Agropedology 2016, 26 (01), 34-39

Effect of treated Domestic Sewage Water Irrigation on Yield and Uptake of heavy metals in cotton - A Case Study from Nagpur City, Central India

A. R. Mhaske*

Agricultural Engineering Division, College of Agriculture Dr. Punjabrao Deshmukh Krishi Vishva Vidhyalaya, Nagpur, India

Abstract: Availability of irrigation water is a crucial problem especially in arid and semi-arid regions; and hence, application of wastewater in agriculture in such regions seems to be an attractive preposition. Increasing need for water has resulted in the use of treated sewage water application for agriculture. In the present study, cotton (*Gossypium hirsutum* L.) crop was irrigated with treated sewage water (TSW) through phytorid sewage treatment plant (anaerobic and aerobic conditions) and well water (WW) following completely randomized design. In both the treatments recommended NPK doses of fertilizers were applied. The results showed better crop growth throughout the growing period. Seed cotton yield was enhanced by 11.82% with treated sewage water irrigation over the irrigation by well water. The accumulation of heavy metal in plant was far below than the prescribed safe limit. Therefore findings give applicable advice to farmers and agricultural researchers for proper management and use of treated sewage water for crop irrigation.

Keywords : *Crops, Domestic wastewater, Irrigation, Plant uptake, cotton*

Introduction

Population in India is growing by geometric proportion whereas food production is growing by arithmetic proportion. Rapid industrial development and increasing population is increasingly exerting pressure on limited natural resources. The population growth has not only increased the fresh water demand but also increased the volume of wastewater generated.

Total waste water generated in India is 38255 MLD and 30% of it is treated by different means. Similarly in Maharashtra 26469 MLD wastewater is generated and 16% is treated, (CPCB, 2010). The advantages of using the TSW for irrigation will reduce the burden on fresh water, similarly it will also reduce fertiliser requirement to some extent. Use of treated wastewater for irrigation of plants and crops is gradually becoming a common practice worldwide (Angelakis *et al.* 1999), although this practice is traditionally still affected by problems of public acceptance (Pollice *et al.* 2004; Menegaki *et al.* 2007). The irrigation water quality is believed to have an effect on the soil characteristics, crops production and management of water (Shainberg and Oster 1998). Application of sewage water practiced for about three decades showed the enrichment of soils with both organic matter and nutrients without excessive accumulation of any toxic elements in soils and plants. Thus, the efficient use of such domestic sewage can effectively increase water resources for irrigation and may prove to be a boon for agricultural production. However, traces of some of the toxic ions like Ni, Cd and Pb were noticed in plants and NO_3 in some well waters should be a matter of concern and indicate the need for continued monitoring or treatment of sewage water before it is let into disposal channel for irrigation. Moreover, it may be pointed out that health hazard emerging from the use of sewage, though not assessed here, can pose restriction on its use if applied for irrigation without the appropriate remedial measures (Yadav *et al.* 2002). With the current emphasis on environmental health and water pollution issues, there is an increasing awareness of the need to use waste waters safely and beneficially. Treated

*Corresponding Author Email: mhaskear@gmail.com

Municipal Waste (TMW) use in agriculture is beneficial for a number of reasons:(a) water shortage can be partly resolved; (b) large volumes of waste water can be disposed off during an entire year; (c) high-quality water resources can be devoted to potable uses; (d) economic benefits, attributed primarily to the nutrient content of the wastewater are probable and possible (e) the availability of this additional water near population centres will increase the choice of crops grown by farmers and (f) the water is an important source of nutrients added to poor fertility soils for crop production (Oron *et al.* 1995; Pescod 1992; Biswas *et al.* 1999; Yadav *et al.* 2002; Jiménez-Cisneros 1995). Therefore, there is an urgent need to conserve and protect fresh water and to use the water of lower quality for irrigation as reported by Al-Rashid and Sherif (2000). The reuse of wastewater for agricultural irrigation purposes reduces the amount of water that needs to be extracted from water resource. It is the potential solution to reduce the freshwater demand for zero water discharge avoiding the pollution load in the receiving sources. It is the necessity of the present era to think about the existing urban wastewater disposal infrastructure, wastewater agriculture practices, quality of water used, the health implications and the level of institutional awareness of wastewater related issues (Rutkowski *et al.* 2006). It has a potential to supply (organic) carbon nutrients, nitrogen, phosphorus, potassium (NPK) and (inorganic) micro nutrients to support crop/plant growth (Weber *et al.* 2006).

