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Impact of amlai paper mill effluent on growth and development of certain agricultural crops

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Abstract
The physico-chemical characteristics of Amlai paper mill industry effluent were measured and some were found to be above the permissible limits prescribed by Indian irrigation water standard. A study was conducted in pots to investigate the effects of different concentrations (10, 20, 30, 40, 50, 60, 70, 80 and 100%) of paper mill effluent on growth and production of rice, mustard and pea for three years. The study reveals that the paper mill effluent has deleterious effect on the growth of crop at higher concentrations. However, at lower concentration (viz. 10 to 40% in rice, 10 to 50% in mustard and 10 to 60% in pea) of effluent, beneficial impact on general welfare of the crops was noticed. Growth and development was increased with increasing the concentration of the effluent up to 30% in rice, 40% in mustard and 50% in pea. Investigation showed that the growth and production of rice, mustard and pea was found maximum at a concentration of 30, 40 and 50% effluent respectively.

Keywords: toxicity, paper mill effluent, crop, growth, soil

1. Introduction

Now-a-days, treated wastewater is considered as a potential water resource because it contains considerable amount of nutrients, which may prove beneficial for plants growth (Sahai *et al.*, 1985 [21] and Mishra and Behera, 1991) [12] and hence the use of wastewater in agriculture is gaining importance rapidly. Generally, the quality of discharged effluent differs from industry to industry, which may or may not be suitable for the irrigation of crop. So, the effluent should be assessed properly prior to its application for irrigation. However, indiscriminate use of industrial effluent may reduce crop growth and contaminants may interfere with natural characteristics of soil.

The paper industry is one of the largest industries in India, consuming large amount of water (Trivedy and Raj, 1992) [23]. Nearly 75 to 95% of the water was discharged by the industries as effluent containing organic, inorganic pollutants and colouring materials. Presence of these chemicals may affect soil and in turn the growth and development of plants (Baruah *et al.*, 1996) [2]. Studies on the effect of paper mill effluent on various crops have been carried out by various investigators (Choudhury *et al.*, 1987; Mishra and Behera, 1991 [12]; Dutta and Boissya, 1996,1999, 2000) [5-7]. Baruah and Das (1997) [3] reported that there is delay, retard and decline of germination of rice seeds and seedling growth with paper mill effluent treatment in comparison to control. Rajannan and Oblismai (1979) [20] reported that paper mill effluent had drastically affected the germination of rice, black gram and tomato seeds, however, the diluted form of effluent (25 and 50%) enhance the growth. Karande and Ghanvat (1994) [9] observed that dilute effluent show negligible effect on the overall growth characteristic in pigeon pea seedling treated with paper mill effluent. Mishra *et al.* (1989, 1991) [13-14] conducted the study of physiotoxicity of the paper mill effluents on *Elusine coracana* and *Oryza sativa* crops. Further, Mishra and Behera (1991) [12] studied the same effect on rice seedlings. Narwal *et al.* (2005) [16] reported that paper mill effluent increased sodium and potassium contents and disturbed the anionic-cationic balance in plants, thereby reducing the yield and quality of crops. Literature survey indicated that diluted form of paper mill effluent could be used for irrigation purpose to enhance production of agricultural crops (Rajannan and Oblisami, 1979 [20]; Baruah and Das, 1997 [3], Medhi, *et al.* 2011 [25] and Bano, 2016) [26]. The concentration of dilution is varied depending upon the crops. On the other hand, after application of paper mill effluent in different concentrations, the physico-chemical properties of the soil may be changed or it may be toxic to the plants. So, before going to apply the effluent in the agricultural field, the physicochemical characteristics of the effluent have to be characterised. The present study was carried out with an objective to analyse the physico-chemical properties of the effluent from the paper mill industry and to study further impact of paper mill effluent on certain crops like rice, mustard and pea.

2. Material and Methods

Approximately, 1000 lit of the effluent was collected in clean plastic container at the point of disposal outlet from Amlai Paper Mill, district Anuppur India. Immediately after collection, the effluent was bought to the laboratory with proper storage for analysis of physicochemical parameters. The soil samples, which were used for the experiment, was collected from agricultural fields situated at Pushprajgarh district Anuppur, India and brought to the laboratory. It was then spread out thinly on a floor for drying. The big lumps of the collected soil sample were dried followed by removal of plant roots, pebbles and other undesirable matter.

The physico-chemical properties of the effluent namely pH, Electrical conductivity, Dissolve oxygen (DO), Biochemical oxygen demand (BOD), Chemical oxygen demand (COD), Total solids (TS), Total dissolve solids (TDS), Total suspended solids (TSS), Total hardness (TH), Sodium, Potassium, Calcium, Magnesium, Chloride and Sulphate were analyzed by standard methods described by APHA (1985) [1]. Heavy metals of effluent were measured by Atomic Absorption Spectrophotometer (Simadzu AA - 680). For that, 5 ml of effluent was digested in Microwave digester (Milstone

Ethos - 900) by using 2 ml hydrofluoric acid (48%) and 3 ml hydrogen peroxide (30%) for 5 min.

