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PHYTOTOXIC EFFECT OF INDUSTRIAL EFFLUENTS ON SEED GERMINATION AND SEEDLING GROWTH OF *VIGNA RADIATA* AND *CICER ARIETINUM*

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ABSTRACT
The paper describes the effect of industrial effluents on seed germination and seedling growth of *Vigna radiata* and *Cicer arietinum.* The treated and untreated effluent samples were collected from three different industries of Jaipur viz. National Engineering Industries (NEI), Sri Seco Industries (SSI) and Raghuvar India Ltd. (RI) and were analyzed for various physicochemical parameters. The untreated effluent of RI and SSI were rich in BOD, COD and oil & grease while the NEI effluent showed maximum levels of electrical conductivity, total dissolved solids and chlorides. Germination percentage and seedling growth of both the plants showed considerable reduction in case of untreated effluents of all the three industries. The treated effluent also showed inhibitory effect to some extent. Root and shoot length of *Vigna* seedling reduced up to 58.66% and 69.06% respectively while in *Cicer* the reduction was upto 53.62% and 67.91% in untreated effluent of RI as compared to control. Minimum reduction in root and shoot length was observed in treated effluent of SSI in both *Vigna* and *Cicer.* Maximum phytotoxicity was observed in untreated effluent of RI for *Vigna* and in untreated effluent of SSI for *Cicer*. Treated effluent of NEI and SSI showed minimum phytotoxicity. *Cicer* was more sensitive towards effluent application as compared to *Vigna.*

KEYWORDS: Physicochemical analysis, effluents, germination, phytotoxicity.

INTRODUCTION

Water pollution due to industrial discharge is obtaining a greater dimension day by day in India. Industries discharge a variety of pollutants with chemical constituents of undesirable concentration which can deteriorate the surface and ground water resources. The waste water treatment system in Indian industries is recommended to be essentially installed to meet the waste water discharge norms, but presently only 10% of the waste water generated is treated and the rest of untreated water is discharged as it is into nearby water bodies. The use of industrial effluents for irrigation has emerged in the recent past as an important way of utilizing waste water, taking the advantage of the presence of considerable quantities of N, P, K and Ca along with other essential nutrients[1]. But there can be both beneficial and damaging effects of waste water irrigation on crops including vegetables [2,3]. Therefore, it is necessary to study the impact of these effluents on crop system before they are recommended for irrigation [4]. The present investigation has been carried out to study the effect of untreated and treated effluents from three major industries situated at Jaipur city on seed germination and early growth of *Vigna radiata* var. RMG 344 and *Cicer arietinum* var. RSG 888.

MATERIALS AND METHODS

The untreated and treated effluent samples were collected from three different industries viz. National Engineering Industries (NEI) (metal bearing unit), Sri Seco Industries (SSI) and Raghuvar India Ltd. (RI) (vegetable oil manufacturing units) and were analyzed for various physicochemical parameters using standard methods [5]. The samples were stored at 4˚C to avoid changes in their characteristics. Seeds of drought resistant varieties of *Vigna radiata* var. RMG 344 and *Cicer arietinum* var. RSG 888 were procured from Agricultural Research Institute, Durgapura, Jaipur. The healthy and uniform seeds were selected and surface sterilized with 0.1% $Hgcl_2$ and thoroughly washed with distilled water to avoid surface contamination. 20 seeds were placed equidistantly on soaked filter paper in petriplates. The seeds were irrigated with equal quantity of different effluent samples and the seeds irrigated with distilled water were taken as control. The number of seeds germinated was recorded after 48hrs. The root length, shoot length, number of lateral roots were recorded after 7 days and dry weight of seedlings was taken after keeping them in hot air oven at 80˚C for 24hrs.

