Journal of Environmental Biology
©Triveni Enterprises, Lucknow (India)
Free paper downloaded from: www.jeb.co.in

March 2008, 29(2) 267-270 (2008)
For personal use only
Commercial distribution of this copy is illegal

Pollution level in distillery effluent and its phytotoxic effect on seed germination and early growth of maize and rice

S.N. Pandey*, B.D. Nautiyal and C.P. Sharma

Department of Botany, Lucknow University, Lucknow - 226 007, India

(Received: December 15, 2005 ; Revised received: February 02, 2006 ; Accepted: December 15, 2006)

Abstract: *The effluent from a Lucknow - based distillery (Mohan Meakin Distillery) was analyzed for physico-chemical and biological parameters of pollution and concentration of potentially toxic heavy metals (Cd, Cr, Ni and Zn) and the effect of the distillery effluent, as such and on 50% dilution with tap water was studied on seed germination and seedling growth of maize (Zea mays L.) and rice (Oryza sativa L.). The effluent was wine red in colour and highly acidic (pH ~ 5.5) and possessed decaying alcoholic smell. The effluent contained high values of different pollution parameters, particularly total solids, 3450 mgl^{-1} (soluble plus suspended solids), alkalinity 1500 mgl^{-1}, biological oxygen demand (BOD, 1649 mgl^{-1}) and chemical oxygen demand (COD, 2036 mgl^{-1}). It had very low values of dissolved oxygen (DO, 0.34 mgl^{-1}). The heavy metals (Cd, Cr, Ni and Zn) content, particularly the nickel concentration (0.029 mg l^{-1}) was high. Use of the distillery effluent, even on 1:1 dilution with tap water, inhibited germination and early seedling growth of maize and rice. In both maize and rice, more so in the former, germination % of seeds, length of radicle and plumule and the fresh and dry weight of the seedlings were significantly reduced. The emerging leaves of the seedlings also developed visible effects of toxicity, some of which resembled the symptoms of nickel toxicity. Our observations suggest that the effluent, as discharged from the distillery, carry a heavy load of pollutants. Its discharge into the river Gomti poses a potential threat to the aquatic life, perticularly during the summer months when the water flow in the river is drastically reduced. The distillery effluent is also harmful for irrigating crops grown along the drain carrying it.*

Key words: *Distillery effluent, Pollution, Heavy metals, Phytotoxicity*
*PDF of full length paper is available with author **(*snpandey511@gmail.com)***

Introduction

Indiscriminate disposal of sewage and industrial effluents is a major cause of pollution of water bodies and rivers into which they are discharged. The use of industrial effluents carrying a heavy load of heavy metals such as Pb, Zn, Cr, Ni and Hg for irrigation of crops also produces adverse effects on plant growth. There are several reports of phytotoxic effects resulting from irrigation of crops with effluents from different types of industries from different parts of India (Somashekar *et al.,* 1992; Hariom and Arya, 1994; Goel and Kulkarni, 1994; Khan and Jain, 1995; Sharma and Singh, 1999; Punmurgan and Jayseelan, 2001; Barman *et al.*, 2001; Pandey, 2006 a, b; Nath *et al.*, 2007; Sahu *et al.,* 2007). The present study is a part of investigations undertaken to evaluate the pollution potential of the effluents from the major industries located within the urban limits of Lucknow (U.P.) and discharged into the river Gomti passing through the city. An earlier paper (Pandey, 2006b) showed high accumulation of heavy metals (Cd, Cr, Cu, Ni and Zn) in vegetables irrigated with the effluents discharged from a major industry involved in electroplating and manufacture of torchlight batteries. In this paper, we make an evaluation of some key parameters of aquatic pollution in the effluent discharged from a city-based distillery (Mohan Meakin Ltd.) and the suitability of the distillery effluent for irrigation purposes.

