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Phytoremediation of copper and ciprofloxacin by *Brassica juncea*: A comparative study

Swarna Shikha and Pammi Gauba

Department of Biotechnology, Jaypee Institute of Information Technology, Noida, Uttar Pradesh, India

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ABSTRACT

In the present world, where there are high technological advancements, there are serious issue of soil and water pollution with contaminants like heavy metals, antibiotics, hormones, dyes, and petroleum products. Hydroponic experiments were performed to test the ability of Brassica juncea to phytoremediate copper and ciprofloxacin. It was found that B.juncea can remediate higher concentrations (15-30 ppm) of copper more effectively as compared to higher concentrations of ciprofloxacin. In addition to this, it was also observed that lower concentrations (5-10 ppm) of ciprofloxacin can be remediated more effectively than lower concentrations of copper.

Keywords: *Brassica*; heavy metals; phytoremediation; pollution; hydroponic, copper, ciprofloxacin

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INTRODUCTION

Heavy metals persist as major pollutants in water bodies and soil and are an increasing environmental issue nowadays. The principle cause of the prolonged presence of heavy metals in the environment is their non-biodegradable nature. By using specially selected and engineered metal-accumulating plants for environmental clean-up is an emerging technology called as Phytoremediation. Phytoremediation is the pioneering field in remediation technology, which uses plants to remove pollutants present in soil in order to reduce its toxicity [1, 2]. It is an innovative, environmentally compatible and economical approach to remove contamination from the environment [3]. This paper focuses on application of phytoremediation technology in remediation of some toxic contaminants like heavy metals and antibiotics. Copper and ciprofloxacin are two common contaminants found in the environment. Main sources of copper contamination are fossil fuels, mining, coal-fired power stations, copper production units, wood production, sewage treatment processes, waste incinerators and phosphate fertilizer production .Ciprofloxacin enters the environment through industries producing ciprofloxacin, veterinary centers, ciprofloxacin released from hospitals, animal feeds and their excreta and sewage waste from households [4]. The high concentration of these contaminants adversely affects humans, animals as well as plants and thus it has become vital to bring them to a level that is non-toxic in the most eco-friendly way possible.

EXPERIMENTAL SECTION

Plant Selection

Brassica juncea was chosen for the study as it has been found capable of tolerating the pollution level in soil. Till now toxins that have been identified to have undergone phytoremediation by *Brassica juncea* include Cadmium, Cesium, Gold, lead, nickel, plutonium, uranium and zinc [5, 6, 7, 8, 9]. In this paper we have compared phytoremediation of a metal, i.e. copper with an antibiotic, i.e. ciprofloxacin. Pollutants include both heavy metals and antibiotics in waste disposed in environment from different sources, so we have done a comparative study on both the pollutant. We have used *Brassica juncea* seeds to check its remediation potential against many other pollutants. Being a fast growing plant and its fast maturation enables it to remediate contaminants sooner than other plants. In addition to this, it can be easily grown in the laboratory and can be cultivated effortlessly [10].

Methodology

B.juncea seeds were grown ***in-vitro*** in Hoagland solution (pH 6.0) with different copper and ciprofloxacin concentrations till they germinate i.e.12 days which is maximum growth period as observed ***in vitro*** and change in concentration were noted using a UV spectrophotometer at 608 nm and 316 nm for copper and ciprofloxacin respectively [11,12].

RESULTS AND DISCUSSION

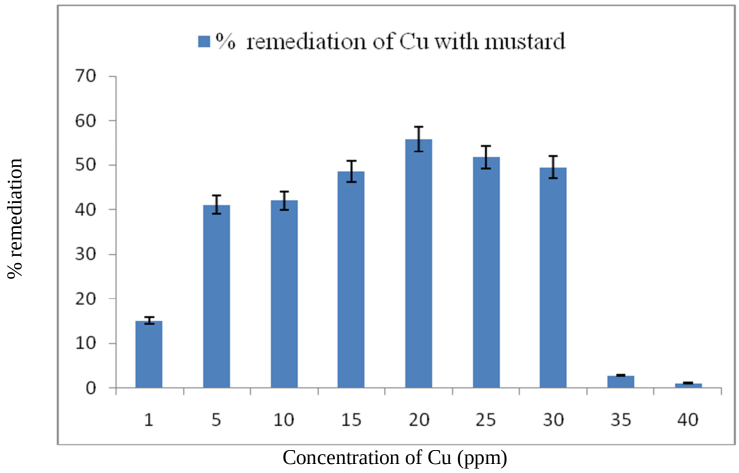
The effect of Copper and Ciprofloxacin of different concentrations on *Brassica juncea* seeds was observed. The results obtained are as follows:

1) Data for remediation of Cu using *B.juncea* seeds over a period of 12 days.

