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Impact of Paper Mill Effluent on Seed Germination and Seedling Growth of Coriander (*Coriandrum sativum*) Varieties

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Abstract— *Diverse nature of agro-based industrial effluents from various industries are disposed off in to soil and water bodies, which has been causing major pollution problem. To economize the irrigation water industrial effluents are now a days commonly used for irrigation. The present study has been carried out to assess the impact of paper mill effluent on seed germination and seedling growth of Coriander (Coriandrum sativum) varieties KS and Mehak. The pot culture experiment was conducted with the different concentrations like viz., 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90% and 100% along with control (Tap water). Physico-chemical parameters included colour, pH, temperature, turbidity, electrical conductivity (EC), total solids (TS), total dissolved solids (TDS), suspended solids (SS), chemical oxygen demand (COD), biochemical oxygen demand (BOD), total hardness (TH), total alkalinity (TA) and chloride (Cl^-). The growth parameters such as germination percentage, seedling vigour, plant length, fresh and dry weight were measured at 14th DAS (days after sowing). The results indicate that at lower concentration there is a significant increase in the percentage of seed germination and other growth parameters but decreased with increase in effluent concentration.*

Keywords— ***Coriander, germination percentage, paper mill, Mehak, seedling vigour.***

I. INTRODUCTION

Pulp and paper industry is very important industry for the overall development of a country and it is partially or completely dependent on ligno cellulose crop residues. In northern India most of the pulp and paper mills manufacture paper using agricultural residues mainly from crops straws. For manufacturing of a huge amount of water is required and thus it release large volume of waste water. It is estimated that 273-450 M^3 of water is required per ton of paper produced **(Subrahmanyam and Hannmanulu, 1976)** that consequently, generate 300 M^3 of waste water **(Khanna *et al*., 1990)**. The effluents generated from pulp and paper mill is dark brown in colour and having high BOD, COD, TS and organic carbon **(Kirk *et al*., 1983; Singh *et al*., 1994)**. From literature it was found that the first alkaline extraction state is the major source of pollutants (approximately 95% of total pollution load) from pulp and paper **(Ragan, 1987; Singh *et al*., 1994)**. At present, there are 666 pulp and paper mills in India, of which 632 units are agro-residue and recycled fiber based units with manufacturing capacity of 7.6 million tons **(CPPRI, 2005)**. The Indian pulp and paper industry is highly water intensive, consuming 100-250 m3 freshwater/ton paper **(Singh, 2004)** and also generate the corresponding wastewater 75-225 m3 wastewater/ton paper **(Thompson, 2001; Ansari, 2004; Tewari *et al*., 2009)**. There are more than 20 types of industries including paper industry falls under red category because of their potentiality in polluting the environment **(CPCB, 2016)**.

Treated industrial effluents can be used for irrigation purpose. When the effluent is used without any treatment, toxic substances present in the effluent reduces crop growth and gives severe adverse effect on soil properties **(Somashekar *et al*., 1984; Juwarker *et al*., 1987, Garg and Kaushik, 2006)**. Studies on the effect of paper mill effluent on various crops have been carried out by various investigators. **Chaudhary *et al.* (1987)** studied the effect of paper mill effluent on germination, seedling growth and chlorophyll content in *Zea mays* L. It was observed that highest overall growth was found upto 25% concentration of effluent but chlorophyll content was higher at 75%. **Dutta and Boissya (1996)** studied the effect of paper industry effluent on germination in *Oryza sativa* L and found that in effluent affected areas, germination percentage and yield were comparatively less. **Singh *et al*. (2002)** studied the effect of effluent in *Triticum aestivum* L. and noticed that diluted effluent showed increase in chlorophyll content, plant height, shoot and root biomass, grain yield

etc. whereas concentrated effluent showed a decrease in parameters.

Coriandrum Sativum family Umbelliferae is highly reputed ayurvedic medicinal tree commonly known as the Dhaniya. Dhaniya consist of dried ripe fruit of Coriandrum Sativum Linn Umbeliferae **(Evans and Treas, 2002)** a slender, glabrous, branched, cultivated all over India, giving characteristic aroma when rubbed. All parts of the plant are edible, but the fresh leaves and the dried seeds are the most common parts used in cooking. The different parts of this plant contain monoterpenes, α-pinene, limpnene, γ-terpinene, p-cymene, borneol, citronellol, camphor, geraniol, coriandrin, dihydrocoriandrin, coriandrons A-E, flavonoids and essential oils. Various parts of this plant such as seed, leaves, flower and fruit, possess diuretic, antioxidant activity, anti-diabetic anti-convulsant activity, sedative hypnotic activity, anti-microbial activity, anti mutagenic, anthelmintic activity **(Pathak *et al*., 2011)**. Coriander has been used for a number of medical problems such as dyspeptic complaints, loss of appetite, convulsion and insomnia **(Benjumea *et al*., 2005; Maghrani *et al*., 2005; Heidar *et al*., 1992; Zargari *et al*., 1991; Duke *et al*., 2002)**.

