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A Case Study :

Waste water utilization in vegetable cultivation-pros and cons

M. PRABHU AND A. RAMESH KUMAR

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See end of the article for authors' affiliations

Correspondence to:
M.. PRABHU
Department of Horticulture, Horticultural College and Research Institute, Tamil Nadu Agricultural University, COIMBATORE (T.N.) INDIA

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Increasing industrialization and urbanization in India has brought in its wake a major problem *i.e.* of safe disposal of waste water which includes sewage, industrial effluents and liquid dairy wastes. Reuse of waste water in agriculture is expected to increase dramatically in future as new water sources become increasingly scarce and expensive to develop and as groundwater is being depleted rapidly. However, indiscriminate use of waste water for irrigating agricultural crops cannot be allowed, because effluents originating from different sources are certain to have different composition. The manurial ingredients of waste water effectively aid the healthy development of crops. Waste water is rich in plant nutrients in the vicinity of large centers of population, where the demand of farm products like fruits and vegetables, makes waste water utilization more important.

Physiological and biochemical basis of plants under effluent irrigation :

High osmotic pressure that results due to high salt concentration in the effluent might be the major cause for a rapid decrease in germination. The delay in seed germination in concentrated effluent might be due to inhibition of enzyme activity. Presence of heavy metals in waste water might also have caused retardation in chlorophyll synthesis or it might be due to changes in the endogenous cytokinin in leaves. The decline in N, P and K may be due to the inability of the plant to absorb the nutrients from the effluent treated soil. This may be due to the accumulation of heavy metals in the roots which may prevent the uptake of these nutrients by the plants.

Cadmium delays growth, inhibits photosynthesis and induces or inhibits distinct enzymes and alters stomatal function. Higher concentrations of cadmium in the soil reduce the zinc uptake. Cadmium content was more in roots. Zinc content was more in shoots. Cadmium uptake is inversely related to soil organic matter content. Nickel inhibits the root growth. Mercury and Cobalt affect the germination in cluster bean. Higher level of copper inhibits root growth, root elongation in apical zone. Higher levels of zinc interfere iron involving enzymatic functions. Cobalt reduced the germination and seedling growth by plugging of sieve tubes, increased deposition of callose and inhibition of ethylene production. Cadmium inhibits the root growth, respiration and mitochondrial transport. Mercury interact with -SH, -S-S group of proteins and inhibiting enzyme synthesis. Chromium affects mineralization of nitrogen. Chromium induces mutations in soil micro organism, which may affect organic matter decomposition. Increasing levels of biological oxygen demand inhibit the soil and root aeration, thus adversely affecting the plant growth. Leafy vegetable crops are more sensitive to heavy metals than the grasses. Use of raw sewage water as a source of irrigation will cause metal accumulation in soils to such an extent that they may lead to toxicity in plants.

Sewage water :

Paulraj and Sree Ramulu (1994) reported that increasing levels of sludge application (5, 10, 15 and 20 t/ha) though increased the heavy metal content in the soil but did not have any detrimental effect on plants. Rather crops (Okra, Amaranthus, Tomato) grown on sludge treated soil showed stimulated plant growth on sludge contained appreciable amounts of major nutrients and its application improved soil physical properties. The higher concentration of metals *i.e.* Fe, Mn, Pb, Zn, Cr was observed without showing any evidence of metals toxicity. However, Haroon and Sree Ramulu (1990) reported that the sludge application (40 or 80 t/ha) tended to increase Cu and Zn contents above accepted toxin levels in different edible parts of crops (Okra, amaranthus onion and radish). Som *et al.* (1994) reported that in cauliflower, spinach, gourd, radish, the concentration of Zn in the leaves was exceptionally high. Pb was detected in cauliflower, spinach and radish.

The effect of irrigation with raw urban sewage effluent mixed with industrial effluent and tube well water on potato yield and plant and soil heavy metal content was studied by Tripathi *et al.* (1988). Maximum tuber yields obtained with treated effluent (28 t/ha) followed by raw sewage (22 t/ha) and tube well irrigation (18 t / ha). Very low concentrations of heavy metal assimilation were observed in tubers from raw sewage irrigation treatment; however Ca, Cd, Ni, Zn and Fe contents in soil increased. Cd, Pb and Zn concentration was high in potato grown in sewage sludge (Musgrove, 1989). Leafy vegetables like spinach and fenugreek are more sensitive to toxic pollutants than other vegetable crops because of higher amounts of accumulation of heavy metals in their leafy growth; concentration of Pb was high in Spinach and Cabbage. Spinach had higher concentration of cadmium when grown on urban sewage sludge (Table 1). Chromium accumulation in root and aerial parts of spinach was decreased as the concentration of selenate increased (Srivastava *et al.*, 1998).