The percentage of phytotoxicity was calculated using the formula [6]

$$\text{Percentage Phytotoxicity} = \frac{\text{Radical length of control} - \text{Radical length of test}}{\text{Radical length of control}} \times 100$$

The vigour index of the seedlings was calculated by using the formula [7]

$$\text{Vigour index} = (\text{MRL}+\text{MSL})\ \text{PG}$$

MRL= Mean Root Length; MSL= Mean Shoot Length;
PG= Percentage Germination

The tolerance index of seedlings was calculated by the formula [8]

$$\text{Tolerance index} = \frac{\text{Mean length of longest root in treatment}}{\text{Mean length of longest root in control}}$$

The data observed in the experiment was statistically analyzed for the calculation of standard error (S.E.) [9]

RESULTS AND DISCUSSION

The physicochemical analysis of effluent samples is given in **Table 1**. The untreated effluent samples were high in certain parameters which are above the permissible limits. The samples are alkaline in nature except untreated effluent of RI (pH 6.15). Untreated effluent of RI showed maximum level of EC (130200µmho/cm), TDS (83400mg/L) and oil & grease (9mg/L). Maximum total hardness (848mg/L) and chloride (505.52mg/L) were recorded in untreated effluent of NEI. COD and BOD which are indicators of pollution load were recorded maximum in untreated effluent of RI (318mg/L) and untreated effluent of SSI (55mg/L). The samples are rich in oil and grease. The higher levels of EC alter the chelating properties of receiving systems, which favors free metal availability to flora and fauna [10,11]. High level of total solids, indicates high concentrations of carbonates, chlorides, sulphates and nitrates of Ca, Mg and Na which increases salinity in water and eventually in soil into which it is leached out [12,13].

TABLE 1: Physico - Chemical analysis of effluent samples

S.No	Parameters	Effluent Samples					
		NEI		RI		SSI	
		Untreated	Treated	Untreated	Treated	Untreated	Treated
1.	pH	8.56	8.63	6.15	8.26	9.21	8.11
2.	Electric Conductivity (µmho/cm)	3846	3394	130200	1120	2920	1926
3.	Total Dissolved Solids.	3420	2736	83400	728	2166	1246
4.	Chloride	1079.20	505.52	124.96	56.80	133.48	249.92
5.	Total hardness	848	500	540	192	440	378
6.	Ca Hardness	168.33	136.27	96.19	48.09	48.09	91.38
7.	Mg hardness	165.83	88.74	108.28	35.11	95.62	69.93
8.	Total Alkalinity	600	450	200	230	440	320
9.	Total acidity	10	50	500	40	240	50
10.	COD	199	103	318	223	224	140
11.	BOD (3 days at 27˚C)	20	11	35	29	55	29
12.	Oil & Grease	7	5	9	5	5	2

(Values in mg/L unit except pH and E.C.)

The laboratory experiment on *Vigna* and *Cicer* showed an inhibitory effect of industrial effluents on seed germination and early growth of both the plants (Table 2 & 3). Supply of untreated effluents produced significant inhibition in seed germination and seedling growth parameters - length of root, length of shoot, number of lateral roots and dry weight of seedling in both *Vigna* and *Cicer*. Even though less severe, the inhibitory effect of treated effluents was also significant. Seeds of *Vigna* showed enhanced germination percentage (66.60%) in treated effluent of SSI as compared to control (53.30%) whereas 50% germination was recorded in treated effluents of NEI and RI. Minimum germination (43.33%) was recorded in untreated effluents of NEI and SSI followed by RI (46.66%) (Table 2). Similar effects were observed in *Cicer* (Table 3). Minimum percentage germination was recorded in untreated effluent of RI (15%) followed by NEI (25%) and SSI (26.66%) as compared to control (75%). Reduction in germination percentage was also recorded up to 48.33%, 63.33% and 71.66% in treated effluents of NEI, RI and SSI respectively. Inhibition of seed germination in untreated effluents may be due to greater amount of dissolved solids that increases the salinity and conductivity of the absorbed solute by seed before germination [14,15,11]. Higher salt content of untreated effluent also changes the osmotic potential outside the seed thereby reducing the amount of water absorbed by the seed which results in retardation of seed germination [16]. Increase in percentage germination in treated effluent may be due to lower salt concentration that has created favorable environmental conditions for germination and utilization of nutrients present in the effluent [17,18].

