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Effect of Treated Sewage Water Irrigation on Yield and Quality of Mulberry

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Authors' contributions

This work was carried out in collaboration among all authors. Author MAK designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript and author SC managed the analyses of the study. Both the authors read and approved the final manuscript.

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ABSTRACT

Aim: Evaluation of raw and treated sewage water irrigation on yield and quality of V1 mulberry.
Study design: The Experiment was laid out in a Randomized Complete Block Design (RCBD) with four replications and six treatments comprises of different proportions of raw sewage water, treated sewage water and borewell water.
Place and duration of study: The study was conducted during *Rabi* 2019 in pre-established irrigated V1 mulberry garden at Department of Sericulture, University of Agricultural Sciences, GKVK, Bengaluru, Karnataka, India.
Results: Data recorded on quality parameters of mulberry revealed that raw sewage water irrigation significantly increased the leaf nutrient content such as N (3.68%), P (0.4%), K(1.91%), S (0.34%), Zn (30.08 ppm), Mn (103.75 ppm), Fe (373.75 ppm) and also leaf yield (804.31 g/plant) is significantly increased in 100% raw sewage water irrigation, whereas higher leaf Ca (2.06%) and Mg (0.71%) content was recorded in 100% borewell water irrigated plot, and the lowest leaf N (2.82%), P (0.28%), K (1.33%), S (0.17%), Zn (18.03 ppm), Mn (75.75 ppm), and Fe (336.5 ppm) content was found lower in 100% borewell water irrigation.

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Keywords: Mulberry leaf quality; leaf yield; raw sewage water; treated sewage water.

1. INTRODUCTION

Sericulture is an agro-based rural industrial sector with immense potential on both economic and social fronts and is a major livelihood of marginal and small farmers in India. India is the second-largest producer of silk in the world next to China and also the only country producing all four varieties of silk *viz.* Mulberry, Eri, Tasar and Muga. The total area under mulberry cultivation in India and state (Karnataka) is about 2.24 lakh ha and 98,135 ha in 2017-18 compared to 2.17 lakh ha and 91,492 ha in 2016-17, respectively. In Karnataka, about 80.0 per cent of the mulberry region is under the irrigated condition and a high yielding mulberry variety (V1) is being cultivated [1].

Water is changing into the foremost vital limiting natural resources today and seventy per cent of global freshwater is being utilized for irrigation. Scarcity of surface and ground water can be partly overcome by recycling or utilization of sewage water and its multiple uses have become an additional importance to satisfy the multiplied demand of agricultural production [2].

United Nations Food and Agricultural Organisation (FAO) stated that nearly 10 per cent of agricultural irrigated land receives raw sewage or primarily treated sewage water globally which encloses around 20 million hectares. This is a largely hidden practice and is illegal in many countries. Sewage water potentially contains nutrients with full of nitrates and phosphates that could be used as a wonderful fertilizer to plants [3]. It reduces the cost of cultivation, with a reliable and cheap means of sewage water disposal.

Chandraju et al. [4] conducted an experiment that mulberry varieties S-30, S-36 and Vishwa (DD) were irrigated with distillery spentwash of various concentrations. In both 33 per cent and 50 per cent spentwash irrigation, the uptake of the nutrients such as calcium, zinc, copper and vitamin carotene and vitamin c were almost similar but the uptake of the nutrients such as protein, fibre, carbohydrate, energy, magnesium and phosphorous were much more in the case of 33 per cent spentwash irrigation than 50 per cent and raw water irrigations.

Ambika et al. [5] compared the quality parameters of mulberry (*Morus alba* L.) leaves irrigated with sewage and borewell water. The results revealed that a significant increase in reducing sugars, phenolic compounds, two micronutrients (Mn & Cu) in the samples collected from sewage irrigated gardens over borewell irrigated mulberry garden. Though higher concentration of carbohydrate, total chlorophyll, carotenoid, nitrogen and potassium were estimated in leaf samples from sewage water irrigated gardens over borewell irrigation, the values were found non-significant.

Bongale and Krishna [6] investigated the impact of untreated sewage and borewell water irrigation on quality traits of mulberry (*Morus indica* L.). Total nitrogen and chlorophyll content, soluble protein content, sugar content, calcium and magnesium were analysed from different leaf samples. Results revealed that significantly higher concentrations of leaf chlorophyll, protein, nitrogen, phosphorous and potassium were observed in raw sewage water irrigated mulberry gardens compared to borewell water irrigated mulberry.

Another important aspect is the precipitation of heavy metals such as Pb, Cd, Fe, Cr, Ni, etc. may negatively impact crop quality [7]. Once heavy metal concentration increase in soils, are generally difficult to remove, so subsequent efforts should be deployed to immobilize the metal accumulation in soils.

