researcharticle International Journal of Plant Sciences, Vol. 6 Issue 1 (January, 2011) : 174-177

Assessment of the impact of dye effluent and the ameliorative potential of waterhyacinth and vermicompost on plant growth and microbial status of the soil

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Received : November, 2010; Accepted : December, 2010

SUMMARY

The present study was carried out to assess the impact of dye effluent (raw effluent, biologically treated effluent and effluent treated in dye factory by chemical process) and the ameliorative potential of vermicompost on plant growth of *Vigna mungo* (L.) Hepper and biological properties of the soil. Diluted effluent, biologically treated effluent and factory treated effluent enhanced plant growth and favoured microbial growth. Amendment of the soil with vermicompost also enhanced the growth of the plant. However, higher concentrations of the raw effluent were deleterious to the plant. Therefore, the dye effluent can be used for irrigation purpose only after proper dilution.

Jayashree, I., Rajeswari, M. and Kalaichelvi, K. (2011). Assessment of the impact of dye effluent and the ameliorative potential of waterhyacinth and vermicompost on plant growth and microbial status of the soil. *Internat. J. Plant Sci.*, **6** (1): 174-177.

Key words : Dye effluent, Biological treatment, Vermicompost amendment, Biological parameters

Industrialization has its inevitable effect on pollution of air, water and soil (Baver and Gardner, 1972; Bose *et al.*, 1973 and Hodges, 1973). The increased industrial activities generate copious quantities of soil and liquid wastes which when dumped on the natural environment slowly degrades the soil and water ecosystems. In this context, the effluent released from textile and dye factory containing a lot of hazardous chemicals exert severe impacts on plant growth and soil bio-ecosystems. The present investigation is aimed to assess the impact of dye effluent on plant growth and microbial populations of the soil. With a view to ameliorate the adverse effects of the soil under effluent irrigation, vermicompost amendment was tried in pot experiment.

MATERIALS AND METHODS

The effluent samples [both raw and effluent treated in dye factory by chemical process (T_3)] were collected from a medium sized dye factory. Some quantity of the effluent was taken in plastic containers and treated biologically using the aquatic macrophyte *Eichhornia crassipes*. The plastic containers were kept in the laboratory at $30^0 \pm 2^0$ C room temperature for 8 days (retention period). After the retention period 1 litre of this biologically treated effluent (T_1) was used for irrigating the crops. *Vigna mungo* (L.) Hepper was used as the test plant. It was grown in pots filled with field soil. In another experimental set, the soil in some of the pots was amended with vermicompost in the ratio of 5:1 (soil: vermicompost) and the plants were irrigated using treated effluents – biologically treated effluent (T_2) and chemically treated effluent (T_4). The plants were irrigated with different concentrations (25%, 50%, 75% and 100%) of raw effluent, biologically treated effluent (T_1) and factory treated effluent (T_3) at fortnightly interval. Tap water was used for intermittent watering whenever necessary. Control was maintained using tap water. No pesticide was applied to the plants during the course of study. The results were observed at four age levels (20, 40, 60, 80 – old days). Seed germination was studied using sand culture method. The growth parameters were studied in terms of root and shoot lengths. The yield was also studied in terms of pod length and number of seeds per pod. Dilution plate method was employed for the enumeration of microbial population in the soil samples.

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RESULTS AND DISCUSSION

The dye effluent was very toxic to the plants. The process of seed germination and early seedling growth were susceptite to the toxic materials in the effluent. Fig.1 depicts the germination percentage of black gram under various treatments. *Vigna mungo* showed 100% seed germination in control water and 25% effluent dilution. The treated [biologically (T_1) and chemically (T_3)] effluent and soil incorporation of vermicompost (T_2 and T_4) had no adverse effect on seed germination. A substantial reduction in the germination percentage was noted in higher concentrations (75% and 100%) of effluent irrigation. This may be attributed to the presence of higher amounts of calcium and magnesium sulphates and chlorides in the effluent, which affect the soil porosity leading to poor germination. This is in consonance with the observations made by Sahai *et al.* (1979), Behera and Misra (1982) and Umamaheswari *et al.* (2003).

The effect of the effluents on the plant growth is given in Table 1. The highest growth in terms of root and shoot length was observed in plants grown in pots irrigated with treated [biologically (T_2) and factory (T_4)] effluents and amended with vermicompost. In general, the plants irrigated with 25% effluent concentration and treated effluents showed significant increases in all growth stages compared to control plants. Irrigation with higher concentrations (75% and 100%) of the raw effluent