TABLE 2: Effect of industrial effluents on seed germination and early growth of *Vigna radiata* var. RMG 344

Parameters	Control	Treated Effluent	Untreated Effluent

		NEI	RI	SSI	NEI	RI	SSI
Seed Germination % (after 48 hrs)	53.3±9.76	50±9.43 (-6.19)	50±12.48 (-6.19)	66.6±5.44 (+24.93)	43.33±17.86 (-18.76)	46.66±7.20 (-12.45)	43.33±2.72 (-18.76)
Root length (cm)	9.58±0.39	5.75±0.26 (-39.97)	7.52±0.49 (-21.50)	8.60±0.31 (-10.22)	4.42±0.30 (-53.86)	3.96±0.26 (-58.66)	6.10±0.33 (-36.32)
Shoot length (cm)	1.81±.08	1.06±0.26 (-41.43)	1.58±0.08 (-12.7)	1.41±0.07 (-22.09)	0.69±0.04 (-61.67)	0.56±0.05 (-69.06)	1.04±0.07 (-42.54)
No. of Rootlets	8.66±0.34	7.60±0.48 (-12.24)	6.56±0.34 (-24.24)	6.68±0.37 (-22.86)	4.44±0.33 (-48.72)	4.74±0.52 (-45.26)	4.85±0.35 (-43.99)
Dry weight (g)	0.026±0.0	0.026±0.00 (0.00)	0.030±0.0 (+15.38)	0.033±0.0 (+26.92)	0.030±0.00 (+15.38)	0.026±0.00 (0.00)	0.029±0.00 (+11.5)

(Values are arithmetic mean ± SEM of three replicates. Values in parentheses represent % change from control)

TABLE 3: Effect of industrial effluents on seed germination and early growth of *Cicer arietinum* var. RSG 888

Parameters	Control	Treated Effluent			Untreated Effluent		
		NEI	RI	SSI	NEI	RI	SSI
Seed Germination % (after 48 hrs)	75±2.35	48.33±9.53 (-35.56)	63.33±8.28 (-15.56)	71.66±3.60 (-4.45)	25±14.73 (-66.66)	15±4.67 (-80)	26.66±9.82 (-64.45)
Root length (cm)	6.49±0.37	4.83±0.3 (-25.57)	4.35±0.47 (-32.97)	3.91±0.43 (-39.75)	3.8±0.54 (-41.44)	3.01±0.26 (-53.62)	2.92±0.3 (-54.97)
Shoot length (cm)	5.61±0.21	3.03±0.26 (-45.98)	3.99±0.15 (-28.87)	4.61±0.23 (-17.82)	1.84±0.36 (-67.20)	1.8±0.18 (-67.91)	2.92±1.21 (-47.95)
No. of Rootlets	1.94±0.63	1.78±0.26 (-8.24)	1.28±0.53 (-34.02)	1.26±0.52 (-35.05)	1.26±0.7 (-35.05)	0.56±0.39 (-71.13)	1.17±0.47 (-39.69)
Dry weight (g)	0.15±0.002	0.13±0.01 (-17)	0.12±0.001 (-24.05)	0.11±0.05 (-30.37)	0.1±0.01 (-34.81)	0.1±0.02 (-34.81)	0.09±0.002 (-39.24)

(Values are arithmetic mean ± SEM of three replicates. Values in parentheses represent % change from control.)

