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Effect of sewage water irrigation on yield, heavy metal accumulation in grain and soil

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Abstract
The shortage of available water for existing living organism received the great attention in present day scenario. One of the suitable alternatives for meeting water demands is the reuse of waste water especially in a field of agriculture to increase the productivity. The Tiruchirappalli district city corporation sewage water is stored near Panchappur and it is stored in open aerated lagoons and eight benchmark sites were selected to monitor the heavy metal accumulation in soil and crops during 2012-13 and 2013-14. The farmer's were selected in different locations of sewage water ways and they have utilised sewage water as a main source of irrigation for their crops. The paddy variety BPT-5204 was used as test crop. The sewage irrigated field recorded the highest yield of 6230 kg ha^{-1} than bore well irrigated field during 2013-14. The increased yield in the soil might be ascribed to the enhanced availability of plant nutrients supplied directly through the raw sewage water (RSW) which had higher nutrient potential. The reuse of wastewater in rice cultivation promises a higher yield than the use of groundwater alone. During 2012-13 and 2013-14 the soil samples were collected from sewage water irrigated field and also from bore well water irrigated field to assess the heavy metal contents. The heavy metals like nickel, lead and cadmium were analysed. The concentration of heavy metal found to be in low concentration during the 2014 than in 2013. The Sewage water irrigation had no significant effect on soil heavy metals (Pb and Cd) accumulation in soil regardless of duration of wastewater irrigation. Soils irrigated with treated wastewater for many years were found to have no significant heavy metal concentrations in soil. The soil application of sewage water could offer the double benefit of safe disposal of waste water and also effective recycling of nutrient for agricultural production.

Keywords: Sewage water, heavy metals, rice and yield

Introduction
Water is an essential component of the environment and it sustains life on the earth. It governs the evolution and function of the universe on the earth hence water is "mother of all living world". The shortage of available water for existing living organism received the great attention since a long time ago. Because of uneven distribution of water resources, nearly 80 countries or more than 40 percent of the world's population are suffering with water shortage. Recently, the reuse of waste water has been suggested as one of the suitable alternatives for meeting water demands, especially in a field of agriculture. The demand for water is continuously increasing in arid and semi-arid countries. Therefore, water of higher quality is preserved for domestic use while that of lower quality is recommended for irrigation. Sewage waste water is less expensive and considered as an attractive source for irrigation. Sewage water is mainly composed of either organic, inorganic matter or both and some toxic substances depending on it source. Rapid growth of urban population and industrialization results in generation of huge quantities of wastewater perennially. Wastewater rich in organic materials and plant nutrients is finding agricultural use as a cheap way of disposal. As demand for fresh water intensifies, wastewater is frequently being seen as a valuable resource and is an important alternative source of water for irrigation (Noori *et al*., 2013) [8]. Moreover, the rising cost of commercial fertilizers have stimulated interest in the use of sewage water for irrigating agricultural crops in the vicinity of big cities because of its essential plant nutrient content which serves as a low analysis fertilizer. Because of limited availability of the good quality water for irrigation, sewage water is being increasingly used in the peri-urban agricultural activities (Maiti *et al*., 1992; Sree Ramulu, 1994) [6, 10]. Hence, the possibilities of its safe disposal on agricultural lands for crop production and its impact on soil and crop have been explored in the present investigation.

The Tiruchirappli district city corporation sewage water is stored near Panchappur and it is stored in open aerated lagoons. This sewage water has been mixed in the Koraiyar river has been surveyed and eight benchmark sites were selected to monitor the heavy metal accumulation in soil and crops during 2012-13 and 2013-14. The farmer's were selected in different locations of sewage water ways and they have utilised sewage water as a main source of irrigation for their crops. The paddy variety BPT-5204 was used as test crop and the fertiliser dose applied was 150 kg N ha^{-1}, 50 kg P ha^{-1} and 50 kg K ha^{-1}. The fertiliser source applied was Urea, Single super phosphate and Muriate of postash. The nitrogen and potash were applied in four equal splits viz., basal, tillering, panicle initiation and heading whereas the full dose phosphourous was applied as basal before transplanting. The yield was recorded in the OFT trials with and without sewage irrigation (Bore well water) and the results showed that the bore well water recorded higher grain yield than sewage water (Table 1). The grain yield of paddy ranged from 5510 to 6350 kg ha^{-1} and 5220 to 5880 kg ha^{-1} in sewage water irrigated and bore well irrigated fields, respectively during 2012-13. During 2013-14 also similar trend of yield pattern was observed but there was a variation yield at different location. The sewage irrigated field recorded the highest yield of 6230 kg ha^{-1} and the lowest (4390 kg ha^{-1}) was recorded in bore well irrigated field during 2013-14.