In Sericulture, irrigation with various waste waters like silk reeling waste water, distillery spent wash, industrial waste discharge are emphasized which are more in plants essential nutrients for mulberry growth and development.

2. MATERIALS AND METHODS

The study was conducted during *Rabi* 2019 in pre-established irrigated V1 mulberry garden at Department of Sericulture, University of Agricultural Sciences, GKVK, Bengaluru, Karnataka, India. The type of soil is clay loam and annual rainfall ranges from 528 mm to 1374.4 mm with the mean of 915.8 mm [8]. The Experiment was laid out in a Randomized Complete Block Design (RCBD) with four replications and six treatments (Fig. 1), comprises of different proportions of raw sewage water, treated sewage water and borewell water. V1 mulberry garden was ploughed once, middle pruned and supplied with the recommended dose of FYM of 20t/ha/year. Recommended dose of fertilizer 350:140:140 kg NPK/ha/yr was applied in five splits in the form of urea, single super phosphate and muriate of potash as sources of nitrogen, phosphorus and potassium, respectively. The cultural practices were followed as per the recommended package of practices [9]. Mulberry leaf samples were collected from each treatment and replication at 45 days after pruning (DAP) for analysis whereas, leaf yield was recorded at 60 DAP.

The crop was irrigated through flood irrigation system once in 7 days for 70 days (totally 10 irrigations). The calculated total water requirement was 1, 15,500 liters for 342 m^2 area in entire crop duration. Number of mulberry plants in experimental plot: 16 rows × 30 plants = 315 plants. Number of mulberry plants per plot: 4 rows × 5 plants = 20 plants (leaving border effect there were 6 plants for recording observations).

The data analyzed on various parameters were subjected to Fisher's method of Analysis of Variance (ANOVA) and interpreted according to Gomez and Gomez [10].The level of significance used in F and t-tests was P=0.05 for RCBD. The critical difference (CD) values were computed where the F test was found significant.

R- Ⅰ	R- Ⅱ	R-Ⅲ	R-Ⅳ

T_5	**T_4**	**T_2**	**T_1**
T_1	**T_2**	**T_6**	**T_3**
T_3	**T_6**	**T_4**	**T_5**
T_2	**T_1**	**T_3**	**T_6**
T_6	**T_5**	**T_1**	**T_4**
T_4	**T_3**	**T_5**	**T_2**

Fig. 1. Plan and layout of the experimental plot designed

Chart 1. The treatment details are presented below

Treatment details:	
T_1-	100% borewell water irrigation
T_2-	25% treated sewage water + 75% borewell water irrigation
T_3-	50% treated sewage water + 50% borewell water irrigation
T_4-	75% treated sewage water + 25% borewell water irrigation
T_5-	100% treated sewage water irrigation
T_6-	100% raw sewage water irrigation

Table 1. Methodology for analysing various parameters in different leaf samples

S.No.	Parameter	Method	Reference
1	Nitrogen	Microkjeldhal Digestion Distillation Method	[11]
2	Phosphorus	Spectrophotometer Method @ 430 nm	Jackson [12]
3	Potassium	Flame Photometer Method	Jackson [12]
4	Calcium	EDTA Versonate-Titration Method	Jackson [12]
5	Magnesium	EDTA Versonate-Titration Method	Jackson [12]
6	Sulphur	Turbidometric Method	Jackson [12]
7	Micro nutrients (Fe, Mn, Cu, Zn) and Heavy metals (Ar, Co, Ni)	Atomic Absorption Spectrophotometer	[13].

Table 2. Physio-chemical characterization of raw sewage water (RSW), treated sewage water (TSW) of STP and borewell water (BW) of GKVK, Bengaluru

Parameters	Raw sewage water	Treated sewage water	Borewell water
pH (1:2.5)	7.90	7.83	7.63
EC (dS/m)	0.79	0.60	0.85
Carbonates	Nil	Nil	Nil
Bicarbonates	88.00	62.00	52.00
Chlorides	190.00	149.00	235.00
Sulphates	2.60	2.20	Nil
Total nitrogen	53.00	25.1	9.30
Total PO_4	1.31	1.08	Nil
Total K	7.31	6.24	0.41
Calcium	13.42	7.21	14.21
Magnesium	1.61	1.03	2.10
Sodium	1.02	0.70	0.99
Iron	1.21	0.42	Nd
Manganese	0.33	0.14	0.08
Zinc	0.19	0.10	0.01
Copper	0.16	0.01	Nd
Arsenic	Nd	Nd	Nd
Cobalt	Nd	nd	Nd
Nickel	0.04	0.03	Nd
SAR	0.37	0.34	0.34
RSC (meq/L)	0.635	0.565	-0.33
Boron	Nd	nd	Nd

Note: - All values are in mg L^{-1}, unless mentioned; - SAR - Sodium adsorption ratio, RSC - Residual sodium carbonate (meq/L); - nd = not detected

3. RESULTS AND DISCUSSION

The data on mulberry leaf yield and quality parameters of V1 mulberry such as leaf nitrogen, phosphorous, potassium, calcium, magnesium, sulphur, iron, zinc, manganese, copper, cobalt, arsenic, nickel as influenced by the different proportion of raw sewage, treated sewage and borewell water irrigation along with recommended dose of NPK and FYM are presented in Table 3, 4, 5, 6 and 7.

