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Impact of Paper Mill Effluent on Seed Germination, Seedling Growth and Chlorophyll Content of *Glycine max* (L.)

Priyanka, Bhawna Bajpai

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ABSTRACT

In order to learn how paper mill effluent affects *Glycine max* (L.) seed germination, shoot development (plumule and radicle length), and chlorophyll concentration (Chl a, Chl b, and Total Chl), a lab experiment was conducted. Through the process of diluting it with distilled water, effluent was created in varying proportions, ranging from 25% to 100%. In the present investigation germination (%), plumule, radicle length and total chlorophyll contents significantly declined with increasing concentration of paper mill effluent as compared to the control. It has been concluded that the acidic nature of effluent is very harmful to soybean growth. Higher concentrations (100%) of wastewater may contain hazardous components for irrigation purposes as compared to the diluted percentages of the paper mill effluent, however, after sufficient treatment lower concentrations of effluent can be used for agricultural irrigation.

Keywords Chlorophyll content, *Glycine max,* Paper mill effluent, Seed germination.

INTRODUCTION

India has 700 pulp and paper factories on an average. It is one of the India's most water-intensive industries and one of the most polluting. The disposal of enormous amounts of wastewater is the most significant issue the pulp and paper sector is currently confronting. Such wastewater contains a variety of floating organic molecules as well as dissolved solids like chlorides and sulphates of Na and Ca. In addition to these components, effluents also contain traces of Hg, Pb, Cr, and other trace metals. The dark color of waste water exhibits the toxic effects on the biota and inhibits the photosynthetic activity by reducing the sunlight (Kesalkar *et al.* 2012). In addition to its other consequences, polluted water immediately affects soil in industrial zones, agricultural fields, and riverbeds, producing a secondary source of pollution. The cultivable terrain has been continuously exposed to large

Dr Priyanka[1]*, Dr Bhawna Bajpai[2]

[1]Assistant Professor
Translam Group of Institutions, Meerut, Uttar Pradesh, India

[2] Assistant Professor
Chaudhary Charan Singh University (CCSU), Meerut, Uttar Pradesh, India

Email: pri03singh@gmail.com
*Corresponding author

amounts of waste water from various enterprises that contains high levels of fertilizers, heavy metals, and toxic compounds. These effluents produce toxicity and exceed tolerance limits in addition to raising the nutrient level (Kumar *et al.* 2017).

Industrialization strengthens a country's economic value, however, it also brings harm to the environment. So, industrialization has resulted in widespread water and soil contamination, which leads to acute unhygienic conditions and negative effects on crops and soil when waste streams are employed for irrigation. However, there has been a recent increase in interest in the direct burning of biomass power products. Among the many different types of trash that the pulp and paper industry releases into the atmosphere, it ranks sixth overall, behind the oil, cement, leather, textile, and steel sectors. Effluent treatment is essential before the pulp and paper industry's massive amounts of effluent are released into the environment; failing to do so poses serious ecological and financial risks. The environmental problems of the pulp and paper industry are not limited by the high water consumption (Jiang *et al.* 2021). The aim of the present study is to investigate the impact of paper mill effluent on the seed germination, seedling growth and chlorophyll content of *Glycine max* (L.).

MATERIALS AND METHODS

The sample for the laboratory experiment was collected in a pre-cleaned plastic bottle from Saini Paper Mill in March 2018. The collected sample was stored at 4°C to avoid changes in the characteristics. The different parameters of collected sample like pH, color, odor, electrical conductivity (EC), dissolved solids (DS), biological oxygen demand (BOD), chemical oxygen demand (COD), chromium (Cr), copper (Cu), and lead (Pb) were estimated according to standard methods (APHA 2005). The certified seeds of *Glycine max* var. JS9305 were procured from Eagle seeds MP. The seeds were surface sterilized with 0.01% of sodium hypochlorite for two minutes and after two minutes washed with distilled water. Different concentrations of effluent (25%, 50%, 75%, and 100%) were prepared by diluting with distilled water along with distilled water as control (0%). Ten healthy seeds of *Glycine max* were placed in a petri dish. Germination percentage was recorded until no seed germination was found. After 10 days of sowing, plumule and radicle length (cm) were recorded. In this study chlorophyll a and b of *Glycine max* were also estimated according to Arnon Daniel (1949) after 9 days of sowing. The experiments were conducted in three replicates at Plant Pathology Lab, Department of Botany, Chaudhary Charan Singh University, Meerut. The results were subjected to one-way analysis of variance (ANOVA) and post-hoc Duncan test for comparison of means to determine statistical significance. Statistical analysis was performed using SPSS 16 software.