Table 1: Average green yield of Spinach, fenugreek and lettuce (g/m^2)

Treatment	Spinach	Fenugreek	Lettuce
Control	300	300	400
Sludge (0) + M.R.P. (125 kg/ha)	900	500	600
Sludge (0) + M.R.P. (175 kg/ha)	1000	500	600
Sludge (15t/ha) + M.R.P(0)	1200	500	600
Sludge (15t/ha) + M.R.P. (125 kg/ha)	1200	400	500
Sludge (15t/ha) + M.R.P. (175 kg/ha)	1100	360	440
Sludge (25t/ha) + M.R.P. (0)	2000	720	780
Sludge (25t/ha) + M.R.P. (125 kg/ha)	2200	900	1000
Sludge (25t/ha) + M.R.P. (175 kg/ha)	2800	1800	1400

Misra and Mani (1994) reported that effect of different doses of sludge and Mussoorie rock phosphate on the growth and yield of leafy vegetables. Irrigations were given at an interval of 7 to 10 days with domestic sewage water. There is no harmful effect of sludge on their vegetative growth (yield) but there is a definite increase in the uptake of heavy metals by these crops when the dose of sludge is increased.

Lone *et al.* (2003) studied the heavy metal contents of okra irrigated by sewage / well water. More iron contents, compared to other micronutrients may be attributed to the fact that iron accumulates more than any other metal ion in plants. The concentration of nickel, Cadmium, lead and Chromium was much higher than the permissible level of these metal ions in edible portion of vegetables. Okra cv. PUSA SAVANI was grown with different concentrations of sewage water and sewage sludge. Cadmium accumulation was more in roots and zinc accumulation was greater in shoots: uptake and translocation of zinc was higher than that of cadmium. An increase in soil metal concentration was found positively correlated with plant metal contents (Table 2).

Table 2: Cadmium and zinc content ($\mu g\ g^{-1}$ dry weight) of *Abelmoschus esculentus* after sewage irrigation

Dilution of sewage water (v/v)		Root	Stem	Leaf	Fruit
Control	Cd	0	0	0	0
	Zn	45.0	38.0	65.0	55.0
1:3	Cd	0.6	1.4	1.8	0.4
	Zn	240.0	295.0	315.0	135.0
1 : 1	Cd	1.3	2.0	2.1	0.9
	Zn	204.0	342.0	325.0	154.0
1 : 0	Cd	1.4	2.3	2.6	1.2
	Zn	165.0	175.0	285.0	178.0

The sewage water should be used after dilution as the heavy metals like cadmium and zinc are readily absorbed by plants and are translocated to edible parts thereby causing a potential danger to consumer.

Effects of paper mill effluent on plants :

Narasimharao and Narasimharao (1992) studied the effect of paper board effluent on chilli. The leaves of chilli were yellow. The chilli plants were stunted in growth and also showed general sickly appearance from all the chilli cropped fields, perhaps due to irrigation with the effluent water having high salinity. The effluent water is not suitable for irrigating chilli, because of salinity hazard and showed abnormal colour on the leaves. The undiluted effluents drastically affected the germination, growth as well as the vigour index of tomato. Though the undiluted effluents inhibited the growth of the plants, the diluted effluents (25-50%), however, enhanced the growth. (Rajannan and Obliusami, 1979). The presence of excess amounts of soluble salts like Ca and Mg in irrigation water caused injuries to plant system. The reduction in growth of seedlings might be due to the greater amounts of Ca, Mg and solid materials in the effluents. In certain cases diluted effluents enhanced the growth of plants. This might be due to the decrease in the concentration of various chemicals in the effluents. The presence of root promoting phenolic compounds might have played a role in influencing the beneficial effect of the plant growth.