Materials and Methods

Samples of effluent discharged from the Mohan Meakin distillery were collected around 8 am for 15 consequtive days during the summer season (May-June). The freshly collected samples were observed for color, odor and temperature and analyzed for pH, alkalinity, hardness, total dissolved salts (TDS), total suspended salts (TSS), chloride, dissolved oxygen (DO), biological oxygen demand (BOD) and chemical oxygen demand (COD). The collection, storage and analysis of samples were carried out as per methods described by APHA (2005). The effluent samples were also analyzed for the concentration of Cd, Cr, Ni and Zn by atomic absorption spectrophotometery (AAS model Spectra AA-250 plus). The range and mean values based on the analysis of the 15 individual samples are given in Table 1, 2. For evaluating the suitability of the distillery effluent for irrigation purposes, the samples collected for the 15 days, and analyzed for the different parameters described above, were pooled to make a composite sample and a part of it was diluted 1:1 with tap water, taken as control. The effect of undiluted (100%) and diluted (50%) effluent was studied on seed germination, seedling growth and development of visible symptoms in maize (*Zea mays* L. var. GK 3014) and rice (*Oryza sativa* L. var. Pant 10). Seedlings were raised in Carning glass petri-plates (10 cm diameter). Prior to sowing, the seeds were surface sterilized by dipping in ethyl alcohol for 1 min and washing with distilled water. For each treatment 100% effluent, 50% effluent and tap water (control) was replicated thrice. The data were put to statistical analysis. The SE values are given in Table 3. Significance of treatment effects was tested by ANOVA and the values of the LSD ($p<0.05$) are given in Table 3.

Results and Discussion

The range and average values of the different pollution parameters estimated in effluents collected from the distillery outlet, along with the standard tolerance limits for industrial effluents

Table - 1: Physico-chemical attributes of the distillery effluent, tap water (control) and ISI standard tolerance limits* for discharge into inland surface water

Parameters	Distillery effluent		Tap water (Control)		ISI* Standards
	Range	Average	Range	Average	(1974)
Temperature °C	26.5 - 27.0	26.8	26.5 - 28.0	27.3	< 40 °C
Colour	Wine red	-	Colourless	-	Colourless
Odour	Decaying	-	Odourless	-	Odourless
pH	5.0-5.5	5.3	7.0-7.1	7.1	5.5-9.0
TSS mg l^{-1}	1890-1920	1905	17.0-23.3	20.2	100
TDS mg l^{-1}	1500-1590	1545	80.0-96.0	88	2100
TS mg l^{-1}	3390-3510	3450	97-119.3	108	2200
Alkalinity (as $CaCO_3$) mg l^{-1}	1400-1600	1500	45.0-60.0	53	—
Hardness (as $CaCO_3$) mg l^{-1}	649-712	681	63.0-80.0	72	600
Chloride mg l^{-1}	532-650	591	19.4-25.4	22.5	600
DO mg l^{-1}	0.23-0.45	0.34	8-10.5	9.3	6.0
BOD mg l^{-1}	1112-2185	1649	1.3-1.5	1.3	30.0
COD mg l^{-1}	1745-2326	2036	3.0-5.0	4.0	250.0

*ISI (1974) No. 2490

Table - 2: Concentration of heavy metals (Cd, Cr, Ni and Zn) in the distillery effluent

Heavy metal	Concentration (mgl^{-1})	
	Range	Average
Cadmium	0.008-0.013	0.011
Chromium	0.029-0.031	0.030
Nickel	0.28-0.35	0.315
Zinc	0.058-0.079	0.069

discharged into inland surface water (ISI, 1974) are given in Table 1. A perusal of the data presented in the Table 1 showed the effluent to be very low in dissolved oxygen (0.34 mg l^{-1}) and high in BOD (1649 mg l^{-1}) and COD (2036 mg l^{-1}). Such high levels of BOD, indicative of relatively high proportion of organic matter, that causes depletion of dissolved oxygen in water, are known to be a threat to aquatic life. High level of total solids (3450 mg l^{-1}) in the distillery effluent, attributed to high concentrations of carbonates, chlorides, sulfates and nitrates of Ca, Mg and Na contributes to high salinity in water and eventually in soils into which it is leached out (Pandey *et al.*, 2002). The distillery effluent also contained heavy metals such as Cd, Cu, Ni and Zn which on discharge into the river could cause toxicity to aquatic life (Zyadah and Abdul–Bakky, 2000) and accumulate in excessive concentrations in river sediments. The latter is in accord with reported increase in the concentration of heavy metals in the freshly deposited sediments of river Gomti (Singh *et al.*, 1997; Gaur *et al.*, 2002) into which the distillery effluent is discharged for several decades.