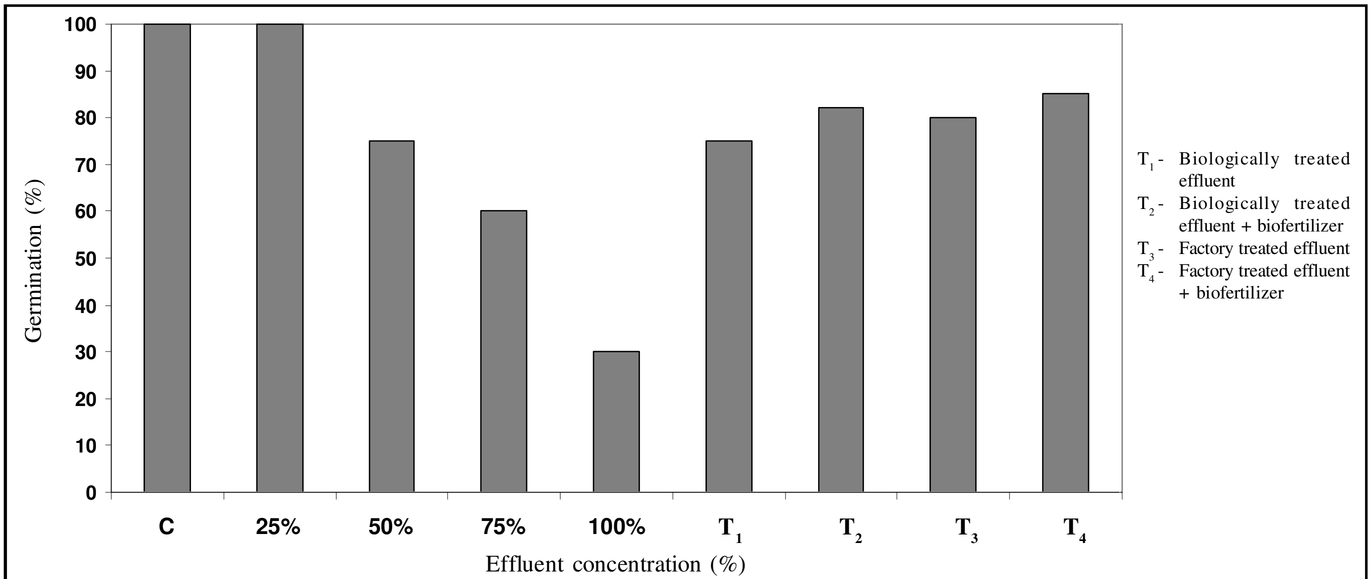

Fig. 1 : Effect of various concentrations of raw dye factory effluent, biologically treated effluent and treated effluent from dye factory in combination with biofertilizer on the seed germination of Vigna mungo (L.) Hepper

Table 1 : Effect of various concentrations of raw dye factory effluent, biologically treated effluent and treated effluent from dye factory in combination with vermicompost amendment on (A) root length (cm)* and shoot length (cm)* of black gram under pot condition

Effluent concentration (%)	Root length (cm)				Shoot length (cm)			
	Plant age (days)				Plant age (days)			
	20	40	60	80	20	40	60	80
Control	16.580 d	20.660 cd	22.340 f	23.800 e	7.900 b	14.420 cd	20.420 c	21.860 d
25	18.620 bc	23.720 b	28.500 a	29.760 b	8.860 ab	18.120 a	20.720 c	22.620 c
50	13.700 e	19.520 d	21.420 g	22.720 g	6.780 c	13.640 d	19.320 d	20.480 e
75	9.300 f	16.900 e	20.620 h	21.680 h	5.720 d	12.480 e	17.200 e	18.760 f
100	7.440 g	15.700 e	18.500 i	19.940 i	4.680 e	9.480 f	15.320 f	13.940 g
T_1- Biologically treated effluent	15.860 d	20.140 d	22.460 f	23.200 f	6.720 c	14.960 c	20.500 c	21.640 d
T_2- Biologically treated effluent + vermicompost	23.780 a	21.600 c	25.460 d	26.980 c	8.020 c	16.760 b	21.620 ab	23.520 a
T_3- Factory treated effluent	17.260 cd	20.860 cd	22.320 f	23.800 e	7.940 b	15.000 c	20.400 c	21.740 d
T_4- Factory treated effluent + vermicompost	18.920 b	26.180 a	28.180 b	30.220 a	9.040 a	18.460 a	21.280 b	23.760 a

*Based on five determinations for each treatment (DMRT- Duncans Multiple Range Test)
Values with same alphabets in each sampling day in the columns do not differ significantly from each other (P<0.05)

significantly altered the root and shoot growth of black gram. The reduction in growth of the seeding is attributed to the toxic effects of the effluents such as presence of heavy metals, excess / deficit level of micronutrients, decomposition products as well as soil porosity and aeration. This is in accordance with the studies of Somashekar *et al.* (1984), Kumawat *et al.* (2001) and Mariappan and Rajan (2002).

