Jr. of Industrial Pollution Control 24 (1) (2008) pp 95-100

RECYCLING OF WASTEWATER THROUGH CROP CULTIVATION

AFROZA AKHTAR, AKHTAR INAM, SABA AZAD, DILSHADA TABASSUM AND ARIF INAM

Plant Physiology Laboratory, Department of Botany, Aligarh Muslim University, Aligarh 202 002, India

Key words : Mustard, NPK & Wastewater

ABSTRACT

A simple randomized pot experiment was conducted during the Rabi season on mustard (*Brassica juncea* L.) cv. Alankar to study the comparative effect of wastewater and groundwater with combined effect of three doses each of nitrogen and phosphorus. The fertilizer doses were N_0P_0, $N_{40}P_{30}$, $N_{80}P_{30}$, $N_{40}P_{60}$ and $N_{80}P_{60}$. Each dose was given with both wastewater and groundwater. A uniform basal dose of potassium @ 30kg/ha was also applied at the time of sowing. $WWN_{80}P_{60}$ proved best for most of the parameters. Chemical characteristics of wastewater were in the permissible limits of BIS for crop irrigation.

INTRODUCTION

In most parts of the developing world, freshwater supply is becoming increasingly limited due to over consumption by the fast growing population of these countries. More than 60% of the valuable water used each year is diverted for irrigating crops. For Asia, which has two third of the world's irrigated land, the figure is still higher (85%) due to unscientific irrigation. The colossal wastage of our scarce freshwater resources can be reduced by various ways, important being the reuse of wastewater in agriculture which is gaining importance nowadays because of its value as a potential irrigation source and a nutrient supplier. In addition to the manorial ingredients, it effectively augments the supply of water, the most important requirement of cultivated crops. This additional availability in the vicinity of large centres of populations, where the demand for farm products is the greatest, renders such utilization all the more important. The present study was, therefore undertaken to study the feasibility of its agricultural use.

MATERIALS AND METHODS

A simple randomized pot experiment was conducted in the net house of Environment Plant Physiology Laboratory, Aligarh Muslim University, Aligarh (India), situated at 27°52′N latitude, 78°51′E longitude and 187.45m altitude.

The comparative effect of thermal power plant wastewater (WW) and ground water (GW) on mustard was studied, supplemented with three levels, each of nitrogen and phosphorus (N_0, N_{40}, N_{80} and P_0, P_{30} and P_{60}) along with a uniform basal dose of potassium at the rate of 30kg ha^{-1}. Nitrogen as urea, phosphorus as super phosphate and potassium as muriate of potash were calculated on the basis that one hectare land contains 2×10^6 kg soil and applied one day before the sowing to avoid seed injury. WW was collected from leachate reservoir of Harduaganj Thermal Power Plant located 14km away from Aligarh city. Tap water without any treatment was used as a source of GW. Six earthen pots of 12" diameter with two plants in each pot were maintained

Email : Arish Inam - arishinamkhan@gmail.com

after thinning for each treatment. Each pot was watered with 250mL on alternate days.

Growth parameters were studied at 50, 70 and 100 DAS (days after sowing) whereas yield and quality was studied at harvest. Leaf area was taken by Watson (1958) and leaf nitrogen was determined in dried plant material at each stage by the Lindner (1944). Total biological yield of three randomly selected plants from each treatment was recorded from sun dried samples before threshing. Oil content was estimated by Soxhlet extraction. Acid, iodine and saponification values of oil were estimated (Anonymous, 1970). Irrigation water was also analyzed for various chemical characteristics according to methods outlined in APHA (1989). Similarly, soil was analyzed before sowing according to Gosh *et al.* (1983). All the data were analyzed statistically (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

The characteristics of WW, GW and soil used in the experiment are given in Table 1. The Bureau of Indian Standard (BIS) has recommended various standards for the disposal of wastewater. The tolerance limits of some of the parameters prescribed for the discharge on land are pH: 5.9-9.0, total solids: 2100 mgL^{-1}, BOD: 500 mgL^{-1}, COD: 250 mgL^{-1} Na: 70 mgL^{-1}, Cl: 600 mgL^{-1}. The pH of the effluent was nearly neutral while higher concentration of several inorganic sources viz. NO_3-N, NH_4-N, phosphate, potassium, calcium, magnesium and sulphate which are considered essential for plant growth, was found in WW than in GW.