Sandana, (1995) observed that the germination and vigour index of tomato seedlings were significantly poor in undiluted effluent and it increased with decrease in concentration of the effluent. Results from pot culture experiment revealed that the pulp and paper mill effluent

Tables 3: Effect of paper mill effluent on Bhendi

Amendments	Bhendi Fresh Fruit Yield (t/ha)	
	Treated effluent	Cauvery river water
NPK alone	6.2	6.1
FYM 12.5 t ha^{-1} + NPK	7.2	7.0
ETP sludge + NPK t ha^{-1}	7.4	7.2
Composted bagasse pith 5 t ha^{-1} + NPK	7.8	7.5
Farm boon 5 t ha^{-1} + NPK	7.2	7.1
Press mud t ha^{-1} + NPK	7.1	6.6
Mean	7.1	6.8

NPK 20:50:30 kg ha^{-1}

were higher in treated effluent than raw effluents in Amaranthus, Bhendi, tomato, chilli, bitter gourd, snake gourd and Moringa (Elayarajan, 2002). Yakusherko *et al*. (1971) successfully utilized sulphate pulp and paper mill waste water on cucumber and squash.

The experimental results revealed significant higher growth and yield of bhendi var. Parbhani Kranti under effluent irrigation than conventional irrigation. The quality parameters like protein, carbohydrate, vitamin C, P and Ca were improved due to the effluent irrigation and amendments addition (Malathi, 2001) (Table 3 and 4).

Reduced level of toxic metabolites and better utilization of inorganic nutrients enhanced better germination in diluted effluent treatment. At the same time presence of toxic compounds like phenols and sodium reduced the germination level in raw effluent treatments.

Effect of sugar factory effluent on plants :

In okra germination percentages increased from 75% with tap water to 90% with 25% effluent, then fell markedly to 10% with 50% effluent, and 0% with 100% effluent. Both shoot and root length and fruit weight together with biomass and root dry weight were greatest with 25% effluent. Shoot dry weight was greatest with 50% effluent (Hari *et al*., 1994).

Table 4: Effect of diluted raw paper mill effluent on germination percentage of vegetables

Dilution ratio effluent : water	Bhendi	Brinjal	Chilli	Amaranthus	Bitter gourd	Beet root	Moringa
Control	89	81	87	87	93	79	92
1:3	81	72	78	79	85	69	85
1:1	75	69	73	74	83	65	81
3:1	71	67	69	73	77	61	76
Undiluted effluent	68	63	67	71	76	59	73
C.D. (P=0.05)	2.96	2.52	2.81	1.74	2.13	1.98	1.83

(Malathi, 2001)

irrigation had an adverse effect on tomato germination and growth parameters (Udayasoorian *et al*. 1999). Crops like potato, corn, bean, cabbage, carrot and tomato could be grown with sulphite pulp and paper mill waste water (Stephenson and Bollen, 1949). Seed germination rate, shoot length, root length and vigour index of seedlings

Rathinasamy and Lakshminarashimhan, (1999) reported that effect of sugar factory effluent on growth and yield of Bhendi. Marked difference between the undiluted treated effluent water and treated effluent water with different dilutions might be due to the high content of Ca, Mg and sulphate of the effluent water. Mixing of

Table 5: Influence of sugar factory effluent on bhendi

Treatments	Plant height (cm)	No. of fruits/ plant	Fruit yield t/ha	Crude fibre (%)
0% dilution (treated effluent)	41.5	4	9.72	1.23
25% dilution	44.5	8	10.65	1.26
50% dilution	49.5	10	11.43	1.28
75% dilution	50.5	12	12.50	1.03
100% irrigation water	52.5	13	13.06	1.25
C.D. (P=0.05)	8.75	2.80	0.70	0.06

treated effluent with irrigation water has favourable effect on the quality of fruits. The palatability of the green bhendi fruits was also good (Table 5)

Conclusion and future strategy :

The basic approach should be to increase the agricultural productivity on the one hand and to avoid soil sickness and health hazards on the other hand. Generally, it has been observed that treated waste water when used in low concentration with canal/tube well water will have an encouraging effect on crop growth and yield. But direct use of wastewater in higher concentrations will adversely affect the crops.

Emphasis should be laid on following points for profitable and safe use of waste water in agriculture.

- Scientific and accurate analysis of wastewaters should be carried out for the chemical, physical and biological composition before such waters are used for irrigation and other agricultural purposes.
- Careful wastewater irrigation schedule must be done for different crops keeping in view the nitrogen requirement of the crop in question.
- Problems of high concentration of toxic heavy metals and presence of disease pathogens in such waters should be addressed properly.
- Stringent quality control measures will have to be enforced on agricultural produce particularly the vegetables, raised with wastewater in order to avoid health hazards to consumers.
- More research efforts are needed to ascertain the long term impact of waste water irrigation on soil health and crops.

Authors' affiliations:
A. RAMESH KUMAR, Departement of Horticulture, Horticultural College and Research Institute, Tamil Nadu Agricultural University, COIMBATORE (T.N.) INDIA

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