Present study deals with the application of phytorid treated sewage water (TSW) for irrigation and its effect on uptake of heavy metals and yield of cotton crop in comparison with Well Water (WW).

Material and Methods

Site Description and crop details: An experimental setup was made for conducting the study to investigate the effects of application of TSW and WW on the uptake heavy metals and yield of cotton. Field experiment was carried out at agricultural farm, Agriculture College, Maharajbag, Nagpur. Phytorid based sewage treatment plant was installed and commissioned during June-2012-13 on the Nag River passing through the Agriculture College Farm (Fig. 1). The experiment design was completely randomized design with two main treatments viz. TSW (T1) and WW (T2). replicated ten times. Cotton (Bt) crop was sown in 2×2 m plots by dibbling method (June, 2012) and recommended dose of NPK (100:50:50) was applied. The crop were irrigated as per treatments.

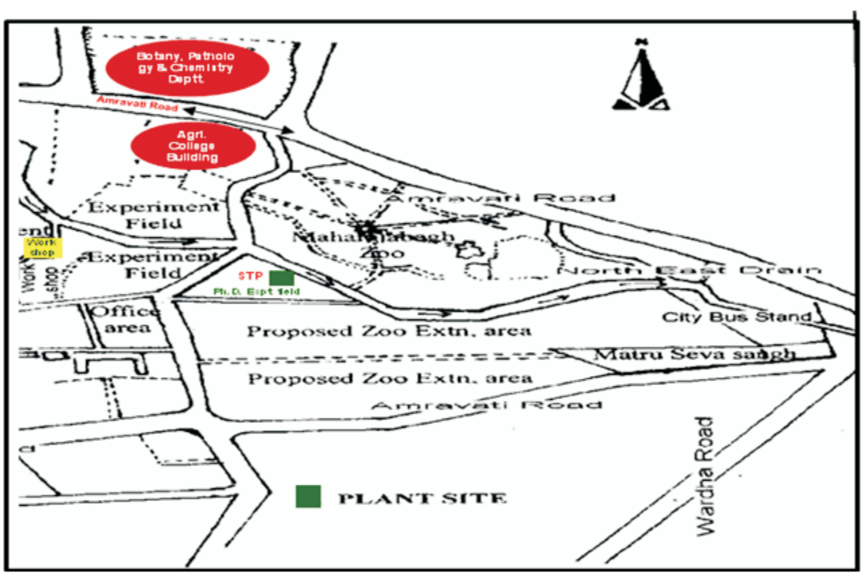

Fig.1. Location map of Nag river, phytorid sewage treatment plant and crop experimental site

Phytorid sewage treatment plant details: Phytorid bed is a scientifically developed, sustainable, constructed wetland treatment methodology for treatment of domestic waste water. Use of plant species with their root system along with natural attenuation process is combined together in phytorid technology. The system is based on use of specific plants normally natural reed with filtration and treatment capacity (Rai 2008 and Journey 2003). This system can be utilized for vide variety of applications. It can be used for secondary and tertiary treatment of municipal waste water, sludge management; treatment of industrial and agricultural effluent as well as landfill leachates. The removal mechanism of the contaminant in Phytorid sewage treatment plant is shown in Fig. 2.