The increased yield in the soil might be ascribed to the enhanced availability of plant nutrients supplied directly through the raw sewage water (RSW) which had higher nutrient potential. Further, the RSW directly would have caused more nutrient availability. The positive correlation established between the available N, P and K on yield also lend support to this reasoning. The sewage water contains large amount of nutrients and therefore could be used as a source of irrigation as evident by the results reported by Juwarkar (1991) [3]; Chakarbarti and Chakarbarti (1995) [1] and Mahida (1981) [5]. Kang *et al*. (2007) [4] also found that the reuse of wastewater in rice cultivation promises a higher yield than the use of groundwater alone.

In the selected benchmark sites soil and plant samples were collected and analysed for heavy metals during 2012-13 and 2013-14. The analytical reports of sewage water irrigated field showed that the Ni content in grain (0.007 ppm) was higher compared to Pb (0.005) whereas the Cd content in grains irrigated with sewage and bore well water did not showed any concentration during 2012-13 (Table 2). The analytical reports of sewage water irrigated field tested during 2013-14 showed that the Pb and Ni content in grain ranged from 0.002 to 0.006 and 0.004 to 0.006, respectively in sewage water irrigated field. Whereas the grain Cd concentration found to be below the detectable limit in both sewage and bore well water irrigated field. Irrespective of the locations the field irrigated with bore well did not showed any heavy metals in the paddy grains.

During 2012-13 and 2013-14 the soil samples were collected from sewage water irrigated field and also from bore well water irrigated field to assess the heavy metal contents. The results showed that there were no heavy metals in the bore well water irrigated soils in different locations whereas the sewage water irrigated field recorded higher Ni content (0.008 ppm) than Pb (0.006 ppm) during 2012-13. With respect to the Cd content in soils of different locations there is no detectable concentration was observed during 2012-13 (Table 3). Whereas during 2013-14, the analytical results showed that there were no heavy metals in the bore well water irrigated soils in different locations whereas the sewage water irrigated field recorded higher Ni content (0.007ppm) than Cd (0.005 ppm) and Pb(0.004) and the lowest Ni content of 0.005 ppm, 0.003 ppm of Cd and 0.002 ppm of Pb (Table 3). Munir *et al.* (2007) [7] noted that wastewater irrigation had no significant effect on soil heavy metals (Pb and Cd) accumulation in soil regardless of duration of wastewater irrigation. Similar results have been reported by Sanjany and Hajrasoliha (1995) [9] and Feigin *et al.* (1991) [2]. Soils irrigated with treated wastewater for about 16 to 28 years were found to have no significant heavy metal concentrations in soil.

On the basis of the results from the on-farm trials, the values of these heavy metals in the soil and paddy grains in different locations were within the permissible limits of WHO, FAO and Indian standards. This waste water is having considerable amount of nutrients and organic matter. The beneficial effect of organic matter for enhancing the soil fertility and thereby improving the crop productivity. Hence, the soil application of sewage water could offer the double benefit of safe disposal of waste water and also effective recycling of nutrient for agricultural production. These findings suggest that further work on use of sewage water on long term basis will provide more details regarding the accumulation of metals in soil and plant system.

Table 1: Grain yield of paddy with and without sewage water irrigation (OFT trials) in different locations of Tiruchirappalli district

S. No	Name of the Farmer	Geographical-Co-ordinates	2012-13 Grain yield (kg ha^{-1})		2013-14 Grain yield (kg ha^{-1})	
			Bore well water	Sewage water	Bore well water	Sewage water
1	Mr. Mariyakanikai Iniyanur	N10° 48.000' E078° 39.135'	5840	6350	5080	6230
2	Mrs. M. Sabariamal Iniyanur	N10° 47.957' E078° 39.236'	5660	6010	4870	5980
3	Mr. M. Ashok kumar Inniyanur	N10° 48.142' E078° 39.005'	5220	5510	4390	6020
4	Mrs. A. Jothimani Iniyanur	N10° 47.782' E078° 39.036'	5400	5920	4500	5100
5	Mr. R. Mani Koraiyar	N 10º 47.729' E 078º39.817'	5880	6320	4800	5700
6	Mr. V. S. Rajendran, Ponneripuram	N10° 46.814' E078° 43.915'	5710	6250	5200	5980
7	Mr. V. S. Paramasivam, Nathamadipatti	N10° 46.659' E078° 43.673'	5480	5800	4980	5880
8	Mr. M. Arokiyaraj Ponneripuram	N10° 45.645' E078° 44.239'	5618	6040	4700	5920

