Asian Journal of Water, Environment and Pollution, Vol. 5, No. 4, pp. 119-122.

Short Note

Appraisal and Impact of Paper Mill Effluent on Crop Growth and Soil Properties

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Received June 1, 2006; revised and accepted July 22, 2007

Abstract: With growing competition for water in different sectors, utilization of effluent water in agriculture is imperative. Paper mill effluent could be used in this sector as the effluents were found to be neutral, low saline and contained Na, Ca, Mg, Fe, F^-, B, Cl^-, SO_4^{2-}, NO_3^-, CO_3^{2-} and HCO_3^- ions at low to moderate concentrations. Irrigation by Emami paper mill effluent at different dilutions with fresh water had improved crops' yield attributes. No adverse impact on crop nutrients' uptake or soil properties was noticed. These depict that >60 to ≤ 80% dilutions of (Emami) paper mill effluent with fresh water is optimal for proper growth of blackgram and maize, >20% for greengram and ≤ 60% for rice and sunflower grown on acidic laterite soil in pots. Thus the study reveals that paper mill effluent holds promise for use in irrigation if diluted to levels within the acceptable limit of crops.

Key words*:* Paper mill effluent, irrigation, crops' yield attributes, nutrients' uptake, soil properties.

Introduction

To cope with continuing demand for water and rapid erosion of fresh water reserve, increasing use of non-conventional water resources in agriculture is an impending reality. Effluent of agro-based paper mill is in general rich in organic matter, contains different amount of suspended solids, alkali and alkaline earth metals, chloride and sulfate (Yong et al., 1992). It has been used for irrigating crops and trees in many locations across the country (Rajannan and Obliasami, 1979; Dutta and Boissya, 1999; Chhonkar et al., 2000). NEERI (1979) had also suggested its use for irrigation while harmful impact of paper mill effluent application on soil and crop was also reported (Srivastava and Yeole, 2002; Udayasoorian et al., 2002). For using effluent in irrigation, development of appropriate soil-crop-water management plan is thus essential to protect soil health and secure environmental quality. Appraisal of paper mill effluent and possibility of its use for irrigation was investigated in this study.

Methods

Paper mill effluent was periodically collected from three different paper mills located in Orissa, analysed for relevant parameters and displayed in Table 1.

Pot experiments were conducted applying (Emami paper mill) effluent at 100, 80, 40, 20 and 0% dilutions with fresh water, under net-house conditions. These were applied to maintain 60% field capacity moisture (0.254 cm^3/cm^3) of soil in maize, greengram, blackgram, and sunflower while ≅ 5±1 cm water level was maintained in rice after transplanting, throughout the growing period. Greengram and blackgram; sunflower and maize were harvested after 89, 110, 118 days of sowing in that order while after 123 days of transplanting in rice. Plant nutrients concentrations and relevant soil properties were analyzed at harvest.

Results and Discussion

The chemical characteristics of paper mill effluent vary depending upon quality of raw materials used and

Table 1: Important characteristics of paper mill effluents

Parameters	*Effluents of different paper mills in Orissa*		
	Jagatpur	*Choudar*	*Emami*
pH	7.22	7.33	7.21
EC dS/m	0.34	0.60	1.79
Na meq/l	0.43	1.94	1.15
K meq/l	0.11	0.46	0.31
Ca meq/l	2.00	2.00	22.56
Mg meq/l	0.50	0.50	5.13
Cl^- meq/l	1.00	2.50	5.85
CO_3^{2-} meq/l	Trace	Trace	11.71
HCO_3^- meq/l	Trace	Trace	23.43
SO_4^{2-} meq/l	0.63	-	0.04
NO_3^- meq/l	10.96	6.15	4.62
F^- meq/l	-	-	3.25
B mg/l	-	-	0.68
Fe mg/l	-	-	0.64
Dissolved organic matter (mg/l)	100.00	1.00	50.00
Total dissolved solids (mg/l)	204.00	328.00	276.00
Sodium adsorption ratio (SAR) $[meq/l]^{1/2}$	0.38	1.71	0.04
Adjusted SAR (SAR_{adj})			0.15
adj R_{Na}			1.97

Note: Cd, Cr, Hg and Pb concentrations were below detectable limits

processing techniques followed by different mills. However comparison of effluents' parameters especially pH, EC, SAR, adj SAR, and adj R_{Na} with corresponding irrigation water quality standards proposed by different workers (Ayars and Westcot, 1985; Das, 1998), these were primarily found suitable for use in irrigation. Low Mg/Ca ratio (<1.0) also enhanced the possibility of supplying Ca required for healthy growth of plant root. Besides low presence of NO_3^- and F^- ions and non-detectable level of Cd, Cr, Pb and Hg further ensured its safe use for irrigation.

