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Effect of Paper Mill Effluents on Some Traditional Rice Cultivars of Assam

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ABSTRACT

The accumulation of the heavy metals which are being released by the paper mill leads to changes in the various physiological and biochemical processes in the plants. It is important to study the effect of the industrial waste on growth of rice. Four traditional rice varieties viz., 'Ranjit', 'Salpuna', 'Kolajoha' and 'Huwagmoni' and one as control viz., 'IR64' were used as seed source. The basis of this study is to observe the effect of the paper mill effluents on the growth behavior of rice and its chlorophyll content. The germination percentage increases from control to the effluent before treatment but decreases in the effluent after treatment. As a result, there may be variation in the length of the root as well as shoot. Hence the observation of the length of the root/shoot is considered as an important indicator of the presence or absence of harmful chemicals in the medium.

Key words: *Chlorophyll, Effluent, Growth behaviour, IR64, Physiochemical*.

INTRODUCTION

Industrialization plays a very important role in the developing nations. Paper industry is a notorious polluter of the environment. The paper and pulp industry expel out Fe^{2+} ions and other metallic salts impart turbidity to water. This in turn inhibits light penetration and will adversely affect the photosynthetic rate of the aquatic flora. Paper and pulp industry and synthetic detergents give rise to foams which are stable due to the presence of surfactants. These stable foams make the effluent treatment ineffective.

The Nagaon Paper mill, a public sector pulp and paper mill under Hindustan Paper Corporation Limited (HPLC) is located at Jagiroad, Morigaon District, Assam, India. The paper mill uses 675,000-960,000 m3 of process daily water in different units and discharges mostly alkaline effluents. The effluent is rich in caustic soda, sulphate, bisulphate, lignin and its derivatives, trace metals like Cr, Pb and Hg, dissolved solids and suspended solids. The high solid and low solid streams are treated in a biological oxidation pond and about 63,400 cm^3/day treated effluent is discharged into a natural water rivulet, known as Elenga beel, which flows for about 25 km to meet the tributary Kolong of the Brahmaputra river (Medhi et al. 2008).

According to some workers, it was suggested that the treated industrial effluents can be used for irrigation, contradictory to this fact, it has been found that growth, yield and soil health gets reduced when farmers used the effluents for irrigation of the cultivated land (Nandy and kaul, 1994). The accumulation of the heavy metals which are being released by the paper mill leads to changes in the various physiological and biochemical processes in the plants.

MATERIALS AND METHODS

Paper mill effluents were collected from the various sites of the Hindustan Paper Corporation Limited, Jagiroad, Assam. The waste water before treatment was collected from the clarifying inlet and the waste water after treatment was collected from the lagoon outlet. Different concentrations (25, 50 and 100 %) of both the samples were prepared by adding distilled water to set up the experiments.

A total of five certified seeds of rice seeds were collected from Regional Rainfed Lowland Rice Research Station (RRLRRS) Gerua, Assam. Four rice were traditional varieties *viz., 'Ranjit', 'Salpuna', 'Kolajoha'* and *'Huwagmoni'* and one hybrid as control *viz., 'IR64'* were used as seed source for conducting the experiment. Seeds were first kept at 37°C for overnight to break dormancy and then were used for the experiment.

Germination index (GI), shoot and root length, root and shoot weight, relative water content (Weatherly, 1950) and the total chlorophyll content were determined by 80% acetone (Kapoor and Pande, 2015). The germination index was calculated using the following formula (Li, 1996).

Shoot:root on length basis and shoot:root on dry weight basis was calculated. Seedling vigour index on length basis was calculated by multiplying the germination % with the mean seedling length (Abdul Baki and Anderson, 1973) and on dry weight basis by multiplying the germination percentage with the mean dry weight of seedlings (Ching, 1973).

Statistical analysis of the data was performed to test the significance at 5% and 1% significance levels using Analysis of Variance (ANOVA) manually. Standard error of the data was also calculated with the help of excel sheet.

RESULTS AND DISCUSSION

The effect of paper mill effluents on seed germination and seedling growth at an interval of 24 hours was recorded till 7 days of sowing in the 5 varieties of rice. Among the 5 varieties taken, *Ranjit* showed the highest GI in control conditions followed by *IR64*, then *Salpuna* and *Kolajoha*, whereas *Huwagmoni* has the lowest GI in control conditions. Now in the different concentrations of the effluent before treatment the GI is highest in 100% in the varieties except for the variety *Ranjit* where GI was found to be higher in 50% concentration.