The reduction in root and shoot length of *Vigna* (Table 2) was recorded up to 58.66% (3.96cm) and 69.06% (0.56cm) respectively in untreated effluent of RI as compared to control (9.58cm and 1.81cm respectively). Similarly untreated effluent of NEI and SSI showed reduced root and shoot length upto 53.86% (4.42cm) and 61.67% (0.69cm) & upto 36.32% (6.10cm) and 42.54% (1.04cm) respectively. Root and shoot length were also decreased in treated effluents of NEI (5.75cm and 1.06cm), RI (7.52cm and 1.58cm) and SSI (8.60cm and 1.41cm) though the effects were less toxic. Number of rootlets reduced up to 48.72% (4.44), 45.26% (4.74) and 43.99% (4.85) in untreated effluents of NEI, RI and SSI respectively while the number was reduced upto 12.24% (7.60), 24.24% (6.56) and 22.86% (6.68) in treated effluents of NEI, RI and SSI respectively as compared to control (8.66). Effluent application showed either an increase or no significant change in dry weight of seedlings. Increase in dry weight was also observed in treated effluent of SSI and RI upto 26.92% (0.033g) and 15.38% (0.03g) as well as in untreated effluent of NEI and SSI upto 15.38% (0.03g) and 11.5% (0.029g) respectively as compared to control (0.026g). Vigour index (Fig. 2) and tolerance index (Fig. 3) of seedlings were minimum in untreated effluent of RI (206.5 and 0.49 respectively) followed by NEI (211.06 and 0.53) and SSI (378.5 and 0.66) respectively. Maximum vigour and tolerance index was recorded in treated effluent of SSI (690.2 and 0.78) followed by RI (492.7 and 0.81) and NEI (345.6 and 0.56). Percentage phytotoxicity (Fig.1) was high in untreated effluents. Maximum % phytotoxicity was recorded in untreated effluents of RI (58.59%) while it was 53.79% and 36.28% in untreated effluent of NEI and SSI respectively. Minimum % phytotoxicity was observed in treated effluent of SSI (10.15%).

Cicer showed 54.97% (2.92cm) and 47.95% (2.92cm) reduction in root and shoot length respectively in untreated effluent of SSI , 53.62% (3.01cm) and 67.91% (1.8cm) in RI and 41.44% (3.8cm) and 67.20% (1.84cm) respectively in NEI (Table 3). However the reduction in root and shoot length was upto 39.75% (3.91cm) and 17.82% (4.61cm) respectively, upto 32.97% (4.35cm) and 28.87% (3.99cm) and upto 25.57% (4.83cm) and 45.98% (3.03cm) in treated effluent of SSI, RI and NEI respectively as compared to control (6.49cm and 5.61cm respectively). Number of rootlets reduced up to 71.13% (0.56), 39.69% (1.17) and 35.05% (1.26) in untreated effluents of RI, SSI and NEI respectively while the number was reduced upto 35.05% (1.26), 34.02% (1.28) and 8.24% (1.78) in treated effluents of SSI, RI and NEI respectively as compared to control (1.94). Reduction in dry weight was noted upto 39.24% (0.09g), 34.81% (0.1g) and 34.81% (0.1g) in untreated effluent of SSI, RI and NEI respectively while the reduction was upto 30.37% (0.11g), 24.05% (0.12g) and 17% (0.13g) in treated effluent of SSI, RI and NEI respectively. Minimum vigour index (Fig. 2) and tolerance index (Fig.3) were recorded in untreated effluent of RI (53.55 and 0.41 respectively) followed by SSI (132.53 and 0.46 resp.) and NEI (162.60 and 0.63 resp.). Low vigour index and tolerance index was recorded in treated effluent of NEI (321.90 and 0.74 respectively), SSI (349.73 and 0.55 respectively) and RI (384 and 0.69 respectively). Maximum phytotoxicity percentage (Fig.1) was noted in untreated effluent of SSI (55%) followed by RI (53.62%) and NEI (41.44%). However, in treated effluent of SSI, RI and NEI the percentage phytotoxicity was 39.75%, 32.97% and 25.57% respectively.

Higher concentration of effluent decreases activities of enzyme dehydrogenase [19] and acid phosphatase [20] which can be considered as one of those various biochemical changes which may interrupt germination and seedling growth and involved in mobilization of nutrient reserves [21]. The low amount of oxygen in dissolved form due to high presence of high concentration of dissolved solids in the effluent reduces the energy supply through anaerobic respiration causing retardation of growth and development of seedling [22]. As per experimental observation it can be concluded that the untreated effluent samples under investigation being a potential source of pollution load are also toxic to the plant. The untreated effluent of RI shows maximum inhibitory effect on both the plants. The treated effluents can be used for irrigation purpose but only after further treatment.