Crops' Yield Attributes and Nutrients' Concentration

Application of effluent at various concentrations invariably improved crops' yield, which was on par at 20, 40, 80 with 100% in Greengram seed and at 40, 80 with 100% in blackgram pod. In maize, tasselling appearance interval was substantially delayed by 11 to 24 days from 20 to 0% dilutions over fresh water (100%) treatment. The cob-length and weight were, however, augmented by 2.55–3.06, and 5–10.32 times respectively under diluted effluent over no dilution (0%) treatment. The cob yield at 80 and 100%, cob-length and stalk yield at 40, 80 and 100% were on par. In rice, plant height (at maximum tillering stage) was improved gradually (42 to 68%) with per cent dilution of effluent, produced no difference between 40 and 80% and get highest under 100%. Root volume and weight were also improved to the tune of 1.67 to 3.91 and 1.42 to 1.68 times due to dilution of effluent over 0% respectively. The grain yield differences between 40 and 80, and 80 and 100% were non-significant. The sunflower head weight was highest at 100%. Head diameter at 80 and 100%; seed number at 80 and 100%, and seed weight at 40, 80 and 100% were on par. These clearly reflect that after dilution the paper mill effluent could be used for irrigation and the level of dilution suitable for crop depends on type and genetic make up of crop. It ranged between 80 and 60% for proper growth of blackgram and maize, and 60 and 20% for greengram, rice and sunflower (Table 2).

Data pertaining to nutrients concentrations in Figure1 depict an increasing trend by 17–49, 24–90, and 52–112% N; 6.4–32, 14–30, and 2–16% K and 5.22–82, 0.6–50 and 15–80% Mg in rice, greengram and blackgram respectively. It was 17–96% N, and 27–44% K, in maize and 6–14% Mg in sunflower. A successive increase of P and Ca by 75–117% and 9–117% was prevalent in rice, and 1.2–20 and 18–137% in maize from 100 to 0% dilutions.

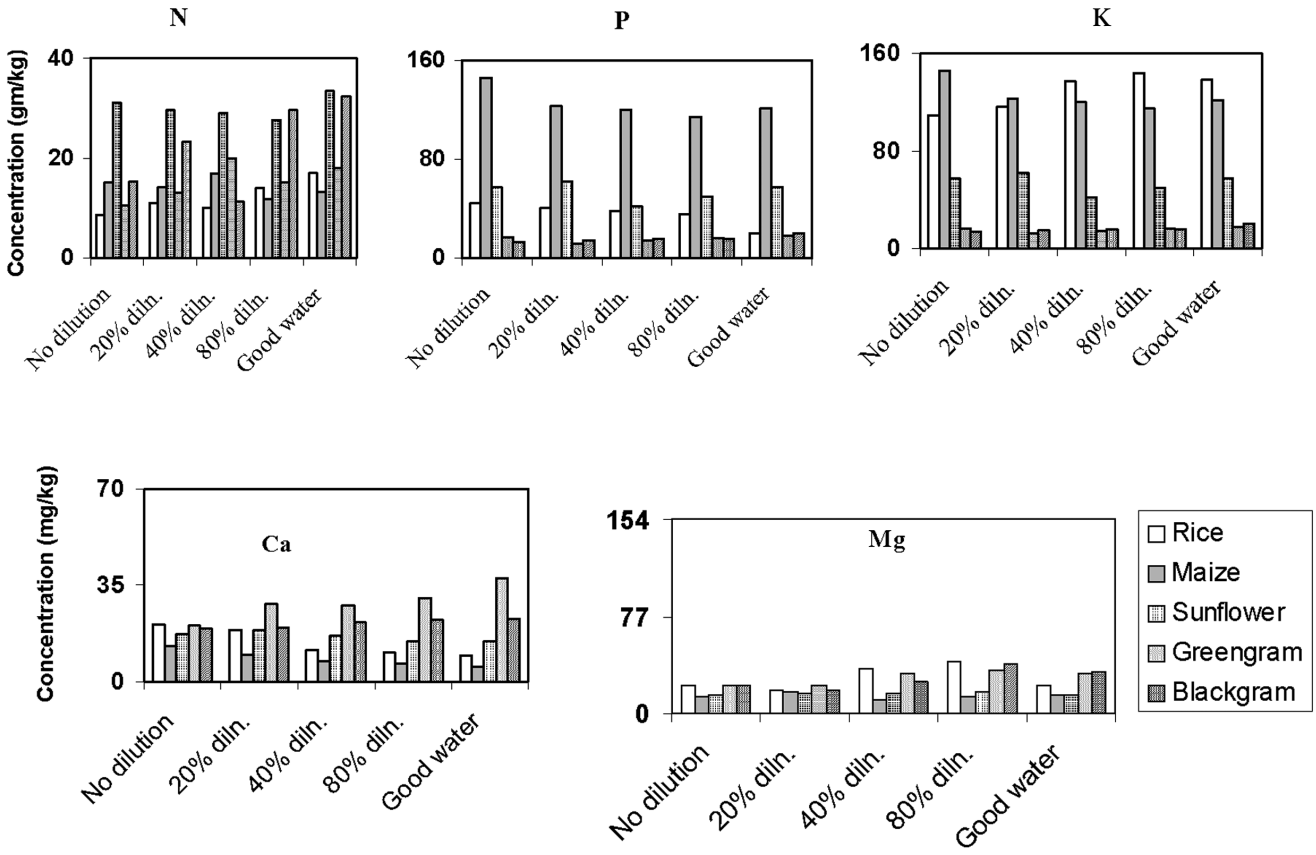

Figure 1: Application of paper mill effluent on nutrients' concentration in crops.