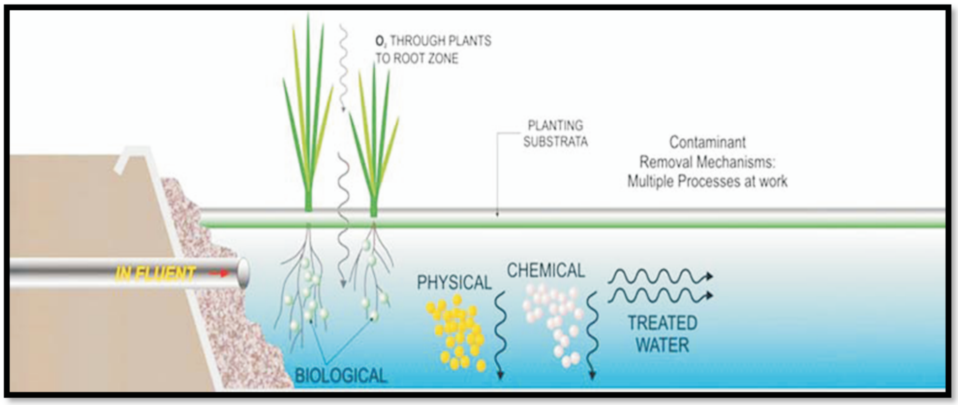

Fig.2 Contaminant removal mechanism in phytorid sewage treatment plant

Sampling of TSW and WW

Samples of TSW from treatment plant were collected two times during the study period in pre-sowing and after harvesting field crops. The samples from TSW and WW were analysed for heavy metals by standard method (Page 1982, APHA 1985)

Results and Discussion

Quality TSW and WW

The quality of irrigation water (TSW and WW) was assessed for its suitability for irrigation as per Indian standards with respect to their pH, EC, SAR, carbonate, bicarbonate, calcium, magnesium, sodium, BOD, COD, nitrogen, phosphate and potassium. The irrigation water of both the sources was slightly alkaline in reaction. (Table 1)

Table 1. Characteristics of TSW and WW used for irrigation

Parameter	DTSW	WW
pH	7.1±	7.5±0.7
Electrical Conductivity (EC) (dS m^{-1})	0.602±0	0.412±0
Specific Absorption Rate (SAR)	0.656±0	0.615±0
Carbonates (CO_3) (mgL^{-1})	0.57±0.	0.30±0.
Bicarbonates (HCO_3^-) (mgL^{-1})	3.81±0.	3.18±0.
Chlorides (Cl^-) (mgL^{-1})	3.68±0.	1.48±0.
Calcium (mgL^{-1})	4.12±0.	2.68±0.
Magnesium (mgL^{-1})	1.42±0.	0.72±0.
Sodium (Na) (mgL^{-1})	1.09±0.	0.80±0.
Biological Oxygen Demand (BOD) (mgL^{-1})	4.14±0.	1.62±0.
Chemical Oxygen Demand (COD) (mgL^{-1})		5.
Total Dissolved Salts (TDS) (mgL^{-1})	399±0.6	278±0.8
Nitrogen (mgL^{-1})	3.7±0.2	1.1±0.0
Phosphate (mgL^{-1})	1.3±0.8	0.26±0.
Potassium (mgL^{-1})	0.32±0.	0.22±0.

The pH of the TSW was (7.1) slightly lower than the WW (7.5), whereas salt content (EC 0.602 dS m^{-1}) was higher than that of WW. Calcium was the dominant cation followed by magnesium and sodium. The sodium content was slightly higher in TSW. The sodium adsorption ratio (SAR) of both the water resources is much less than the critical limit. Carbonate and bicarbonate of the TSW were slightly higher than the WW, whereas chloride content was 2 to 3 fold higher in TSW than WW. On the basis of SAR both the water were suitable for irrigation. On the basis of BOD and COD, the TSW was rated as suitable for irrigation purpose when compared with the prescribed limit of 100 and 250 mg L^{-1} for BOD and COD respectively (prescribed limits by BIS for irrigation). All the major nutrients (NPK) were slightly higher in TSW than WW. Nitrogen was three times higher, phosphorus was five times more and potassium was slightly higher in TSW.