3.1 Influence of Raw and Treated Sewage Water Irrigation on Plant Yield

The data presented in the Table 3 revealed that leaf yield per plant varied in the range from 696.63 g to 804.31 g at 60 DAP. The significant higher leaf yield per plant (804.31 g) was recorded in 100% raw sewage water irrigation, which was statistically on par with 100% treated sewage water irrigation (795.14 g). However, lowest leaf yield/plant (696.63 g) was recorded when mulberry was raised by irrigating borewell water alone. The significantly higher leaf yield/ha/yr (54319 kg) was estimated in 100% raw sewage water irrigation whereas, lower leaf yield/ha/yr (46760 kg) was calculated when mulberry was raised by irrigating borewell water alone.

The results of the present investigations are similar with the findings of Chikkaswamy et al. [14] recorded higher leaf yield of 860 g/plant and 1480 g/plant in S-54 and M-5 mulberry varieties respectively when irrigated with raw sewage water. The results are in agreement with previous findings of Kasiviswanathan et al. [15] who stated that increased total leaf yield in mulberry due to increased NPK level in soil which attributed to increased growth parameters particularly number of leaves per plant, leaf area per plant and leaf dry weight per plant.

3.2 Influence of Raw and Treated Sewage Water Irrigation on Primary Nutrients (N, P, K) Content of Mulberry Leaves

Significantly higher leaf nitrogen, phosphorus and potassium contents of 3.68, 0.40, 1.91 per cent, respectively was noticed in mulberry irrigated with 100% raw sewage water at 45 DAP which was on par with 100% treated sewage water irrigation (3.56% N, 0.39% P and 1.86% K). The lowest nutrient content in leaf (2.82% N, 0.28% P and 1.33% K) was noticed when mulberry was raised by irrigating borewell water alone (Table 4).

The results are in conformity with the research findings of Ravindra Chary [16] recorded higher leaf N (4.31%), P (0.53%) and K (1.99%) with the application of raw sewage water to V-1 mulberry garden along with the recommended dose of NPK fertilizer and FYM.

3.3 Influence of Raw and Treated Sewage Water Irrigation on Secondary Nutrients (Ca, Mg, S) Content of Mulberry Leaves

Significantly higher leaf calcium and magnesium contents of 2.06, and 0.71 per cent, respectively was noticed in mulberry irrigated with 100% Borewell water which was statistically on par with 100% raw sewage water irrigation (1.93% Ca, and 0.70% Mg) at 45 DAP. The lowest leaf Ca (1.43%) and Mg (0.42%) was noticed in mulberry irrigated with 100% treated sewage water (Table 5). Significant higher leaf Sulphur content (0.34%) was recorded in mulberry irrigated with 100% raw sewage water.

This may be due to the presence of higher concentration of calcium and magnesium in borewell water (Table 2) when compared to sewage water. This clearly indicates that leaf nutrient availability is based on the irrigation water and fertilizer application.

3.4 Influence of Raw and Treated Sewage Water Irrigation on Micronutrients (Fe, Mn, Cu, Zn) and Heavy Metal (Ar, Co, Ni) Content of Mulberry Leaves

Among all the treatments, the leaf micronutrients were significantly higher in 100% raw sewage water irrigated plots with 30.08 ppm zinc, 103.75 ppm manganese, and 373.75 ppm iron. There is no significant difference found in availability of copper in leaf however higher copper concentration of (4.16 ppm) found in 100% raw sewage water irrigated plots (Table 6).

Similar results were also observed by Prince et al. [17] who reported that in case of copper, lower mobility from soil to mulberry root was observed. The current study is supported by Chandrakala et al. (2009) who recorded maximum zinc (46.3 ppm, 43.3 ppm, 122.3 ppm), and iron (605.3 ppm, 340.9 ppm, 639.7 ppm) content in mulberry leaf samples collected from three different places Kengeri, Mayagaanhalli, Byramangala areas of Bengaluru, respectively irrigated with Vrishabhavathy stream water which is polluted by domestic sewage water.

The heavy metals translocation in leaf were showed non- significant increase in 100% raw sewage water irrigated plot with 1.51 ppm nickel. The lowest Ni (0.89 ppm) content of leaf was recorded when mulberry was raised by irrigating borewell water alone (Table 7). Similarly, arsenic and cobalt level were below detection level in all leaf samples.

