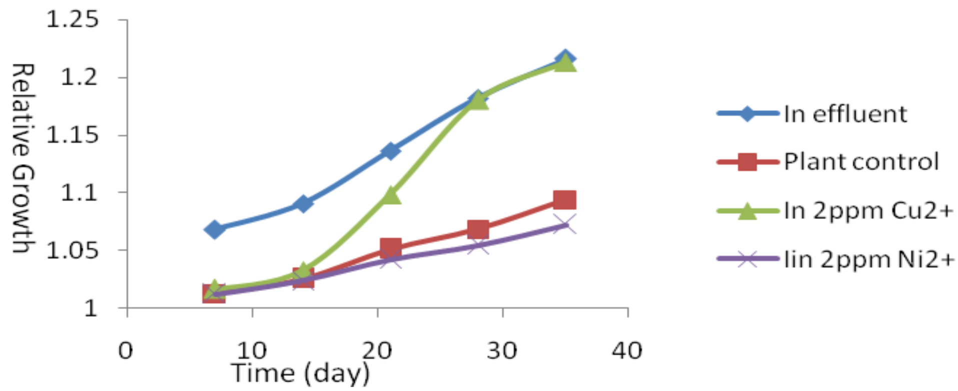

Figure-7
Variation in relative growth of the plants in synthetic solution and industrial effluent during phytoremediation

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