II. MATERIALS AND METHODS

Experimental design

The pot culture experiment was conducted in the laboratory of Department of Energy and Environmental Sciences, Chaudhary Devi Lal University, Sirsa. The effect of paper mill effluent on the initial growth parameters such as germination percentage, seedling vigour, plant length, fresh and dry weight were studied using disposable pots (8.5 cm height and 7 cm width), filled with air dried soil taken into separate pots. The soil used in the experiment was sandy loam in nature. The methodology of **Aery (2010)** was adopted for surface sterilization of the test seeds of both varieties with 0.1% mercuric chloride ($HgCl_2$) for 30 seconds and vigorously rinsed with DDW three times to remove traces of $HgCl_2$. 10 seeds were sowed in each pot of each variety in different dilutions i.e control, 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90% and 100% along with control to study the response of both the varieties. All pots were watered to field capacity daily.

Effluent collection and analysis

The sample of paper mill effluent was collected from outlet in precleaned, sterilized plastic containers from Shree Jagdambe paper mills ltd., Sirsa, Haryana, India and was stored at 4^oC till further investigation as described by **APHA (2010)**. Physico-chemical parameters, such as colour, pH, temperature, electrical conductivity (EC), total solids (TS), total dissolved solids (TDS), total suspended solids (TSS), chemical oxygen demand (COD), biochemical oxygen demand (BOD), total hardness (TH), total alkalinity (TA) and chloride (Cl^-) were measured using standard methods **(APHA, 2010)**. Different concentrations i.e 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90% and 100% were prepared by adding desired volume of tap water (municipal supply) collected from sector 13, Bhiwani and used for the proposed pot trials.

Collection of seeds

Commercially available seeds of Coriander (*Coriandrum sativum*) varieties KS and Mehak were procured from the certified local seed supplier, Bhiwani, used in the study. Seeds with uniform size, colour and weight were chosen for the experimental purpose.

Initial Growth analysis

The test plant samples of both varieties were harvested 14th days after sowing. Three plants from each pot were analysed for various initial growth parameters such as germination percentage, seedling vigour, plant fresh weight, dry weight and plant length by following the methodology of **Aery (2010)**.

Germination percentage

The number of seeds germinated in each treatment was observed on 14^{th} DAS (day after sowing). The total germination percentage was calculated by using the following formula:

$$\text{Germination percentage} = \frac{\text{Total number of seeds germinated}}{\text{Total number of seeds sown}} \times 100$$

Seedling vigour index

Vigour index of the seedling were calculated by using the formula proposed by **Aery (2010)**.

Seedling vigour index = Germination percentage × seedling length

Statistical analysis

The statistical analysis was carried out by using SPSS software (Version 20). Data were analyzed for mean, standard error and one way analysis of variance. ANOVA was done at 0.05 levels to find out the significant difference between different concentrations of effluent and different parameters of growth and development of the crops.

III. RESULTS AND DISCUSSION

In the present study paper mill waste water which was used for irrigation of Coriander (*Coriandrum sativum*) varieties KS and Mehak was analysed to know the physico-chemical

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parameters of waste water and its effect on initial growth parameters such as germination percentage, seedling vigour, plant length, fresh and dry weight. The results of physico-chemical characteristics of paper mill effluent are presented in **Table-1**.