The increased availability of nickel in all the treatments might be due to increased concentration of nickel in soil which is due to raw and treated sewage water irrigation. Prince et al. [18] stated that mulberry was found to be a non- hyper accumulator of Co, when the initial concentration of Co was low the bio accumulation in mulberry leaf also reduced. When nickel chloride treatment was given, the lipid content increased in *Bombyx mori* at 0.25 and 0.5 per cent. But higher concentration *i.e.* 0.75 per cent the reverse effects were noticed, it clearly indicates the deleterious effects of nickel at higher concentrations [19].

However close monitoring of heavy metals contents in soil is necessary in the area where sewage water is given as irrigation.

Table 3. Effect of raw and treated sewage water irrigation on leaf yield of V1 mulberry at 60 DAP

Treatments	Leaf yield (g/plant)	Leaf yield (kg/ha/yr)
T_1 (100 % BW)	696.63	46760
T_2 (25% TSW + 75% BW)	724.31	48641
T_3 (50% TSW + 50% BW)	739.32	49649
T_4 (75% TSW + 25% BW)	746.82	50153
T_5 (100% TSW)	795.14	53412
T_6 (100% RSW)	804.31	54319
F-test	**	**
S.Em.±	13.47	856.93
CD @ 1%	56.14	3571.08

BW= borewell water, TSW= treated sewage water and RSW= raw sewage water.

Table 4. Effect of raw and treated sewage water irrigation on primary nutrient (N_2O, P_2O_5 and K_2O) content of V1 mulberry leaf at 45 DAP

Treatments	Nitrogen (%)	Phosphorous (%)	Potassium (%)
T_1	2.82	0.28	1.33
T_2	3.07	0.30	1.58
T_3	3.18	0.32	1.63
T_4	3.23	0.35	1.66
T_5	3.56	0.39	1.86
T_6	3.68	0.40	1.91
F-test	*	*	*
S.Em.±	0.046	0.004	0.030
CD @ 5%	0.139	0.013	0.090

BW= borewell water, TSW= treated sewage water and RSW= raw sewage water.

Table 5. Effect of raw and treated sewage water irrigation on secondary nutrient (Ca, Mg and S) content of V1 mulberry leaf at 45 DAP

Treatments	Calcium (%)	Magnesium (%)	Sulphur (%)
T_1	2.06	0.71	0.17
T_2	1.73	0.61	0.27
T_3	1.56	0.58	0.28
T_4	1.46	0.47	0.30
T_5	1.43	0.42	0.33
T_6	1.93	0.70	0.34
F-test	*	*	*
S.Em.±	0.060	0.013	0.006
CD @ 5%	0.183	0.042	0.020

BW= borewell water, TSW= treated sewage water and RSW= raw sewage water

Table 6. Effect of raw and treated sewage water irrigation on micronutrient (Zn, Mn, Cu and Fe) content of V1 mulberry leaf at 45 DAP

Treatments	Zn (ppm)	Mn (ppm)	Fe (ppm)	Cu (ppm)
T_1	18.03	75.75	336.50	3.28
T_2	21.75	82.02	355.09	3.50
T_3	24.00	87.25	357.25	3.78
T_4	27.13	91.50	364.25	3.80
T_5	29.25	100.75	369.50	4.13
T_6	30.08	103.75	373.75	4.16
F-test	*	*	*	NS
S.Em.±	0.397	1.394	1.754	-
CD	1.199	4.203	5.289	-

BW= borewell water, TSW= treated sewage water and RSW= raw sewage water; NS- Non- significant

Table 7. Effect of raw and treated sewage water irrigation on heavy metal (Ar, Co, Ni) content of V1 mulberry leaf at 45 DAP

Treatments	Arsenic (ppm)	Cobalt (ppm)	Nickel (ppm)
T_1	nd	nd	0.89
T_2	nd	nd	1.30
T_3	nd	nd	1.42
T_4	nd	nd	1.45
T_5	nd	nd	1.48
T_6	nd	nd	1.51
F-test	-	-	NS
S.Em.±	-	-	-
CD	-	-	-

BW= borewell water, TSW= treated sewage water and RSW= raw sewage water; NS- Non- significant, nd- not detected

4. CONCLUSION

The raw sewage water irrigation along with recommended dose of NPK and FYM have given significantly positive results in terms of yield and quality parameters of V1 mulberry thus fodder and forage crops, where vegetative parts are of economic importance expressed better growth under sewage effluent irrigation. The above study showed that raw sewage water and primarily treated sewage water has high nutrient load and dissolved nitrates which are essential for mulberry growth and quality. However long term irrigation of raw sewage water containing higher concentration of heavy metals and poor irrigation water quality may deteriorates the soil health as well as the growth and quality of plant. Therefore, it is concluded that primarily treated sewage water can be used for irrigation unless water scarcity arises.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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