Table1: Percentage remediation of Cu using *B.juncea* seeds over a period of 12 days

	Initial Cu conc. (ppm)	Final Cu conc. (ppm)	Amount remediated (ppm)	% remediation
A	1	0.85	0.15	15
B	5	2.95	2.05	41
C	10	5.58	4.42	42
D	15	7.718	7.28	48.5
E	20	8.83	11.17	55.85
F	25	12.05	12.95	51.8
G	30	15.18	14.18	49.4
H	35	34.28	0.979	2.8
I	40	39.55	0.45	1.1

Graph1: Percentage remediation of Cu using *B.juncea* seeds over a period of 12 days



When *B.juncea* seeds were grown with lower concentrations of copper (1ppm to 40 ppm), significant remediation was observed, But when the concentration was increased to 50, 100, 250 and 500 ppm, *B.juncea* seeds turned black and neither any remediation nor any growth was observed. The reason behind this observation is that such high concentrations of copper were toxic to *B.juncea*. Remediation rate was found to increase with an increase in copper concentration up to 20 ppm and then decreased on increase in copper concentration. Although percentage remediation was maximum at this concentration, toxicity was seen/noted in terms of decrease in root and shoot length. As the concentration of copper increased percentage decrease in shoot and root length also increased. Toxicity was observed after the concentration of 30 ppm and there was little or no percentage remediation.

Table2: Percentage remediation of Cu using *B.juncea* seeds over a period of 12 days

	Initial Cu conc. (ppm)	Final Cu conc. (ppm)	Amount remediated (ppm)	% remediation
A	1	0.85	0.15	15
B	5	2.95	2.05	41
C	10	5.58	4.42	42
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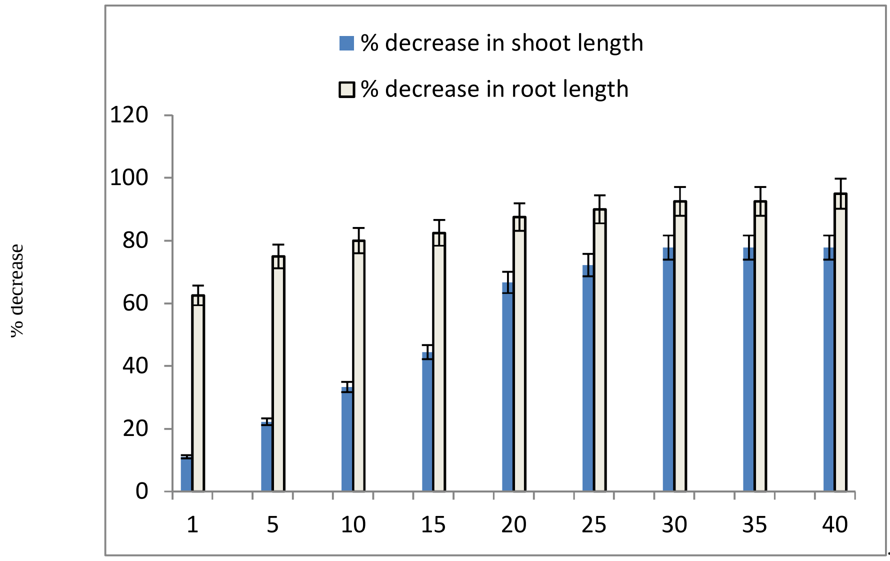
I	40	39.55	0.45	1.1

Graph2. Effect of remediation on root and shoot length of *B.juncea* grown in different copper concentrations over a period of 12 days



Concentration of Cu (ppm)

2 a) Data for remediation of ciprofloxacin using *B.juncea* seeds over a period of 12 days.

Table3. Percentage remediation of ciprofloxacin using *B.juncea* seeds over a period of 12 days

Sample	Initial Cipro Conc. (ppm)	Final Cipro Conc. (ppm)	amount remediated	% remediation
A	5	1.84	3.16	63.2
B	10	5.045	4.95	49.55
C	15	11.085	3.91	26.1
D	20	15.67	4.33	21.65
E	25	19.67	5.33	21.32

Graph3. Percentage remediation of ciprofloxacin using *B.juncea* seeds over a period of 12 days