The characterization of the effluent revealed that it is dark brown in colour having temperature of 20.2 ^{o}C and turbidity of 12 NTU. The pH of the effluent was found alkaline in nature having pH of 8.2. The value of total solids, total dissolved solids and suspended solids were 1700 mg/l, 1440 mg/l and 260 mg/l respectively. The electrical conductivity (EC) value was 2.25 µS. The effluent had higher BOD, 282 Mg/l and COD, 960 mg/l. The higher concentration of BOD and COD indicated the higher concentration of organic and inorganic substances in the effluent. The recommended BIS values for BOD and COD are 100 mg/l and 250 mg/l respectively. Further the values of total hardness (TH), total alkalinity (TA) and chloride were 770 mg/l, 440 mg/l and 510 mg/l respectively. The presence of high amount of COD, BOD, suspended solids, total hardness were also recorded by **Baruah *et al*., 1996**; **Medhi *et al*., 2008.**

The observation made on the effects of paper mill effluent on growth parameters of Coriander (*Coriandrum sativum*) varieties KS and Mehak are presented in **Table 2 & 3**. The results clearly indicate the growth parameters like germination percentage, seedling vigour, plant length, fresh and dry weight of both varieties varied with respect to different concentrations of paper mill effluent. The degree of inhibitory effect of paper mill effluent on the growth of test varieties KS and Mehak increased with the increase in the concentration of effluent when compared to the control.

Table.1: The physico-chemical analysis of paper mill effluent

S.No.	Parameters	Effluent	Control	BIS for drinking water	BIS for irrigation water
1	Colour	Dark brown	Colourless	Colourless	
2	pH	8.2	7.3	6.5-8.5	5.5-9
3	Temperature (^{o}C)	20.2	18.1	-	-
4	Turbidity(NTU)	12	1.5	5	10
5	TS (mg/l)	1700		600	1900
6	TDS (mg/l)	1440	84	500	2100
7	SS(mg/l)	260		100	200
8	EC (µS)	2.25	0.13	-	-
9	BOD (mg/l)	282	1.8	4	100
10	COD (mg/l)	960			250
11	TH (mg/l)	770	202	300	600
12	TA (mg/l)	440	72	200	600
13	Chloride (mg/l)	510	56	250	500

The result shows that 90% germination was recorded for KS variety in pot treated with 40% concentration of effluent while 20% germination was recorded at 100% concentration. From 50% onwards the germination percentage was found to be gradually declined in KS variety. 50% germination was recorded in control. Mehak variety showed 83.3 germination percentage in pot treated with 60% concentration of effluent while 16.7 germination percentage was recorded at 100 % concentration. 33.3 percent germination was recorded in pot treated with tap water. From 60% onwards the germination percentage was found to be gradually declined in Mehak variety. The KS variety resulted better in terms of early seed germination than Mehak variety showing the inter-varietal difference. The observation was conformity with **Medhi *et al*. (2008)**. In present study ANOVA analysis on data showed that effluent concentration 40% significantly ($P<0.05$) affected germination as compared to control in KS variety while in Mehak variety 50%, 60% and 70% significantly ($P<0.05$) affected germination as compared to control.

The result shows that 25cm plant length was recorded for KS variety in pot treated with 50% concentration while at 100 % concentration 13.23cm length was recorded. 16.23 cm plant length was recorded in control. From 50% onwards the length was found to be gradually declined in KS variety. Mehak variety showed 23.5 cm plant length in 30% concentration of effluent while 12.43 cm and 13.8 cm plant length was recorded in control and 100%

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concentration respectively. Plant length was found to be gradually declined from 30% concentration onwards. In present study ANOVA analysis on data showed that effluent concentration 20%, 30%, 40%, 50%, 60%, 70% and 100% significantly (P<0.05) affected plant length as compared to control in KS variety while in Mehak variety 20% to 90% concentration significantly (P<0.05) affected plant length as compared to control.

The value of seedling vigour recorded in pot treated with 40% concentration was 2353.3 while at 100 % concentration 261 vigour was recorded. Value of seedling vigour for control was found to be 812 for KS variety. Mehak variety showed 1731.3 seedling vigour at 60% concentration of paper mill effluent while value of seedling vigour for control and 100% concentration was observed to be 392 and 227.7 respectively. Vigour was found to be gradually declined from 60% concentration onwards in Mehak variety. ANOVA analysis on data showed that effluent concentration 20%, 30%, 40% and 50% significantly (P<0.05) affected seedling vigour as compared to control in KS variety while in Mehak variety 30% to 70% concentration significantly (P<0.05) affected vigour as compared to control.