Table 2: Heavy metal content in paddy grains under OFT trials with and without sewage water irrigation in Tiruchirappalli district

S. No	Name of the Farmer	2012-13 Heavy metals in grains						2013-14 Heavy metals in grains					
		Pb (ppm)		Cd (ppm)		Ni (ppm)		Pb (ppm)		Cd (ppm)		Ni (ppm)	
		SW	BW	SW	BW	SW	BW	SW	BW	SW	BW	SW	BW
1	Mr. Mariyakanikai Iniyanur	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	0.002	BDL	BDL	BDL	0.005	BDL
2	Mrs. M. Sabariamal Iniyanur	0.002	BDL*	BDL*	BDL*	0.006	BDL*	BDL	BDL	BDL	BDL	BDL	BDL
3	Mr. M. Ashok kumar Inniyanur	0.004	BDL*	BDL*	BDL*	BDL*	BDL*	0.006	BDL	BDL	BDL	0.004	BDL
4	Mrs. A. Jothimani Iniyanur	BDL*	BDL*	BDL*	BDL*	0.007	BDL*	BDL	BDL	BDL	BDL	BDL	BDL
5	Mr. R. Mani Koraiyar	0.005	BDL*	BDL*	BDL*	BDL*	BDL*	0.004	BDL	BDL	BDL	0.006	BDL
6	Mr. V. S. Rajendran, Ponneripuram	BDL*	BDL*	BDL*	BDL*	0.004	BDL*	BDL	BDL	BDL	BDL	BDL	BDL
7	Mr. V. S. Paramasivam, Nathamadipatti	0.003	BDL*	BDL*	BDL*	BDL*	BDL*	BDL	BDL	BDL	BDL	BDL	BDL
8	Mr. M. Arokiyaraj Ponneripuram	BDL*	BDL*	BDL*	BDL*	0.002	BDL*	0.006	BDL	BDL	BDL	0.004	BDL

*Below the detection limit

Table 3: Heavy metal content of soil of OFT trials with and without sewage water irrigation in Tiruchirappalli district

S. No	Name of the Farmer	2012-2013 Heavy metals in soil						2013-2014 Heavy metals in soil					
		Pb (ppm)		Cd (ppm)		Ni (ppm)		Pb (ppm)		Cd (ppm)		Ni (ppm)	
		SW	BW	SW	BW	SW	BW	SW	BW	SW	BW	SW	BW
1	Mr. Mariyakanikai Iniyanur	BDL*	BDL*	BDL*	BDL*	BDL*	BDL*	BDL	BDL	BDL	BDL	BDL	BDL
2	Mrs. M. Sabariamal Iniyanur	0.003	BDL*	BDL*	BDL*	0.006	BDL*	BDL	BDL	BDL	BDL	0.006	BDL
3	Mr. M. Ashok kumar Inniyanur	0.004	BDL*	BDL*	BDL*	BDL*	BDL*	0.002	BDL	0.003	BDL	BDL	BDL
4	Mrs. A. Jothimani Iniyanur	BDL*	BDL*	BDL*	BDL*	0.008	BDL*	BDL	BDL	BDL	BDL	BDL	BDL
5	Mr. R. Mani Koraiyar	0.006	BDL*	BDL*	BDL*	BDL*	BDL*	0.003	BDL	0.004	BDL	0.007	BDL
6	Mr. V. S. Rajendran, Ponneripuram	BDL*	BDL*	BDL*	BDL*	0.005	BDL*	0.004	BDL	BDL	BDL	0.005	BDL
7	Mr.V.S. Paramasivam Nathamadipatti	0.004	BDL*	BDL*	BDL*	BDL*	BDL*	0.003	BDL	0.005	BDL	BDL	BDL
8	Mr. M. Arokiyaraj Ponneripuram	BDL*	BDL*	BDL*	BDL*	0.003	BDL*	BDL	BDL	BDL	BDL	0.006	BDL

*Below the detection limit

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