As irrigation of crops with effluents from breweries and distilleries affects the growth of plants (Trivedi and Shinde, 1983; Ajmal *et al.,* 1984; Chandra *et al.*, 2004), we explored the effect of the Mohan Meakin distillery effluent on germination and seedlings growth of maize and rice. A study was made of the effect of the effluent as collected from the distillery (100%) and diluted 1:1 with tap water (50%), with tap water serving as control (Table 3, Fig. 1). These studies showed the distillery effluent to have an inhibitory effect on seed germination and early growth of plants. Supply of the undiluted (100%) effluent produced significant inhibition in seed germination and seedling growth parameters - length of radicle and plumule and fresh and dry weight in both maize and rice (Table 3, Fig. 1). Even though less severe, the inhibitory effect of the 1:1 diluted (50%) effluent was also significant. It was, however, observed that, compared to rice, maize was more sensitive to the inhibitory effect of the effluent. Maize seedlings irrigated with the undiluted (100%) effluent also developed visible symptoms. Most conspicuous of those were burning of leaf tips and formation of loops by the young emerging leaves. These leaves failed to expand, resulting in marked decrease in leaf size. Growth of roots was also inhibited and root tips turned brown and necrotic. Irrigation with diluted (50%) effluent produced similar but less severe effects. Somewhat similar effects were produced in rice. The leaves of rice seedlings irrigated with the undiluted (100%) effluent failed to unroll and remained needle-like. Their apical part also turned chlorotic. The root tips of the rice seedlings also turned brown and necrotic. Growth of a large percentage of both maize and rice seedlings was severely arrested beyond 15 days from sowing. Inhibition of growth in response to irrigation with the distillery effluent has also been reported in pigeon pea and black gram (Pandey, 2006a). Possibly, the inhibitory effect of the distillery effluent on seed germination, seedling growth and development of phytotoxic effects is an outcome of its high salt content (Lauchli and Luttge, 2000) and presence of toxic heavy metals (Kabata-Pendias and Pendias, 1992). The visible effects produced in the roots and aerial parts of the seedlings show great resemblance to the nickel-toxicity effects described by Bisht *et al.* (1976), Baccouch *et al.* (1998), Pandey and Sharma (2002) and Pathak and Pandey (2006). These findings are also in consonance with growth inhibition of radish and spinach plants accumulating heavy metals, including Cr, Ni and Zn in response to irrigation from effluents from other Lucknow based industry (Pandey, 2006b). In conclusion, the distillery effluent under investigation is not in only a potential source of pollution to the Gomti river, into which it is discharged, but is also toxic to growth of plants irrigated with it.

Table - 3: Effect of distillery effluent on seed germination and seedling growth of maize and rice

	DAS	Effluent concentration (%) 0	50	100	LSD ($p<0.05$)
Maize					
Seed germination %	4	80 ± 1.67	60 ± 2.90	55 ± 2.89	19
Length of radical (cm)	5	6.92 ± 0.21	3.1 ± 0.06	2.76 ± 0.29	1.6
Length of plumule (cm)	5	5.88 ± 0.17	3.56 ± 0.15	3.41 ± 0.17	0.9
Seedling biomass					
Fresh weight (g/seedling)	15	1.08 ± 0.30	0.73 ± 0.25	0.62 ± 0.20	0.25
Dry weight (g/seedling)	15	0.089 ± 0.009	0.066 ± 0.010	0.055 ± 0.008	0.008
Rice					
Seed germination %	4	100 ± 0.4	82.5 ± 0.9	70 ± 2.9	14
Length of radical (cm)	5	5.6 ± 0.2	4.3 ± 0.1	4.0 ± 0.2	1.1
Length of plumule (cm)	5	6.1 ± 0.1	5.2 ± 0.1	4.7 ± 0.1	0.8
Seedling biomass					
Fresh weight (g/seedling)	18	0.093 ± 0.12	0.071 ± 0.11	0.058 ± 0.11	0.11
Dry weight (g/seedling)	18	0.016 ± 0.008	0.012 ± 0.006	0.009 ± 0.005	0.006