Crop Yield

Effect of TSW irrigation on yield and growth of cotton

The growth parameters like height, number of branches (monopodia: single continuous vegetable axis and simpodia : number of branches more than one), bolls per plant, weight per boll and seed cotton yield got significantly influenced by irrigation with TSW as compared to irrigation by WW.

Table 2. Effect of TSW irrigation on growth and yield of cotton

Treatment	**Plant height(cm)**				**No. of branches**		**Bolls Per plant**	**Wt/boll (g)**	**Seed cotton Yield (q ha^{-1})**
	30	**60**	**90**	**120**	**Monopodia**	**Sympodia**			
T_1- TSW	26.28	62.70	82.30	104.4	6.40	23.10	32.70	4.45	26.91
T_2- WW	24.00	60.00	75.40	96.0	5.10	18.90	30.0	4.31	23.52
SE (m)±	0.64	0.97	1.78	1.84	0.33	00.61	0.91	0.07	0.666
CD at 5 %	1.93	2.89	5.30	5.47	0.97	1.81	2.61	----	2.133
F Test	*	*	*	*	*	*	*	NS	*

*Significant

The data pertaining to the growth parameters and yield (Table 2) revealed that the plant height increased by 4.50 to 11.66% during 30 to 120 days of growth period. Similarly higher monopodia (6.40) and sympodia (23.10) were noticed in case of the irrigation with TSW. The seed cotton yield was increased by 11.82% over the irrigation by WW. Similar findings of increased yield of cotton was also reported by Alikhashi *et al.* (2012) in treatments consisting of surface irrigation by different mixtures and as well, through different intervals of freshwater plus treated municipal wastewater. The enhancement in the yield might be attributed to the higher nutrient contents in the TSW as compared to the WW.

The concentration of micronutrients Zn, Fe, Cu, and Mn in cotton plant (leaves, stem and roots) irrigated with the TSW were 48.20, 557, 17.60 and 40.40 mg kg^{-1} respectively, which were slightly higher than the irrigation with WW. By and large, accumulation of these elements due to irrigation with TSW was well below the critical limits prescribed for the phytotoxicity Similar findings was also reported by Al-Ansari *et al.* (2013) for the vegetable crop irrigated with TSW through Khirb alsamara wastewater plant (not based on phytorid treatment).

Table 3. Concentration of heavy metals in cotton

Treatments	Heavy metals content (mg kg^{-1})							
	Zn	Fe	Cu	Mn	Co	Cd	Cr	Pb
T_1-Treated water	45	489	7.90	18	0.53	0.42	0.79	0.96
T_2-Well water	39.5	471	6.80	14.30	0.49	0.39	0.76	0.94
Safe limit	1-400	500	20-1000	5-20	0.02-1	0.1-2.4	0.03-1.4	0.2-20
'F' test	NS	NS	NS	NS	NS	NS	NS	NS
SEm (±)	3.86	10.58	0.75	1.96	0.05	0.05	0.05	0.08

Reference for safe limit: Fundamentals of Soil Science pp: 352

Data reported in Table 3 indicated that the content of extractable heavy metals *viz*., Co, Cd, Cr and Pb in the cotton plant were not accumulated due to irrigation with TSW. The content of Co, Cd, Cr and Pb was observed to the tune of 0.53, 0.42, 0.79 and 0.96 mg kg^{-1} respectively in the cotton plant irrigated with TSW which were below the critical limits prescribed for the phytotoxicity of these metals. Similar finding was also reported for the crops irrigated with domestic sewage and TSW respectively by Yadav *et al.* (2002).