Table 2 depicts the yield parameters of black gram under different treatments. The yield was maximum in 25% effluent concentration, treated [biologically (T_2) and chemically (T_4)] effluents with vermicompost amendment. Higher concentrations (75% and 100%) of the raw effluent significantly decreased the yield. This is in agreement with Subrahmanyam *et al.* (1984) and Jabeen and Saxena (1990).

Significant changes were noticed in the microbial population of the soil after effluent irrigation (Table 3). The maximum microbial counts were observed in the rhizosphere of 40-day-old plants. The microbial count registered increases upto 50% effluent concentration. Thereafter a gradual decline in the microbial counts was noted. The rhizosphere of plants grown in soil amended with vermicompost and irrigated by treated effluents (T_2 and T_4) also registered maximum microbial counts. This was at par with Chauhan and Kaur (1991), Kannapiran (1995) and Sulaiman *et al.* (2002). Irrigation using diluted

Table 2 : Impact of raw effluent dilutions, biologically treated effluent and treated effluent from dye factory in combination with vermicompost amendment on the yield* of *Vigna mungo* (L.) Hepper

Effluent concentration (%)	Yield	
	Pod length (cm)	Number of seeds per pod
Control	5.820 ab	8.400 bcd
25	6.120 a	9.400 a
50	4.940 c	6.800 e
75	3.960 d	5.000 f
100	2.920 e	4.200 f
T_1- Biologically treated effluent	5.840 ab	7.800 cd
T_2- Biologically treated effluent + vermicompost	5.940 ab	8.200 bcd
T_3- Factory treated effluent	5.800 ab	8.600 abc
T_4- Factory treated effluent + vermicompost	6.100 a	9.400 a

*Based on five determinations for each treatment (DMRT – Duncans Multiple Range Test)
Values with same alphabets in each sampling day in the columns do not differ significantly from each other (P<0.05)

Table 3 : Effect of various concentrations of raw dye factory effluent, biologically treated effluent and treated effluent from dye factory in combination with vermicompost on the rhizosphere (A) bacterial population ($x10^6$ cfu g^{-1})* and (B) fungal population ($x10^3$ ppg g^{-1})* of black gram

Effluent concentration (%)	A. Bacterial population ($x10^6$ cfu g^{-1}) Plant age (days)					B. Fungal population ($x10^3$ ppg g^{-1}) Plant age (days)				
	0	20	40	60	80	0	20	40	60	80
Control	11.480 d	14.720 e	23.840 f	12.200 cd	10.820 d	6.780 de	10.740 e	15.640 e	10.740 f	6.480 h
25	13.660 bc	16.700 d	26.720 c	15.360 a	12.420 b	8.500 ab	11.720 b	16.220 c	11.540 d	8.160 d
50	10.880 de	13.680 g	20.380 i	11.820 de	9.160 e	8.260 b	9.780 d	13.320 g	9.780 g	7.820 e
75	10.580 e	12.660 h	19.600 j	11.120 e	8.800 e	7.540 c	8.580 e	12.400 h	8.620 h	7.360 f
100	9.200 f	10.320 i	13.560 k	10.100 f	8.060 f	4.120 f	6.360 f	9.460 i	6.380 i	4.080 j
T_1- Biologically treated effluent	11.300 d	14.500 f	23.380 h	12.060 cd	10.520 d	6.460 e	10.580 e	15.480 f	10.640 f	6.160 i
T_2- Biologically treated effluent + vermicompost	13.460 c	17.420 c	24.880 d	15.240 a	13.560 a	8.680 ab	12.800 a	17.260 b	12.800 ab	8.720 a
T_3- Factory treated effluent	11.480 d	14.420 f	23.600 g	12.760 c	10.680 d	7.590 c	11.740 b	16.230 c	11.540 d	7.840 c
T_4- Factory treated effluent + vermicompost	14.160 b	17.940 b	24.460 c	13.920 b	11.980 c	8.700 ab	13.040 a	17.680 a	12.860 a	8.640 ab

*Based on five determinations for each treatment (DMRT – Duncans Multiple Range Test)
Values with same alphabets in each sampling day in the columns do not differ significantly from each other (P<0.05)

effluent leads to the enrichment in the nutrient status of the soil which in turn enriches the microbial population.

Finally it may be concluded that the dye effluent had an adverse effect on the plant growth and soil property when used in high concentrations. Dilution of the effluent brings down its toxicity and can be useful for irrigation (Sujatha and Gupta, 1996; Subramani *et al.,* 1998). To overcome the deleterious constraints the use of biosystems like aquatic macrophytes (*Eichhornia* sp.) may be employed. These macrophytes can scavenge inorganic and organic pollutants by absorbing and incorporating them into their own structure. Further the incorporation of soil amendments like vermicompost enriched the nutrients in the soil by its degradation and can alleviate the impact of dye effluent. Thereby, the treated dye effluent can be safely used for irrigation purposes or it can be directly reused in the industry. This would pave the way not only for the safe disposal of wastes but also boosts our agricultural production.

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