DAS = Days after sowing

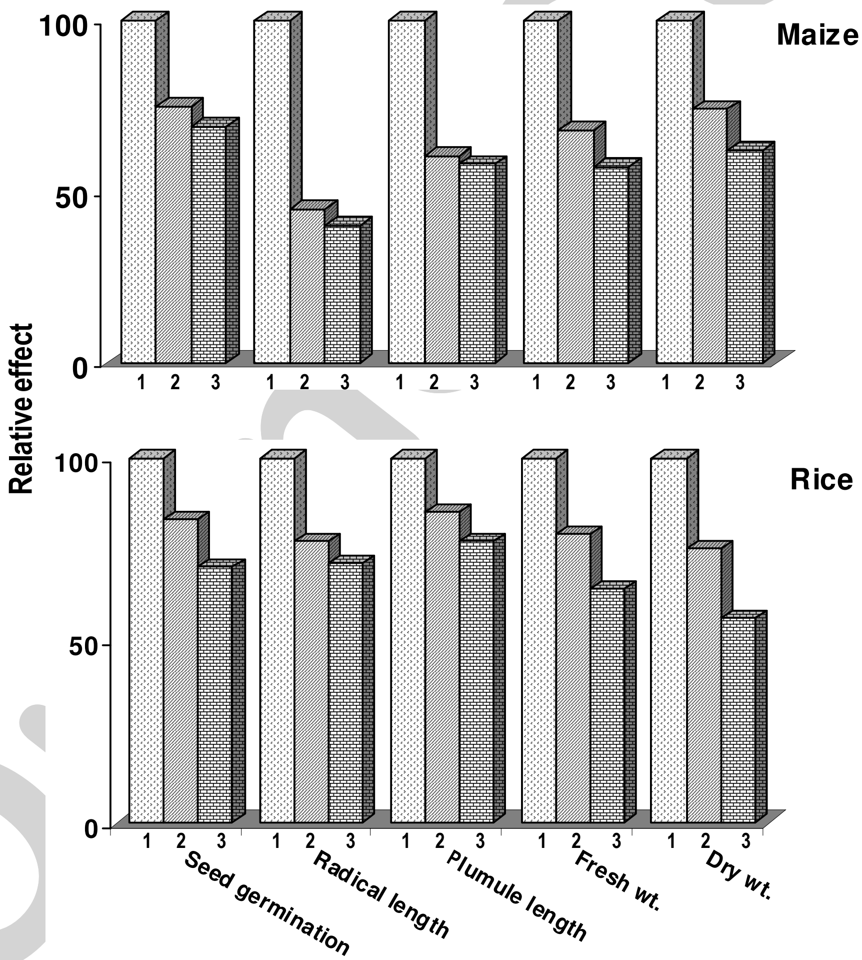

Fig. 1: Relative effect of distillery effluent on seed germination, early growth and biomass yield of seedlings (1= tap water (control), 2= distillery effluent (diluted 1:1), 3= distillery effluent (undiluted)

References

Ajmal, M., A.U. Khan and A.A. Nomani: Effect of brewary waste on agricultural soil and crop plants. *Environ. Pollut. (Sec. A)*, **34**, 341-351 (1984).

APHA.: Standard methods for the examination of water and waste water. 21st Edn., American Public Health Association, Washington, D.C. (2005).

Baccouch, S., A. Chaoui and E.E. Ferjani: Nickel toxicity effect on growth and metabolism of maize. *J. Plant Nutr.*, **21**, 577-588 (1998).

Barman, S.C., G.C. Kisku, P.R. Salve, D. Mishra, R.K. Sahu, P.W. Ramteke and S.K. Bhargava: Assessment of industrial effluent and its impact on soil and plants. *J. Environ. Biol.,* **22**, 251-256 (2001).

Bisht, S.S., C.P. Sharma and A. Kumar: Plant response to excess concentrations of heavy metals. *Geophytology,* **6**, 296-307 (1976).

Chandra, R., K. Kumar and J. Singh: Impact of anaerobically treated and untreated (raw) distillery effluent irrigation on soil microflora, growth, total chlorophyll and protein contents of *Phaseolus aurens* L. *J. Environ. Biol.,* **25**, 381-385 (2004).