The variety *Ranjit* has high GI in 25% concentration, whereas *Salpuna*, *Kolajoha* and *Huwagmoni* has high GI in 50% concentration, whereas *IR64* has high GI in 100% concentration. Although the GI of the rice varieties is high in the rice sown in effluent after treatment than the effluent before treatment (Table 1).

Ranjit has the highest germination percentage, followed by *IR64*, *Kolajoha*, *Salpuna and Huwagmoni*. The germination percentage is highest in the rice varieties sown in the effluent before treatment except for the variety *Ranjit*. It has a higher germination percentage in the effluent after treatment.

The germination percentage increases from control to the effluent before treatment but decreases in the effluent after treatment. But in case of the variety *Ranjit*, the germination percentage is highest in the effluent after treatment.

IR64 has the highest germination percentage among the other four varieties in the effluent before treatment, followed by *Kolajoha, Salpuna and Huwagmoni*. *Huwagmoni* has the lowest germination percentage among the five varieties whereas the variety *Ranjit* has the highest germination percentage (Table 2).

The root length is maximum in *IR64* in the effluent before treatment and *Huwagmoni* has the lowest root growth in the effluent after treatment. Root emergence was minimum in case of *Huwagmoni* whereas it was maximum in case of *IR64.* In case of the variety *Ranjit*, the emergence of root was maximum in the effluent after treatment, followed by the rice grown in the effluent before treatment and it was minimum in the control. *Salpuna* showed the maximum root growth in control, followed by the effluent before treatment and the minimum root growth was seen in the effluent after treatment. *Kolajoha* has the maximum root growth in control followed by the effluent before treatment and then the effluent after treatment. *IR64* has the maximum root growth in the effluent before treatment followed by the effluent after treatment and the minimum in control. *Huwagmoni* has the maximum root growth in the effluent before treatment, followed by control and the minimum in the effluent after treatment (Table 3).

The growth of shoot was observed maximum in control conditions in all the varieties except *IR64* and *Huwagmoni*. The variety *Ranjit*, *Salpuna* and *Kolajoha* had maximum shoot growth in control conditions, followed by the effluent before treatment and the minimum shoot growth was seen in the effluent after treatment. In case of *IR64* and *Huwagmoni* the maximum shoot growth was seen in the effluent before treatment, followed by control conditions and the minimum shoot growth was seen in the effluent after treatment (Table 4, 7).

The shoot root ratio (length wise) was maximum in the control in the rice varieties except for *Salpuna* and *Huwagmoni.* In case of the variety *Ranjit*, *Kolajoha* and *IR64* the shoot root ratio was maximum in control. In case of *Salpuna* and *Huwagmoni* the shoot root ratio (length basis) was maximum in the grains grown in the effluent after treatment. Then it was followed by the control and the effluent before treatment in case of *Huwagmoni*, *Salpuna* the control and the grains grown in the effluent before treatment were same (Table 5).

In the case of the variety *Ranjit,* the shoot root ratio (dry weight) was maximum in the grains grown in the effluent before treatment, whereas the minimum was in the grains grown in the control. In *Salpuna,* the shoot root ratio (dry weight) was maximum in control. In *Kolajoha,* the shoot root ratio (dry weight) was maximum in control, and was minimum in the grains grown in the effluent before treatment, the ratio rises in the effluent after treatment. In *IR64,* the ratio was maximum in control, and was minimum in the grains grown in the effluent after treatment. In *Huwagmoni*, the ratio was maximum in control and was minimum in the effluent before treatment and the ratio rises in the grains grown in the effluent after treatment (Table 6).

The fresh weight is minimum in the grains grown in the effluents after treatment in all the rice varieties *i.e., Salpuna, Kolajoha, IR 64* and *Huwagmoni* except for the variety *Ranjit.* The fresh weight in control conditions was maximum only in case of *Huwagmoni*, whereas in case of *Salpuna, Kolajoha* and *IR64* the fresh weight was lower than the fresh weight of the grains grown in the effluent before treatment. However, in case of *Ranjit,* the fresh weight was constant in case of control and the effluent before treatment and was slightly higher in case of the grains grown in the effluent after treatment (Table 7).