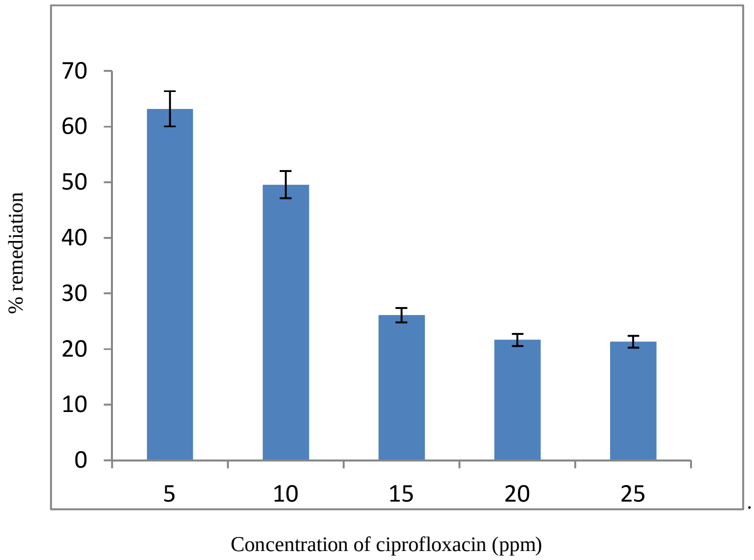
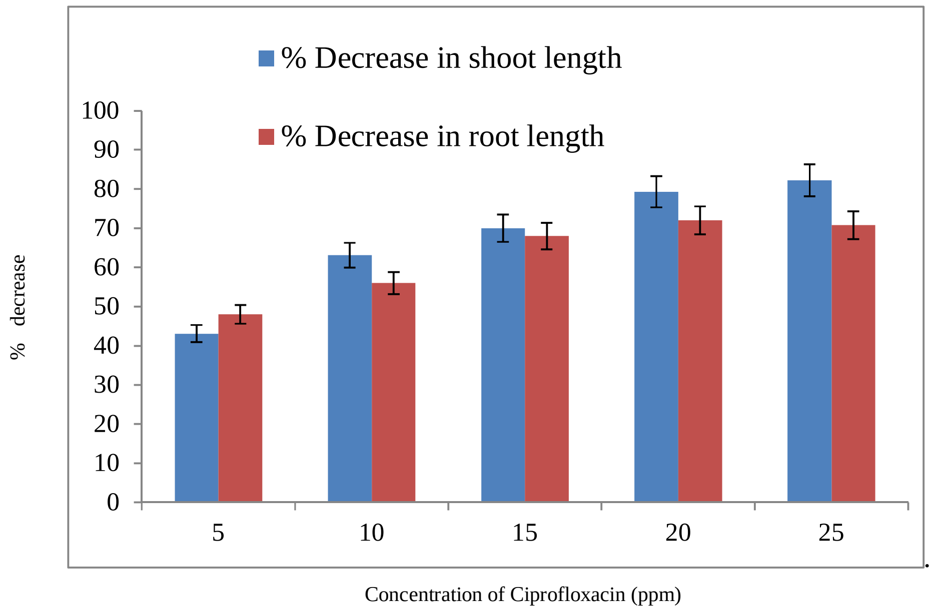


Table 4: Root and shoot length of *B.juncea* grown in different ciprofloxacin concentrations over a period of 12 days

	SHOOT			ROOT		
	Length (cm)	Dec. In length (cm)	% Dec.	Length (cm)	Dec. In length (cm)	% Dec.
BLANK	4.5			2.5		
A	2.56	1.94	43.11	1.3	1.2	48
B	1.66	2.84	63.11	1.1	1.4	56
C	1.35	3.15	70	0.8	1.7	68
D	0.93	3.57	79.33	0.7	1.8	72
E	0.8	3.7	82.22	0.73	1.77	70.8

Graph4. Effect of remediation on root and shoot length of *B.juncea* grown in different ciprofloxacin concentrations over a period of 12 days



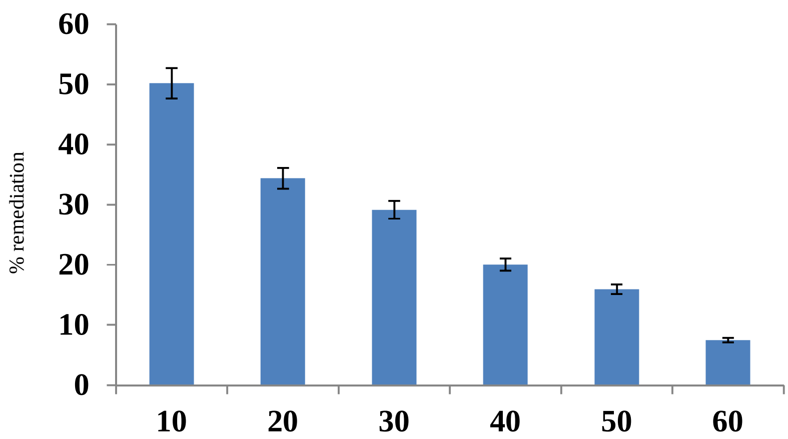
When *B.juncea* was treated with ciprofloxacin concentrations (i.e., 5,10,15,20 and 25), it was observed that there was a decrease in percentage remediation with an increase in ciprofloxacin concentration. This is because as ciprofloxacin concentration increased toxicity also increased. Due to toxicity, the percentage decrease in shoot and root length increased with an increase in concentration of ciprofloxacin. There was greater than 50% decrease in root and shoot length after a concentration of 10 ppm.