Table.2: Growth parameters of Coriander variety (KS) under different concentration of paper mill effluent (n=3, Mean ±SE)

Treatment	Germination %	Plant Length (cm)	Seedling vigour	Fresh weight (gm)	Dry weight (gm)
Control	50.0 ± 5.77	16.23 ± 0.12	812 ± 96.03	0.028 ± 0.0	0.002 ± .000
10%	73.3 ± 6.67	18.43 ± 0.67	1360 ± 165.31	0.025 ± 0.001	0.003 ± .001
20%	80.0 ± 5.77	21.17 ± 0.72a	1689 ± 102.5a	0.025 ± 0.001	0.004 ± .001
30%	83.3 ± 3.33	22.90 ± 0.38a	1908.7 ± 86.07a	0.028 ± .001	0.003 ± .000
40%	90.0 ± 5.77a	24.57 ± 0.78a	2353.3 ± 124.89a	0.027 ± .000	0.003 ± .000
50%	73.3 ± 6.67	25.00 ± 0.12a	1834.7 ± 173.39a	0.023 ± .002	0.003 ± .000
60%	70.0 ± 5.77	20.83 ± 0.30a	1456 ± 108.3	0.024 ± .001	0.004 ± .001
70%	66.7 ± 8.82	18.80 ± 0.31a	1258 ± 181.27	0.026 ± .003	0.002 ± .000
80%	50.0 ± 5.77	18.00 ± 0.12	899.3 ± 101.72	0.022 ± .001	0.002 ± .000
90%	46.7 ± 8.82	17.20 ± 0.52	795.7 ± 142.36	0.020 ± .000a	0.002 ± .000
100%	20.0 ± 5.77	13.23 ± 0.69a	261 ± 74.36	0.019 ± .001a	0.002 ± .000
F-value	10.024	53.301	22.320	4.522	1.809*

** Not significant at (P<0.05), a =significantly different to control*

For Mehak variety maximum value for fresh weight 0.024 gm was found in pot irrigated with 50 % and 60% concentration of effluent while for dry weight 0.002 gm was found in 40 % to 60% concentrations. The value of fresh weight and dry weight for control was found to be 0.023 gm and 0.001 gm respectively. ANOVA analysis on data showed that effluent concentration 90% and 100% significantly (P<0.05) affected fresh weight as compared to control in KS variety. Fresh and dry weight did not differ significantly (P<0.05) for Mehak variety.

Similar observations were also studied by many workers. **Medhi *et al*., (2008)** studied effect of pulp and paper mill effluent on seed germination and seedling growth of mustard, pea and rice and found that lower concentrations of effluent had a growth promoting effect than control. **Reddy and Borse (2001)** studied the effect of the effluent on germination and seedling growth in *Trigonella foenum graceum* L. and found that there was increase in germination and seedling growth upto 25% concentration and above it, there was decline in parameters. **Kamlesh and Kidwai, (2016)** studied effect of sugar mill effluent on Fenugreek (*Trigonella foenum-graecum*) varieties (Kasuri) and (Pusa Bold) and found that higher effluent concentrations affect initial growth parameters while lower dilutions favoured initial plant growth of both the plant varieties.

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Table.3: Growth parameters of Coriander variety (Mehak) under different concentration of paper mill effluent (Mean ±SE)

Treatment	Germination %	Plant Length (cm)	Seedling vigour	Fresh weight (gm)	Dry weight (gm)
Control	33.3 ± 8.82	12.43 ± 1.27	392 ± 61.78	0.023 ± 0.003	0.001 ± 0.0
10%	40 ± 5.77	15.2 ± 0.77	614 ± 117.36	0.024 ± 0.0	0.001 ± 0.0
20%	43.3 ± 3.33	19.3 ± 0.72a	832 ± 36.3	0.022 ± 0.003	0.001 ± 0.0
30%	46.7 ± 3.33	23.5 ± 0.71a	1096 ± 90.86a	0.019 ± 0.004	0.001 ± 0.001
40%	60 ± 5.77	23.2 ± 0.46a	1394.7 ± 147.25a	0.020 ± 0.001	0.002 ± 0.0
50%	73.3 ± 3.33a	22.4 ± 0.55a	1648.7 ± 115.95a	0.024 ± 0.003	0.002 ± 0.0
60%	83.3 ± 6.67a	20.7 ± 0.29a	1731.3 ± 159.01a	0.024 ± 0.001	0.002 ± 0.001
70%	70 ± 5.77a	19.9 ± 0.18a	1396.7 ± 122.7a	0.017 ± 0.0	0.001 ± 0.0
80%	46.7 ± 8.82	19.3 ± 0.18a	900.7 ± 174.95	0.019 ± 0.0	0.001 ± 0.0
90%	36.7 ± 8.82	17.2 ± 0.64a	632.7 ± 162.28	0.020 ± 0.001	0.001 ± 0.0
100%	16.7 ± 3.33	13.8 ± 0.38	227.7 ± 41.43	0.017± 0.001	0.001 ± 0.0
F-value	10.132	34.902	17.490	2.134*	0.776*