In case of *Ranjit*, the dry weight of shoot is maximum in the effluent after treatment (0.00546 gm) and is minimum in the control. The dry weight of the shoot was maximum in control in case of *Salpuna*, *Kolajoha* and *Huwagmoni* and was minimum in case of the effluent after treatment in *Salpuna, Kolajoha, IR64* and Huwagmoni. In case of *IR 64* the dry weight is maximum in the effluent before treatment (Table 8).

In case of *Ranjit*, RWC is maximum in control whereas in the effluent before treatment it was 90.97 % and in the effluent after treatment it was 92.73 %. Now, in case of *Salpuna*, *Kolajoha*, *IR 64* and *Huwagmoni*. RWC was minimum in the control. In case of *Kolajoha* and *IR64* RWC was maximum in the grains grown in the effluent before treatment. In case of *Salpuna* and *Huwagmoni*, there was a gradual increase in the RWC from control to the effluent before and after treatment (Table 9).

The seedling vigour index (length basis) was seen maximum in case of *IR64* in the effluent before treatment and it was minimum in *Huwagmoni* in the effluent after treatment. In case of *Ranjit,* there was a gradual increase in the seeding vigour index from control to the effluent before treatment and was highest in the effluent after treatment. In case of *Salpuna*, there was a gradual decrease in the seedling vigour index from control to the effluent before treatment and was minimum in the effluent after treatment. In case of *Kolajoha,* the seedling vigour is maximum in the effluent before treatment and was minimum in the effluent after treatment. In *IR64*, it was maximum in the effluent before treatment then in control and was lowest in the effluent after treatment. In *Huwagmoni*, the seedling vigour index was maximum in control, And it gradually decrease in the effluent before treatment and was minimum in the effluent after treatment (Table 10).

In case of *Ranjit*, seedling vigour index (dry weight basis) was maximum in the effluent after treatment followed by the effluent before treatment and was minimum in case of control. In *Salpuna*, it was highest in case of control, and then it was in the effluent before treatment and was lowest in the effluent after treatment. In *Kolajoha*, it was maximum in the effluent before treatment, then in control and was minimum in the effluent after treatment. In *IR64*, it is highest in the effluent before treatment, followed by control and is lowest in the effluent after treatment. In *Huwagmoni*, it was maximum in the effluent before treatment then in control and was minimum in the effluent after treatment (Table 11).

The chlorophyll *'a'* content is maximum in the control in all the five varieties of rice, and then it was a bit low in the grains grown in the effluent before treatment and was minimum in the grains grown in the effluent after treatment (Table 12). Chlorophyll *'b'* content is maximum in the control as compared to other treatments in all the rice varieties except *Salpuna*. It is minimum in *Salpuna, Ranjit, Kolajoha* and *IR 64*. In *Huwagmoni* it is minimum in the effluent before treatment (Table 13).

The total chlorophyll content was maximum in control in all the rice varieties. Then there was a decrease in the total chlorophyll content in the grains grown in the effluent before treatment and it was least in the grains grown in the effluent after treatment. In control the maximum amount of chlorophyll is attained by *Ranjit a*nd the minimum was attained by *Kolajoha* (Table 14).