Compared to GW, WW proved more beneficial. This is evident from higher values for plant height, leaf number, leaf area and plant dry weight at 50, 70 and 100 DAS (Fig.1) confirming the earlier findings of Aziz *et al.* (1999) and Hayat *et al.* (2000). The beneficial effect of WW on growth of crop plants may possibly due to the presence of some essential and beneficial nutrients in it (Table 1) which ensured better growth and development in the treated plants, noted in terms of enhanced growth parameters. The role of these essential nutrients is well documented, for example, nitrogen is involved in cell division and expansion (Gardner *et al.* 1985) and potassium in photosynthesis by directly increasing growth and leaf area and as a co-factor for many enzymes (Mengel and Kirkby, 1996). Yield is the final manifestation of physiological, morphological and biochemical traits of a crop. These traits are themselves dependent on various environmental factors, including water and nutrients. WW, in general, also proved effective in enhancing seed yield and oil yield (Table 2) corroborating the findings of Aziz *et al.* (1999) while working on mustard and refinery wastewater. In the present study, higher values for seed and oil yields were likely due to the cumulative effect of increase in biomass, pod number, seed number and 1000 seed

Table 1. Physico-chemical characteristics of ground water (GW). Wastewater (WW) and soil. All determinations in mg l 1 or as specified.

Parameters	GW	WW	Parameters	Soil
pH	7.4	8.4	Texture	Sandy loam
EC (ds/m)	0.68	0.96	CEC (meq/100g soil)	3.100
TDS	534	682	pH	8.300
TSS	379	585	Organic carbon	0.800
TS	913	1277	EC (μ mhos/cm)	381.00
BOD	3.70	17.49	NO3–N (g kg 1 soil)	0.330
COD	38	70	Available phosphorus (g kg 1 soil)	0.131
Mg	15.92	41.68	Potassium	12.00
Ca	26.47	45.54	Calcium	29.79
K	7	14	Magnesium	21.64
Na	20	39	Sodium	11.59
H	58	83	Carbonate	18.00
22	45		Bicarbonate	86.00
Cl-	66.22	103.92	Sulphate	17.00
PO4	0.12	0.93	Chloride	26.79
NO3–N	0.79	1.86		
NH3–N	3.62	7.40		
SO4	61	85		

weight. This enhanced effect was noted to be associated with the presence of essential nutritents in the wastewater. In addition, Mg, which is found in the porphyrin moiety of the chlorophyll molecule and is also involved in the activation of numerous critical enzymes. Also, the supply of additional S, which is particularly important in the structure of some proteins (Patnaik, 1980) from wastewater could also platy a positive role. Similarly, the presence of Ca which is important to dividing cells and is required for the physical integrity of membranes and of (i) which is required for cell division in leaves and shoots, and plants deprived of it tend to exhibit reduced growth (Hopkins, 1995). This finding was further confirmed by linear regression analysis of seed yield with growth and yield attributing characteristics (Fig. 2).

Among fertilizer treatments, $WWN_{80}P_{60}$ proved

Table 2. Effect of Ground water (GW) and Wastewater (WW) on biological yield (g plant 1), seed yield (g plant 1), oil yield (g plant 1), number of pods, number of seeds and 1000 seed weight (g) of mustard (Brassica juncea L.) grown with three levels each of nitrogen and phosphorus.

Treatments	Biological yield	Seed yield	Oil yield	Number of ponds	Number of seeds	1000 seed weight
N0P0+GW	7.36	3.94	1.54	62	10.7	6.19
N40P30+GW	9.85	5.58	2.37	74	12.2	6.34
N40P60+GW	11.10	6.44	2.85	81	13.2	6.45
N80P30+GW	14.02	8.66	3.46	98	14.7	6.99
N80P60+GW	14.82	9.25	3.80	104	15.5	7.19
N0P0+WW	9.24	5.12	2.05	66	11.5	6.42
N40P30+WW	11.83	6.94	3.06	81	13.2	6.62
N40P60+WW	13.63	8.25	3.83	94	14.5	6.75
N80P30+WW	16.73	10.83	4.54	110	16.7	7.17
N80P60+WW	17.64	11.93	5.18	118	17.7	7.43
C.D. at 5%	0.51	0.49	0.206	3.04	0.66	0.51