In order to study the impact of paper mill effluent on growth and development of crop, an experiment was carried out at green house of the institute. For the experiment, 3 kg of previously collected soil were taken in earthen pots. The effluent of paper mill was considered as 100% concentration. From this 100% concentration of effluent, 10, 20, 30, 40, 50, 60, 70 and 80% level of effluent concentrations were prepared by using tap water. The pots were irrigated with effluent of above concentrations separately. Three replications were maintained for each treatment.

The soil of the effluent treated pots was kept in submerging condition for a week. After one week submerging and equilibration, pots allocated for rice sapling were prepared for rice cultivation. For the experiment, one month old rice saplings of *Oryza sativa* L. Masuri (variety Aijong), which was procured from local farmers of Anuppur (M.P.), India, was planted in a bunch of four saplings in each pot. The levels of different concentration of effluents in the pots of rice crop were continuously maintained at 5-8 cm above the soil surface throughout the growing season. Before one week of harvest, irrigation was discontinued.

In the rest of the pots, when soil moisture content was closed to field capacity, 10 numbers of certified seed of mustard (*Brassica napus* L. variety C.V.M.-27) and pea (*Pisum sativum* L. variety Rashna. 30) were shown separately in the pots having different concentration of effluent. After germination, the seedlings were reduced to two per pot and grown to full maturity. Thus for three replications, a total of six plants of each crop were maintained for each treatment. Pots of pea and mustard were irrigated with respective concentration of effluent according to requirement. One set of experiment for each crop was prepared without effluent where tap water was used to compare the data with effluent treatment pots, which was marked as control. All the experiments were carried out for three years.

The statistical analysis was carried out by using SPSS software (Version 6.0). One-way analysis of variance (ANOVA) was done at 0.05 levels to find out the significant difference between different percentages of effluent and different parameters of growth and development of the crops.

3. Results and Discussion

The physicochemical characteristics of paper mill effluent are presented in the Table 1. Results revealed that effluent is dark brown in colour and it is alkaline in nature having pH of 8.2. The value of electrical conductivity, suspended solids, total dissolved solids, biological oxygen demand and chemical oxygen demand and some other parameters present in the treated effluent is very high in comparisons to ISI prescribed limit (IS:2296 1982) [8] despite the industry had installed adequate effluent treatment system to treat the raw effluent.

It was revealed from the data of three years (Fig. 1) that the plant height, panicles number, seed number and seed weight of rice showed an increasing trend up to 30% concentration of effluent applied soil and thereafter, it was gradually decreased. However, up to 40% concentration of effluent applied soil, the general welfare as well as production of rice was found higher than control soil (without effluent). Best result was observed in the soil treated with 30% concentration of effluent. Plant height, panicles number, seed number and seed weight of rice and the different concentrations of effluent are negatively correlated. The plant height, panicles number, seed number and seed weight of mustard showed an increasing trend up to 40% concentration of effluent applied soil and thereafter, it was gradually decreased. However, up to 50% concentration of effluent applied soil, the general welfare as well as production of mustard was found higher than control soil (without effluent). Best result was observed in the soil treated with 40% concentration of effluent. Plant height, panicles number, seed number and seed weight of mustard and the different concentrations of effluent are negatively correlated.

The plant height, panicles number, seed number and seed weight of pea showed an increasing trend up to 50% concentration of effluent applied soil and thereafter, it was gradually decreased. However, up to 60% concentration of effluent applied soil, the general welfare as well as production of pea was found higher than control soil (without effluent). Best result was observed in the soil treated with 50% concentration of effluent. Plant height, panicles number, seed number and seed weight of pea and the different concentrations of effluent are negatively correlated.

It was revealed from the results that among various levels of irrigation with treated effluent only lower concentrations proved beneficial and it had significant effect on growth and development of rice, mustard and pea than control soil where only water (without application of effluent) was used for irrigation. But all the growth parameters of rice, mustard and pea were reduced significantly with the increasing concentrations of effluent. The treated paper mill effluent was sufficient to satisfy all the growth parameters significantly at 30% for rice, 40% for mustard and 50% for pea. The effect of inhibition was not uniform as the rate of inhibition was varied from crop to crop.

Many workers have also reported beneficial effect of paper mill effluent on rice (Dutta and Boissya, 2000) [7], green gram (Malla and Mohanty 2005) [11], maize (Choudhary *et al.*, 1987) [4], lentil (Raina and Aggarwal, 2003) [19] and Black gram (Bano, 2016) [26].