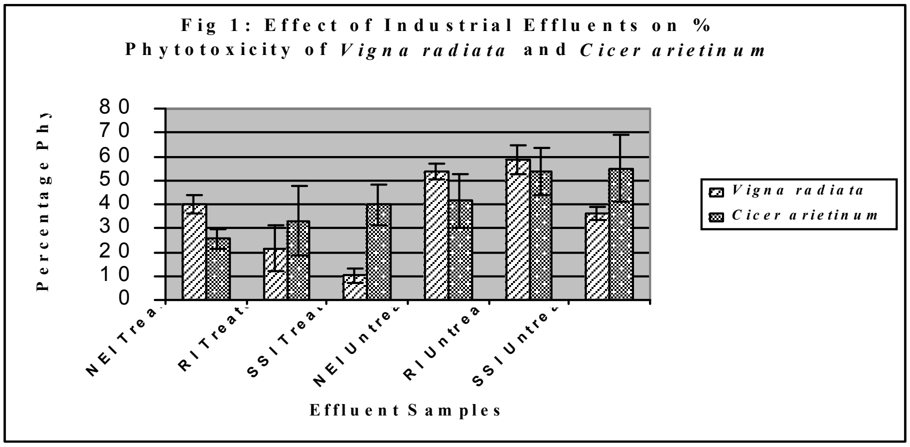

Fig 1: Effect of Industrial Effluents on % Phytotoxicity of *Vigna radiata* and *Cicer arietinum*

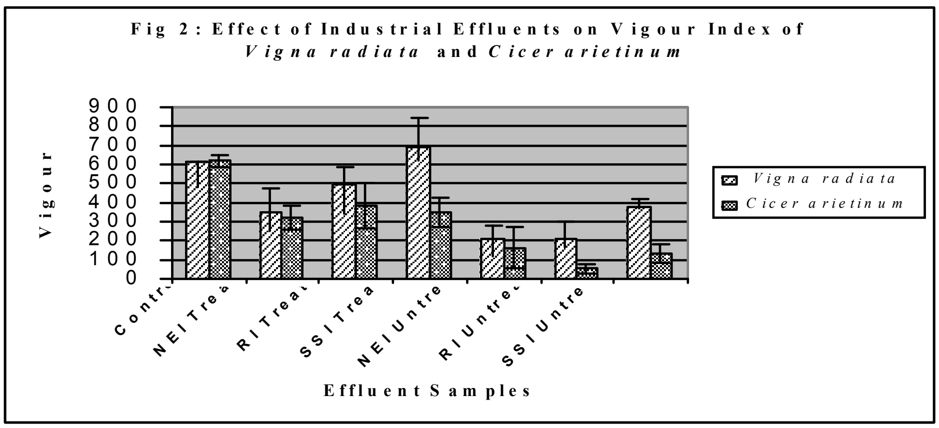

Fig 2: Effect of Industrial Effluents on Vigour Index of *Vigna radiata* and *Cicer arietinum*

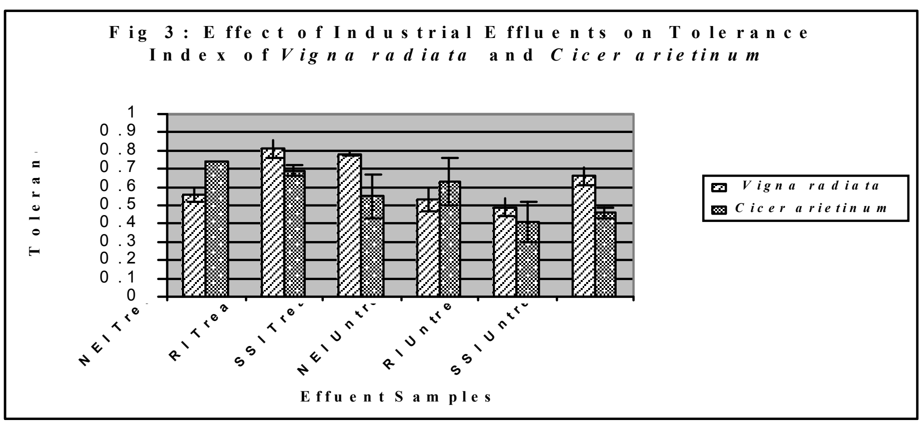

Fig 3: Effect of Industrial Effluents on Tolerance Index of *Vigna radiata* and *Cicer arietinum*

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