Table 2: Influence of Emami Paper Mill effluent treatments on yield response of crops

Treatments, Dilution levels of effluent	*Crop yield attributes (weight in gm/plant)*											
	Greengram		*Blackgram*		*Maize*			*Sunflower*		*Rice*		
	Seed	*Total biomass*	*Pod*	*Haulm*	*Cob*	*Cob length (cm)*	*Stalk*	*Seed*	*Head*	*Plant height (cm)*	*Root*	*Grain/ panicle*
0%	0.30	0.07	0.06	0.38	5.32	4.25	43.98	0.91	4.06	71.66	9.10	12.37
20%	0.50	1.03	0.33	0.59	26.6	10.85	50.77	0.91	4.34	75.00	11.52	64.65
40%	0.70	1.16	0.49	0.75	31.2	11.27	64.36	1.46	5.45	85.66	19.16	77.55
80%	0.80	1.63	0.63	0.70	50.77	12.27	65.01	1.89	4.55	90.33	21.48	90.15
100%	1.10	1.85	0.72	1.34	54.91	13.00	70.31	2.26	8.78	91.00	28.30	102.15
LSD (P.05)	2.68	0.80	0.35	1.23	6.63	1.64	8.82	0.45	2.30	10.27	10.03	15.53

Influence on Soil Properties

Soil was initially acidic (pH 5.33), had EC_2, 1.32 dS/m; organic carbon, 0.6%; P, 0.13 mg/kg; and 375.95, 1.02 and 2.1 mg/kg as exchangeable K, Ca and Mg respectively. Soil organic carbon was modified by effluent application and showed relatively high content under greengram (40 to 102%), followed by maize (1.6 to 35%) and sunflower (43 to 102%) and marginal in rice (3%) at harvest. Humus carbon was also enriched by 33 to 163% (over the initial i.e. 0.27%) in greengram, 41 to 92% in blackgram, 18 to 104% in sunflower, 63 to 74% in maize, and 58 to 115% in rice (Table 3).

The paper mill effluent irrigation improved N, P, K, Na, Ca and Mg contents in soil over their corresponding initial values and also over 100% (fresh water) without showing any trend with concentrations of effluent. But

Table 3: Soil properties as influenced by paper mill effluent irrigation under different crops after harvest

Treatments, dilution levels of effluent	*Important soil properties under different crops*														
	Rice			*Maize*			*Sunflower*			*Greengram*			*Blackgram*		
	pH	*Org. C, %*	*Av. P, mg/kg*	*pH*	*Org. C, %*	*Av. P, mg/kg*	*pH*	*Org. C, %*	*Av. P, mg/kg*	*pH*	*Org. C, %*	*Av. P, mg/kg*	*pH*	*Org. C, %*	*Av. P, mg/kg*
0%	6.39	0.62	56.53	6.10	0.81	41.70	5.51	0.91	42.46	5.83	0.71	45.59	5.86	0.53	43.50
20%	6.83	0.53	24.30	6.89	0.45	36.00	5.34	0.90	44.69	5.71	0.84	38.70	5.60	0.41	32.10
40%	6.67	0.62	39.00	6.35	0.53	34.50	5.31	0.93	19.24	5.61	0.99	23.04	5.50	0.40	43.50
80%	6.33	0.60	19.37	6.28	0.61	31.80	5.18	0.86	33.90	5.72	0.54	59.66	5.44	0.41	28.73
100%	6.03	0.47	12.10	6.27	0.39	24.90	4.34	0.26	17.47	5.39	0.52	29.50	5.36	0.45	33.52

Note: Org. C and Av. P indicate organic carbon and available phosphorous respectively

the 'F ratio' (0.01%) was significant in all cases. Increase of organic carbon, P and K in soil due to paper mill effluent application was also reported by Mishra and Rout (1999). The paper mill effluent appears as a fair source of plant nutrients; with proper dilution it could be effectively utilized for growing crops. The paper mill effluent (Emami Paper Mill) has thus come up as a promising irrigation source to grow greengram, blackgram, sunflower, maize and rice particularly in acidic laterite soils. But cropwise optimum concentrations of effluent need to evaluate in field and that way the full benefit of effluent irrigation could be achieved.

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