Conclusions

The growth parameters and yield response of cotton crop with the TSW irrigation showed significant increase over WW irrigation. Hence sewage water treated with phytorid wetland technology can be a potential water resource with nutrients content. Higher cotton yield (26.00 q ha^{-1}) was observed in treated sewage irrigation as compared to WW irrigation (23.25 q ha^{-1}). The concentration Zn, Fe, Cu, and Mn in cotton irrigated with TSW showed no significant change over WW. The concentration of heavy metals like Co, Cd, Cr and Pb in cotton plants irrigated with TSW showed non significant change over WW. The accumulation of heavy metals due to irrigation with TSW was observed well below the critical limits prescribed for the phytotoxicity of these metals.

References

Al-Ansari, Nadhir., Aldardor W., Siergieiev D. and S. Knutsson (2013). Effect of treated wastewater irrigation on vegetables. *Journal of Environmental Hydrology*,1-12.

Alikhasi, M., Kouchakzadeh M. and Baniani E. (2012).The effect of treated municipal wastewater Irrigation in non-agricultural soil on cotton plant. *Journal of Agriculture Science Technology* 14 1357-1364.

Al-Rasherid, M.F. and Sherif, M.M.(2000) Water resources in the GCC countries: an overview, *Water Resource Management* 14. 59–73.

Angelakis, A. N., Marecos Do Monte, M. H. F., Bontoux, L. and Asano, T. (1999). The status of Wastewater reuse pactice in the Mediterranean Basin: Need for Guidelines. *Water Resource Management* 33, 2201-2217.

APHA (American Public Health Association) (1995). Standard Methods for the examination of water and wastewater. American Public Health Association, Washington, DC.

Biswas, T. K., Higginson, F. R. and Shannon, I. (1999). Effluent nutrient management and resource recovery in intensive rural industries for the protection of natural waters. *Journal of Water Science Technology,* **40,** 19-27.

Jiménez-Cisneros, B. (1995). Wastewater reuse to increase soil productivity. *Journal of Water Science Technology,* **32,** *173-180.*

Journey, Tim (2003). Vetiver grass use in constructed wetlands to recover water from waste waterat .

Menegaki, A. N., Hanley, N. and Tsagarakis, K. P. (2007). The social acceptability and valuation of recycled water in crete: A study of consumers' attitudes. *Ecology Econ.,* **62,** 7-18.

Oron, G. and DeMalach, Y. (1995). Response of cotton to treated domestic wastewater applied through trickle irrigation. *Irrigation . Science,* 8: 291-300.

Page, A. L., Miller, R. H. and Keemey, D. R. (1982). Methods of soil analysis. 2nd Edn., *American Society of Agronomy*, Madison, WI., USA.

Pescod, M. B. (1992). Wastewater treatment and use in Agriculture. Paper 47, Irrigation and Drainage, FAO, Rome.

Pollice, A., Lopez, A., Laera, G., Rubino, P. and Lonigro, A. (2004). Tertiary filtered municipal wastewater as alternative water source in Agriculture: A field investigation in Southern Italy. *Sci. Total. Environ.,* **324** , 201–210.

Rai, Prabhat Kumar (2008). Heavy metal pollution in aquatic ecosystems and its phytoremediation using wetland plants: an eco-sustainable approach. *International Journal of Phytoremediation* 10, 133–160.

Rutkowski, T., Raschid-Sally L., Buechler S (2006). Wastewater irrigation in the developing world – Two case studies from the Kathmandu valley in Nepal, *Agric Water Management,* 88, 83–91.

Shainberg, I. and Oster J.D. (1978). "Quality of Irrigation water", *Pergam on Press*, London.

Weber, B., Avnimelech Y. and Juanico M. (2006). Salt enrichment of municipal sewage : New prevention approaches in Israel, *Environment Management,* 20 487–495.

Yadav, R.K., Goyal B., Sharma R.K. , Dubey S.K. and Minhas P.S. (2002). Post-irrigation impact of domestic sewage effluent on composition of soils, crops and ground water- A case study. *Environment International*, 481-486.

Received : April, 2016 *Accepted : June, 2016*