CONCLUSION

This experimental work was conducted to investigate the effect of the Hindustan paper mill effluents on the germination and growth of five different varieties of rice *(Oryza sativa* L.*)* out of which some are traditionally cultivated and one is hybrid. The GI in case of the seeds treated with the waste water before treatment increases from 25% to 100% concentration and in case of the seeds treated with waste water after treatment it increases up to 50% and then lowers. The germination percentage is maximum in case of the seeds treated with waste water before treatment and is low in case of the seeds treated with waste water after treatment. A delay in the speed of germination was observed in the seeds treated with waste water after treatment in all the five varieties of rice. The seedling root length was higher in case of the seeds treated with the waste before treatment and is comparatively lower in the seedlings grown in the waste water after treatment. The seedling shoot length was maximum in control conditions than it was higher in the seeds treated with the waste water before treatment than in the waste water after treatment. Shoot:root on length basis showed varied effect on the plants; it was high in case of *Ranjit, Kolajoha, IR64* in the waste water before treatment conditions. But it was seen that it was high in the waste water after treatment in case of *Salpuna* and *Huwagmoni.* Shoot:root on dry weight basis also showed a varied effect on the plants, it was high in the waste water before treatment in case of *Ranjit , IR64, Salpuna* but in case of *Kolajoha* and *Huwagmon*i it was high in case of waste water after treatment. The fresh weight of the shoot was high In case of the grains grown in the waste water before treatment and was comparatively lower in case of the seeds sown in the waste water after treatment. The dry weight of the shoot was more in case of the seeds grown in the waste water before treatment and was lower in case of the seeds grown in the waste water after treatment. The relative water content of the seeds of the variety *Kolajoha, IR64* was high in case of the waste water before treatment and in case of *Ranjit*, *Salpuna*, and *Huwagmoni* it was high in the waste water after treatment. In case of the grains of *Ranjit* the seedling vigour index was high in the waste water after treatment and in case of the other varieties *viz, Salpuna, Kolajoha, Huwagmon*i and *IR 64* it was high in the waste water before treatment. The seeds of *Ranjit* grown in the waste water after treatment showed higher seedling vigour index and the seeds of the other varieties showed higher seedling vigour in case of the seeds grown in the waste water before treatment. Photosynthetic pigments *viz*. total chlorophyll; chlorophyll 'a' and chlorophyll 'b' showed higher content in case of the seeds grown in the waste water before treatment and comparatively lower content in case of seeds grown in the waste water after treatment. Increased pigment may be due to increased uptake of nutrients that influence the chlorophyll synthesis. The reduction in the pigment content may be due to the presence of inhibitory effect of toxicants in the effluent or due to the chemicals used to treat the waste water.

Thus from this experimental investigation on the traditionally cultivated plants and the hybrid varieties of economically important crop i.e. rice (*Oryza sativa*) varieties - *Ranjit , Salpuna, Huwagmoni, IR64* and *Kolajoha*, it could be concluded that the waste water released by the mill after treatment has an significant effect in inhibiting the growth of the plant. Whereas the use of the waste water before treatment in a certain concentration is useful in promoting germination and the seedling growth.

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Table 1. Germination index of the rice cultivars used in different concentration of waste water

Rice varieties	**Waste water before treatment**				**Waste water after treatment**		
	Control	25%	50%	100%	25%	50%	100%
Ranjit	4.27±0.45	5.11±0.24	5.22±0.45	5.01±0.12	6.13±1.12	5.38±0.42	5.50±0.03
Salpuna	2.90±0.58	2.54±0.21	2.63±1.04	2.76±0.09	2.45±0.48	2.80±0.43	2.60±0.14
Kolajoha	2.50±0.65	1.49±0.45	2.03±0.82	2.57±0.14	2.05±0.16	2.60±0.28	2.44±0.68
IR64	3.65±0.11	3.29±0.46	3.61±0.19	4.43±0.84	2.73±0.51	2.28±0.28	2.98±0.15
Huwagmoni	0.3±0.14	0.17±0.04	0.41±0.18	0.88±0.36	0.27±0.09	1.11±0.24	0.38±0.05

Table 2 Germination percentage

Treatment Variety	Control	Waste water before treatment	Waste water after treatment
Ranjit	64±5.66	82±2.82	84±1.84
Salpuna	56±11.31	56±1.65	50±2.82
Kolajoha	56±16.97	60±5.65	52±16.97
IR 64	66±8.48	70±8.45	50±2.82
Huwagmoni	6±2.82	20±5.65	10±2.82

Table 3. Root length of treated rice seedlings (cm)

Variety treatment	*Ranjit*	*Salpuna*	*Kolajoha*	*IR 64*	*Huwagmoni*
Control	7.1±2.29	11.46±2.70	6.56±2.53	8.73±1.43	10.6±3.21
Waste water before treatment	8.5±3.06	10.8±5.05	6.43±0.66	16.56±0.55	10.9±3.40
Waste water after treatment	11±0.96	7.56±3.50	5.8±1.32	11.4±3.35	4.33±0.57

Table 4. Shoot length of treated rice seedlings (cm)