Table 1: Physico-chemical parameters of paper mill effluent

S. No.	Parameters	Permissible limits (IS)	Value
1.	Colour	-	Light brown
2.	pH	-	8.1
3.	EC($\mu S / cm^{-1}$)	300.00	4.26
4.	TSS	200.0	430.4
5.	TDS	1000.0	1370.2
6.	TS	1200.0	1802.0
7.	DO	>6.0	1.26
8.	BOD	100.0	77.8

9.	COD	350.0	646.2
10.	Hardness	600.0	462.4
11.	Calcium	200.0	174.2
12.	Magnesium	100.0	69.4
13.	Chloride	600.0	497.8
14.	Alkalinity	200.0	360.6
15.	Potassium	-	11.8
16.	Sodium	-	88.5
17.	Phosphate	10.0	1.4
18.	Sulphate	400.0	444.6
19.	Pb	0.1	0.66
20.	Zn	5.0	0.094
21.	Ni	2.0	0.0.83
22.	Cu	3.0	1.14
23.	Mn	-	0.144
24.	SAR	-	8.35

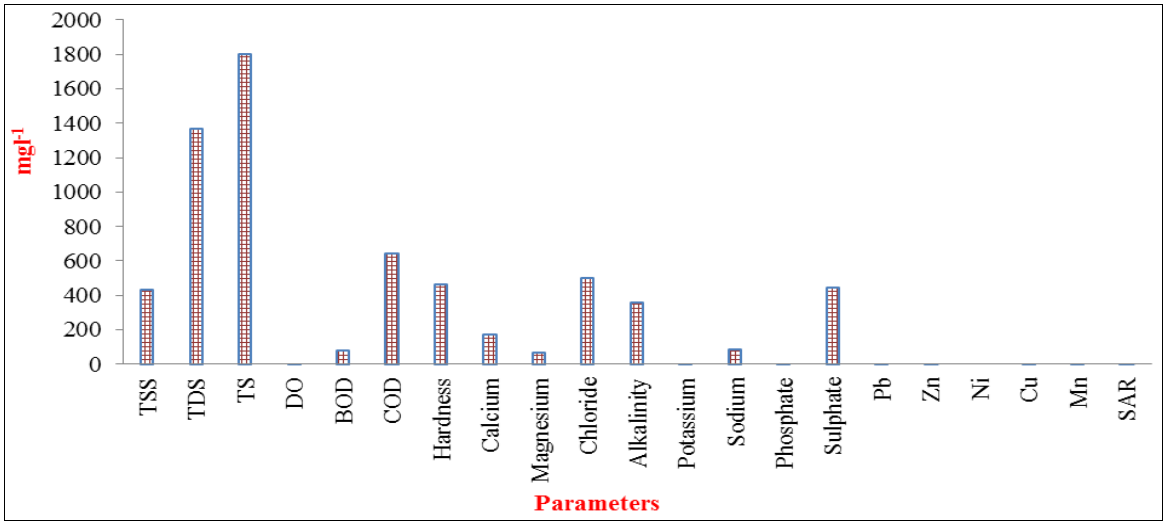

Fig 1: Graphics analysis of Physico-chemical parameters of paper mill effiuent

Height, number of pods/panicles per plant, number of seeds, and weight of seeds of mustard, pea and rice in the present study were increased when irrigated with diluted paper mill effluent. The same result was observed by Mishra and Sahoo (1989) [15]; Dutta and Bossiya (1996) [5]. The presence of nutrients like, nitrogen, potassium, phosphorous, calcium, sulphate and magnesium in the diluted effluents, which are at optimum level, may promote the growth through enhanced cell division, expansion and differentiation. These findings were similar with earlier reports (Rajannan and Oblisami, 1979 [20]; Kumar *et al.*, 2003 [10], Singh and Tripathi, *et al.* 2013) [24]. However, in the undiluted effluent concentration, nutrients are increased so as to become toxic resulting in retardation of growth and development of plants by affecting different metabolic processes in the plants (Subramani *et al.*, 1995) [22].

Total dissolved solids (more than 1000 mg l-1) are not permissible for irrigation as per Indian Standard,1982 [8]. However, total dissolved solids in the effluent of the paper mill were found 1370 mg l-1, which caused high osmotic pressure of soil solution. It might be major cause for rapid deterioration of soil properties like irregulate the flow dynamics of salt, storage and distribution of nutrients and water uptake by plant roots. Chemical contaminant including higher amount of salts and high concentration of sodium in the effluent may increase the salinity and exchangeable sodium percentage (ESP) of the soil to the harmful level of phytoxicity. There is possibility of saline soil turning into sodic (alkaline) soil under higher concentrations of effluent. The soil productivity is decreased due to the reduced nutrient availability and poor plant growth (Prashanthi *et al.*, 2001) [17]. When concentrations of effluent increased, suspended solids also interfere with physical condition of soil. High amount of suspended solids have a tendency to clog sprinkler nozzles and soil pores leading to anaerobic condition in root zone (Raghuveer, 1994) [18]. The aerobic conditions necessary for soil microbial processes are inhibited, which might have an adverse effect on quality of soil as well as crop growth.

The present study showed that paper mill effluent had an adverse effect on growth and development of rice, mustard and pea crops at higher concentration, but in lower concentration there is no toxic effect on general welfare of the crops, rather it has some beneficial effect on the growth and development of the crops in certain concentration of effluent. The beneficial effects of effluent on the crops are varied depending upon the crops. In our present investigation, beneficial impact on general welfare of the crops was gradually increased with increasing the concentration of the effluent up to 30 in rice, 40 in mustard and 50% in pea. It can be recommended from the study that appropriate dilution of the effluent of paper mill could be used for irrigation in agricultural field to enhance the productivity of crops.

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