Gaur, V.K., S.K. Gupta, S.D. Pandey, K. Gopal and V. Mishra: Assessment of pollution load in sediment/water of river Gomti with reference to heavy metals. Acad. Environ. Biol. Proc. 22nd Annual Session. NBFGR, Lucknow. p. 150 (2002).

Goel, P.K. and S.M. Kulkarni: Effect of sugar factory waste on germination of gram seeds (*Cicer arietnum* L.). *J. Environ. Pollut.,* **1**, 35-43 (1994).

Hariom, N. S. and M.S. Arya: Combined effect of wastes of distillery and sugar mill on seed germination, seedling growth and biomass of okra (*Ablemoschus esculentus* L.). *J. Environ. Pollut.,* **15**, 171-175 (1994).

ISI.: Tolerance Limits for Industrial Effluents Discharged into Inland Surface Water (first revision) No. 2490 New Delhi (1974).

Kabata - Pendias, A. and H. Pendias: Trace Elements in Soils and Plants. 2nd Edn., CRC Press, Boca Raton*,* Fl. (1992).

Khan, T.I. and V. Jain: Effect of textile industry waste water on growth and some biochemical parameters on *Triticum aestivum* var. Raj, 3077. *J. Environ Pollut.*, **2**, 47-50 (1995).

Lauchli, A. and U. Luttge: Salinity – Environments-Plants Molecules. Kluwer Academic Publishers, Dordrecht*,* The Netherlands (2000).

Nath, Kamlesh, Dharam Singh and Yogesh Kumar Sharma:Combinatorial effects of distillery and sugar factory effluents in crop plants. *J. Environ. Biol.*, **28**, 577-582 (2007).

Pandey, A.K., S. Dutta and K.C. Sharma: Impact of marble slurry on sub-surface water – A case study of Kishangarh, district Ajmer. *Environ. Pollut. Technol.*, **1**, 5-11 (2002).

Pandey, N. and C.P. Sharma: Effect of heavy metals Co^{2+}, Ni^{2+}, and Cd^{2+} on growth and metabolism of cabbage. *Plant Sci.,* **163**, 753-758 (2002).

Pandey, S.N.: Effect of brewery effluent on seedlings of *Cajanus cajan and Vigna mungo. J. Appl. Biosci.*, **32**, 119-122 (2006a).

Pandey, S.N.: Accumulation of heavy metals (Cd, Cr, Cu, Ni and Zn) in *Raphanus sativus* L. and *Spinacea oleracea* L. plants, irrigated with industrial effluent. *J. Environ. Biol.*, **27**, 381-384 (2006b).

Pathak, G.C. and N. Pandey: Nickel alters antioxidative defense and water status in green gram. *Indian J. Plant Physiol.,* **11**, 113-118 (2006).

Ponmurugan, P. and S. Jayseelan: Effect of match works and fire works effluent on *Typha angustata*. *J. Ind. Bot. Soc.*, **80**, 191-194 (2001).

Sahu, R.K., S. Katiyar, Jaya Tiwari and G.C. Kisku: Assessment of drain water receiving effluent from tanneries and its impact on soil and plants with particular emphasis on bioaccumulation of heavy metals. *J. Environ. Biol.*, **28**, 685-690 (2007).

Sharma, S.K. and V.P. Singh: A comparative study of the mutagenic efficiency of rubber factory effluent and city wastewater in black gram (*Vigna mungo* L. Hepper). *J. Ind. Bot. Soc.,* **78**, 357-362 (1999).

Singh, M., A.A. Ansari, G. Muller and I.B. Singh: Heavy metals in freshly deposited sediments of the Gomti river: Effects of human activities. *Environ. Geology*, **29**, 246-252 (1997).

Somashekar, R.K., S. Ramaioh and R.L. Laxminarayan: Effect of distillery effluent on growth of *Vigna sinesis* L. and *Trigonella foenum-graecum* L. *J. Indian Bot. Soc.,* **71**, 115-118 (1992).

Trivedi, R.K. and D.B. Shinde: Effect of distillery waters irrigation on soil characteristics. *Pollut. Res.,* **2**, 71-76 (1983).

Zyadah, M.A. and T.C. Abdul-Bakky: Toxicity and bioaccumulation of copper, zinc and cadmium in some aquatic organims. *Bull. Environ. Contam. Toxicol.,* **64**, 740-747 (2000).