** Not significant at (P< 0.05), a =significantly different to control*

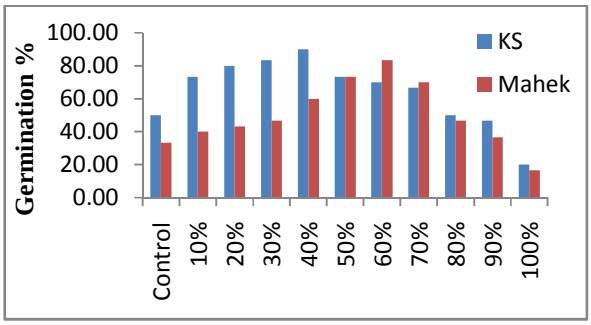

Fig.1: Impact of paper mill effluent on germination (%)

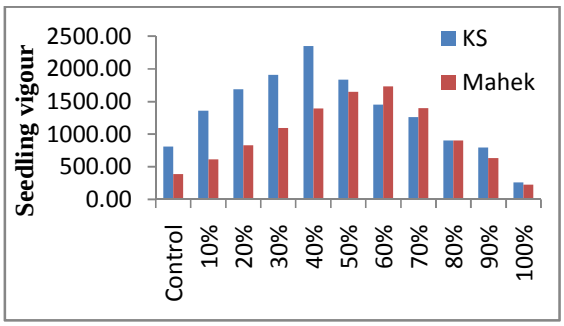

Fig.2: Impact of paper mill effluent on seeding vigour

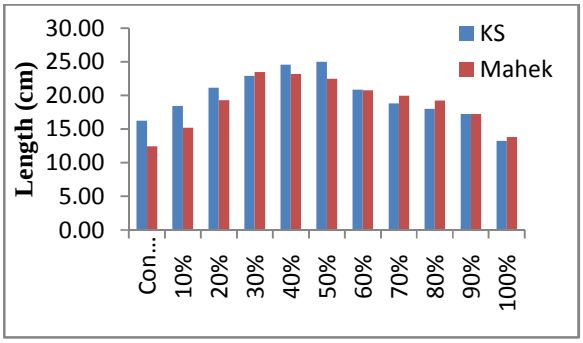

Fig.3: Impact of paper mill effluent on plant length

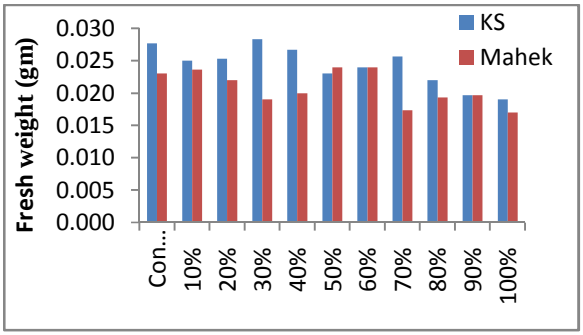

Fig.4: Impact of paper mill effluent on fresh weight

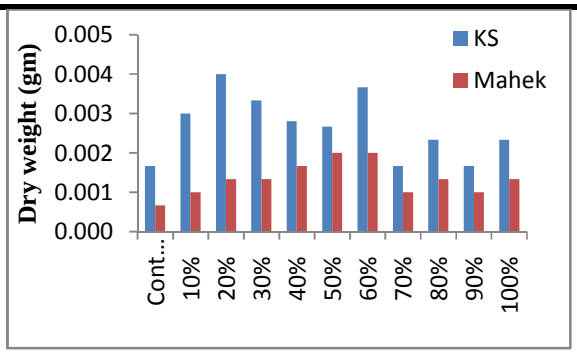

Fig.5: Impact of paper mill effluent on dry weight

IV. CONCLUSION

In the present study paper mill effluent was studied to know its effect on initial growth parameters such as germination percentage, seedling vigour, plant length, fresh and dry weight of Coriander (*Coriandrum sativum*) varieties KS and Mehak. From the conducted work, it is concluded that paper mill effluent had adverse effect on growth parameters at higher concentration, but lower concentrations favoured initial plant growth of both the plant varieties. However, long term research work should be conducted to explore the effect of paper mill effluent on above suggested aspects before its use for irrigation.

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