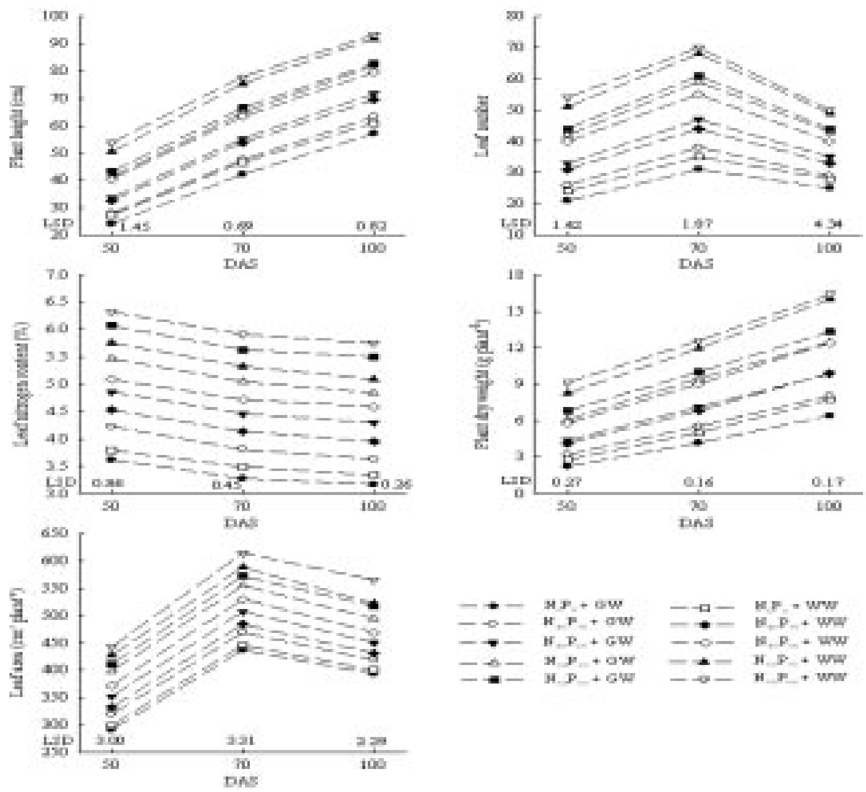


Fig. 1 Effect of ground water (GW) and wastewater (WW) on growth characteristics of mustard (*Brassica juncea* L.)

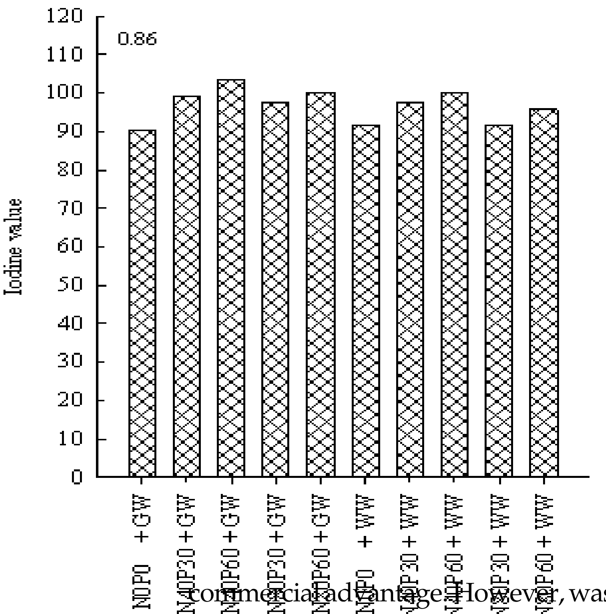
Fig. 2 Lenear regression curves showing correlation of plant dry weight, pod number, leaf area and seed number with seed yield.

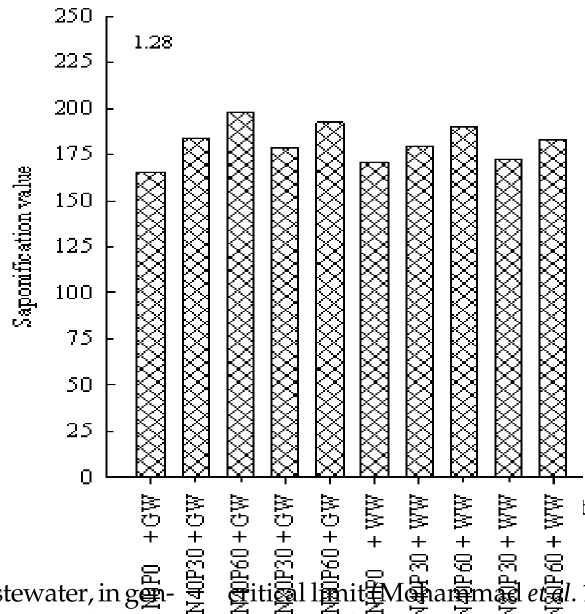
superior for growth and yield characteristics. The superiority of the treatment $WWN_{80}P_{60}$ manifested itself early at vegetative stage (50 DAS). The enhanced growth and yield as a result of this treatment may be due to the cumulative effect of nutrients present in wastewater as well as added doses of inorganic fertilizers. A high rate of growth only occurs when sufficient nitrogen together with other essential nutrients is available (Mengel and Kirkby, 1996) as was the case in present study.

Similarly, leaf nitrogen content was more in plants grown with WW as compared to GVV, treatment $WWN_{80}P_{60}$ proving superior (Fig. 1). A similar observation has been made by Jonathan and Wagner (1999). Effect of wastewater in enhancing the leaf nitrogen concentration may be due to the development of large canopies expressed as leaf area, which puts an extensive demand on roots to extract more available nutrients. The enhancing effect of $WWN_{80}P_{60}$ in maximizing the leaf nitrogen content may be due to synergistic effect of nitrogen and phosphorus present in wastewater as well as added dose of both of these nutrients as both are known to accelerate root proliferation (Grimes and Krantz, 1958), thus, facilitating the uptake of nutrients.