Variety Treatment	*Ranjit*	*Salpuna*	*Kolajoha*	*IR 64*	*Huwagmoni*
Control	10.9±2.07	8.13±0.55	7.8±1.15	8.53±3.96	7.26±1.96
Waste water before treatment	8.23±1.24	7.6±2.55	7±0.5	10.13±0.47	7.3±1.58
Waste water after treatment	6.03±0.73	5.8±1.27	6.1±1.15	6.93±1.60	6.23±2.91

Table 5. Shoot root ratio (length basis)

Variety treatment	*Ranjit*	*Salpuna*	*Kolajoha*	*IR 64*	*Huwagmoni*
Control	1.53	0.70	1.18	0.97	0.68
Waste water before treatment	0.96	0.70	1.08	0.61	0.66
Waste water after treatment	0.54	0.76	1.05	0.60	1.43

Table 6 Shoot root ratio (dry weight)

Variety treatment	*Ranjit*	*Salpuna*	*Kolajoha*	*IR 64*	*Huwagmoni*
Control	2.33	4.44	3.35	1.72	5.65
Waste water before treatment	3.32	1.55	1.66	1.67	1.14
Waste water after treatment	2.87	1.08	2.55	1.66	1.46

Table 7. Fresh weight of shoot (in gm)

Variety **treatment**	***Ranjit***	***Salpuna***	***Kolajoha***	***IR64***	***Huwagmoni***
Control	0.03172	0.02566	0.0182	0.0273	0.0273
Waste water before treatment	0.03172	0.02862	0.02014	0.0313	0.02122
Waste water after treatment	0.03174	0.01522	0.0178	0.01838	0.01367

Table 8. Dry weight of shoot (gm)

Variety treatment	***Ranjit***	***Salpuna***	***Kolajoha***	***IR 64***	***Huwagmoni***
Control	0.00504	0.01412	0.00436	0.00468	0.0147
Waste water before treatment	0.00512	0.00524	0.00352	0.0056	0.00334
Waste water after treatment	0.00546	0.0026	0.00342	0.00352	0.00176

Table 9 Relative water content (RWC) %

Variety treatment	***Ranjit***	***Salpuna***	***Kolajoha***	***IR 64***	***Huwagmoni***
Control	94.60	65.79	68.65	65.26	57.32
Waste water before treatment	90.97	74.88	78.99	83.87	60.12
Waste water after treatment	92.73	76.67	73.81	82.09	65.87

Table 10. Seedling vigour index (length basis)

Variety Treatment	***Ranjit***	***Salpuna***	***Kolajoha***	***IR 64***	***Huwagmoni***
Control	1152	1097.04	804.16	1139.16	1071.6
Waste water before treatment	1371	1030	805.8	1868.3	364
Waste water after treatment	1430	668	618.8	916.5	105.6

Table 11. Seedling vigour index (dry weight basis)

Variety treatment	***Ranjit***	***Salpuna***	***Kolajoha***	***IR 64***	***Huwagmoni***
Control	0.460	0.968	0.316	0.4884	0.103
Waste water before treatment	0.546	0.482	0.338	0.6258	0.1252
Waste water after treatment	0.618	0.250	0.247	0.282	0.0296

Table 12. Chlorophyll *'a'* content

Variety treatment	***Ranjit***	***Salpuna***	***Kolajoha***	***IR 64***	***Huwagmoni***
Control	14.47	6.04	4.48	8.71	8.18
Waste water before treatment	10.56	5.225	3.53	5.97	3.98
Waste water after treatment	2.55	0.67	0.72	2.55	2.05

Table 13. Chlorophyll *'b'* content

Variety treatment	***Ranjit***	***Salpuna***	***Kolajoha***	***IR64***	***Huwagmoni***
Control	3.22	2.105	1.52	1.96	1.73
Waste water before treatment	2.225	2.43	0.79	1.1	0.84
Waste water after treatment	0.875	0.36	0.19	1.37	1.045

Table 14. Total chlorophyll content

Variety treatment	***Ranjit***	***Salpuna***	***Kolajoha***	***IR 64***	***Huwagmoni***
Control	16.7± 4.10	8.14±2.82	6.01±0.90	10.67±1.61	9.91±1.47
Waste water before treatment	12.78±1.52	7.65±1.70	4.33±1.99	7.07±0.03	4.82±0.27
Waste water after treatment	3.42±1.32	1.03±0.127	0.91±0.183	3.92±0.007	3.1 ±1.4