2 b) Data for remediation of ciprofloxacin using *B.juncea* seeds over a period of 12 days.

Table5: Percentage remediation of ciprofloxacin using *B.juncea* seeds over a period of 12 days

Cipro Conc. (ppm)	Cipro Conc. (ppm)	amount remediated (ppm)	% remediation
10	4.98	5.02	50.2
20	13.12	6.88	34.4
30	21.25	8.75	29.16
40	31.98	8.02	20.05
50	42.03	7.97	15.94
60	55.45	4.55	7.5

Graph5. Percentage remediation of ciprofloxacin using *B.juncea* seeds over a period of 12 days

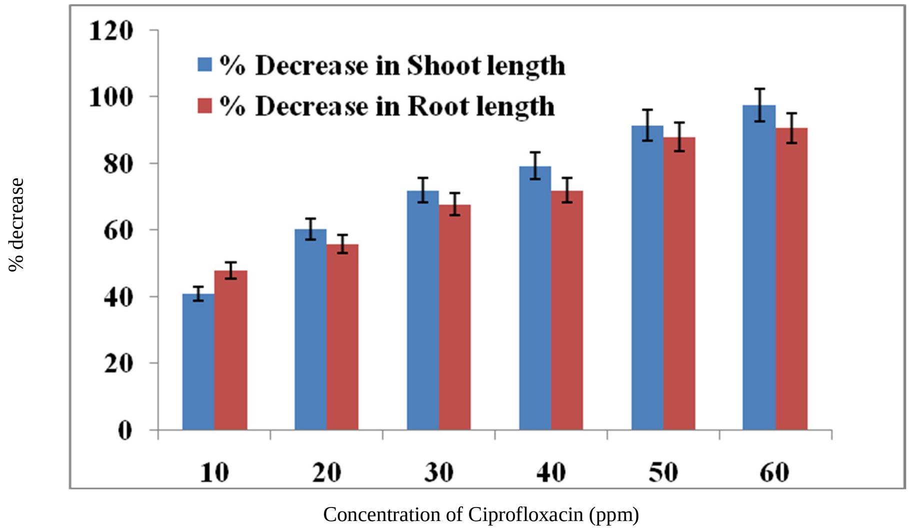


Concentration of ciprofloxacin (ppm)

Table 6: Root and shoot length of *B.juncea* grown in different ciprofloxacin concentrations over a period of 12 days

	SHOOT			ROOT		
Cipro Conc. (ppm)	Length (cm)	Dec. in length (cm)	% Dec. In Shoot Length	Length (cm)	Dec. in length (cm)	% Dec. In Root Length
Blank	4.5	-	-	2.5	-	-
10	2.66	1.84	40.88	1.3	1.2	48
20	1.78	2.72	60.44	1.1	1.4	56
30	1.26	3.24	72	0.8	1.7	68
40	0.93	3.57	79.33	0.7	1.8	72
50	0.38	4.12	91.55	0.30	2.2	88
60	0.1	4.4	97.77	0.23	2.27	90.8

Graph6: Effect of remediation on root and shoot length of *B.juncea* grown in different ciprofloxacin concentrations over a period of 12 days



When *B.juncea* seeds were grown with ciprofloxacin concentrations of 10, 20, 30, 40, 50 and 60 ppm, a decrease in percentage remediation was observed with an increase in ciprofloxacin concentration in media. This is because there was an increase in toxicity as ciprofloxacin concentration increased. It was also noted that at 60 ppm ciprofloxacin concentration, percentage remediation was negligible. Due to toxicity, the percentage decrease in shoot and root length increased with an increase in concentration of ciprofloxacin.

CONCLUSION

A decrease in the lengths of roots and shoots of the germinating *B.juncea* seeds was observed which indicates the toxicity in the germinated plants due to presence of copper and ciprofloxacin. The germination time of *B.juncea* seeds was 3-4 days, where as seeds grown along with contaminant in media took 12 days time to germinate ***in vitro***. When *B.juncea* seeds were grown with copper, maximum percentage remediation of 55.85 % was observed at 20 ppm, while when they were grown with ciprofloxacin, maximum percentage remediation of 63.2 % was observed at 5 ppm. From this data, it can be inferred that *B.juncea* can remediate higher concentrations (15 - 30 ppm) of copper more effectively as compared to higher concentrations of ciprofloxacin. In addition to this, it also indicates that lower concentrations (5 - 10 ppm) of ciprofloxacin can be remediated more effectively than lower concentrations of copper. Concentration at which maximum toxicity was observed was 40 ppm and 60 ppm when *B. juncea* seeds were grown with copper and ciprofloxacin respectively.

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