RESULTS AND DISCUSSION

Paper mill effluent was transparent and somewhat brown in color, according to the physico-chemical characterization in Table 1. With a pH of 5.4, the effluent is acidic, meaning it has a pH of 5.5 or below. The water is unsuitable for irrigation due to the pH, which is a critical component in the development of algal blooms. Soil acidification and stunted crop growth and productivity are the results of using this water for irrigation purposes over farmland. There are a lot of solids, as well as biological and chemical oxygen demands. The toxicity of the effluent is likely due to the high concentrations of Cr, Cu, and Pb, as well as the significant quantities of biological and chemical oxygen demand (Malakar *et al.* 2019).

At a concentration of 25% in the paper mill effluent, the highest germination percentage was observed (Table 2). When compared to the control,

Table 1. Physico-chemical characteristics of paper mill effluent.

Sl. No.	Parameters	Observation
1	pH	5.4 ± 0.20
2	Color	Translucent, little brown
3	Odor	Mild pungent
4	Electrical conductivity (mS)	10.5± 0.2
5	Dissolved solids (mg/l)	601 ± 10.76
6	BOD (mg/l)	57.5 ± 0.28
7	COD (mg/l)	126 ± 0.25
8	Chromium (ppm)	0.065 ± 0.003
9	Copper (ppm)	0.014 ± 0.0002
10	Lead (ppb)	0.106 ± 0.002

This table shows the arithmetic mean and standard error values of three replicates.

Table 2. Impact of paper mill effluents on the seed germination % and seedling growth (plumule and radicle length) of *Glycine max* (L.). Mean value with different letters in the same column differs from each other by means of ANOVA, Duncan test 0.05 level.

Treatments	Germination (%) (mean ± SE)	Plumule length (cm) (mean ± SE)	Radicle length (cm) (mean ± SE)
Control	95 ± 0.15 a	3.15 ± 0.25 a	2.73 ± 0.30 a
25%	92 ± 0.03 a	2.88 ± 0.12 b	2.56 ± 0.20 a
50%	78 ± 0.22 b	2.43 ± 0.05 c	1.82 ± 0.22 b
75%	72 ± 0.19 b	1.88 ± 0.22 d	1.51 ± 0.18 c
100%	49 ± 0.07 c	1.34 ± 0.05 e	1.40 ± 0.14 d

the germination percentage of *G. max* seedlings reduced as the effluent concentration increased. An imbalance in the osmotic connections between the seed and water could potentially be the cause, leading to a reduction in water absorption and a subsequent delay in seed germination. Perhaps the organic and inorganic compounds contained in the wastewater will prevent the germinated seeds from receiving any oxygen (Kannan 2001, Kaushik *et al.* 2005). The extra minerals and nutrients present in the effluent may also contribute to decreased seed germination at higher concentrations (Mishra *et al.* 2023). The plumule and radicle length (cm) of *G. max* declined significantly with increasing concentration of paper mill effluent in the present study (Table 2). The total seedling length also declined with an increasing percentage of effluents. High levels of dissolved solids in effluents could be enhanced the salinity and conductivity of the solute that seeds absorb prior to germination, which can hinder seed germination (Gassama 2015).

The effluent-treated seeds showed a decrease in chlorophyll content (chl a, chl b and total chl) of *G. max* when compared to control seedlings after 9 days. The lowest value of chl a, chl b and total chl were recorded at 100% concentration of effluent (Table 3). Changes in total chlorophyll concentration indicate that the crop's chlorophyll synthesis ability has decreased, influencing the entire photosynthetic process. Similar results and observations have been documented in other studies (Wang *et. al.* 2022, Garg and Kaushik 2007).

Table 3. Impact of paper mill effluents on the chlorophyll content of *Glycine max* (L.) after 9 days imbibition. Mean value with different letters in the same column differs from each other by means of ANOVA, Duncan test 0.05 level.

Treatments	Chlorophyll a (mean ± SE)	Chlorophyll b (mean ± SE)	Total chlorophyll (mean ± SE)
Control	1.011± 0.014 a	0.669±0.031 a	1.68 ± 0.071 a
25%	0.913± 0.023 b	0.581 ± 0.09 b	1.49 ± 0.054 b
50%	0.868± 0.038 c	0.225±0.029 c	1.093±0.056 c
75%	0.567± 0.003 d	0.113±0.003 d	0.680±0.003 d
100%	0.474± 0.006 e	0.032±0.004 e	0.506 ±0.010 e

CONCLUSION

In the present investigation, paper mill industrial effluent significantly influences seed germination, seedling growth and chlorophyll content of *Glycine max*. It can be concluded that acidic nature of effluent very harmful to soybean growth. Higher concentrations (100%) of wastewater may contain hazardous components for irrigation purposes as compared to the diluted percentages of the paper mill effluent, however after sufficient treatment lower concentrations of effluent can be used for agricultural irrigation.

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