Like growth and yield characteristics, oil content was more in seeds of WW grown plants. However, it was maximally enhanced by the treatment $WWN_{40}P_{60}$ (Fig. 3). Improvement in oil content as a result of wastewater irrigation could be attributed to the increased availability of nutrient present in the wastewater as well as improved partitioning of photosynthates at the site of oil synthesis in treated plants. The apparent explanation for the adverse effect of higher nitrogen levels on oil content may be the preferential utilization of carbon skeletons at the time of seed filling, towards protein synthesis rather than oil formation (Chourasia *et al*. 1992).

However, the positive effect of applied nitrogen on seed yield was so spectacular that it outbalanced the lower oil content value of seeds in providing considerably enhanced oil yield per plant an obvious





tard (*Brassica juncea* L.)

commercial advantage. However, wastewater, in general, recorded lower iodine, acid and saponification value, which is usually considered good as far as acid and iodine value in mustard oil are concerned (Fig. 3). The treatment GW$N_{40}P_{60}$ recorded the highest value for these parameters.

The lower values for these parameters recorded in wastewater grown plants and also in high nitrogen treatments may be due to nitrogen crossing its critical limit (Mohammad *et al*. 1985). This detrimental effect of higher nitrogen levels was compensated by increasing the phosphorus level from P_{30} to P_{60}.

The authors in present observation lead to the tentative conclusion that thermal power plant wastewater can be profitably used for cultivation of mustard, as it proved more efficient in enhancing growth and yield attributes and finally seed and oil yield. Thus, its application fro crop use may solve its disposal problem and may lower pressure on fertilizer industry as well as meager freshwater resources of our country.

REFERENCES

Anonymous, 1970. *Pharmacopeia of India*. 2nd ed. Manager of Publications, Ministry of Filth, Government of India, N. Delhi.

APHA 1989. *Standard Methods for Examination of Water and Wastewater*. 17th ed. American Public Health Association, Washington D.C.

Aziz, O., Inam and Samiullah, A. 1999. Utilization of petrochemical industry wastewater for agriculture. *Water Air Soil Pollnt*. 115: 321-335.

Chourasia, S.K., Namdeo, K.N. and Chaurasia, S.C. 1992. Effect of nitrogen, sulphur and boron on growth, yield and quality of linseed (*Linum usitatissimum*). *Indian J. Agron*. 37 : 496-499.

Gardner, F.P., Mitchell, L.R. and Pearce, R.B. 1985. *Physiology of Crop Plants*. Iowa State University Press, USA.

Ghosh, A.B., Bajaj, J.C., Hasan, R. and Singh, D. 1983. *Soil and Water Testing Methods: A Laboratory Manual*, IARI, New Delhi.

Gomez, K.A. and Gomez, A.A. 1984. *Statistical Procedures for Agricultural Research*. 2nd ed. John Wiley & Sons, New York.

Grunes, D.L., Viets, F. G.jr. and Shah, S.H. 1958. Proportionate uptake of soil and fertilizer P by plants as affected by N fertilization. I. Growth Chamber experiments. *Proc. Soil Sci. Soc. Amer*. 22 : 43-48.

Hayat, S., Ahmad, I., Azam, Z.M., Ahmad, A., Inam, A. and Samiullah, 2000. Impact of treated wastewater from an oil refinery on growth and yield of *Brassica juncea* and on heavy metal accumulation in the seeds and soil. *J. Environ. Studies & Policy*. 3 : 51-59.

Hopkins, W.G. 1995. *Introduction to Plant Physiology*. John Wiley & Sons Inc., New York.

Jonathan, H. and Wagner, R.M. 1999. Effects of pulp mill effluent irrigation on the distribution of elements in the profile of an arid region soil. *Environ. Pollut*. 105 : 129-135.

Lindner, R.C. 1944. Rapid analytical methods for some of the more inorganic constituents of plant tissues. *Plant Physiol*. 19: 76-89.

Mengel, K. and Kirkby, A.E. 1996. *Principles of Plant Nutrition*. 4th ed. Panima Publishing Corporation, N. Delhi.

Mohammad, F., Samiullah and Afridi, M.M.R.K. 1985. Note on the yield attributes and quality of mustard under varying levels of nitrogen. *Geobios*. 12 : 162-164.

Patnaik, N. 1980. Soil fertility and fertilizer use. In: *Handbook of Agriculture*. pp. 212. Indian Council of Agricultural Research (ICAR), New Delhi.

Watson, D.I. 1958. The dependence of net assimilation rate on leaf area index. *Am. Bot*. 22 : 37-54.