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# Effect of treated sewage water irrigation on soil nutrient status of mulberry garden

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**Abstract**
A field experiment was conducted in V1 mulberry garden established under paired row system to study the influence of raw and treated sewage water irrigation on nutrient availability and heavy metal status of soil. Experimental soil was collected and tested for its physio-chemical properties whereas, the raw and treated sewage water were collected from GKVK sewage treatment plant and analyzed for its chemical properties. Data recorded on chemical analysis of water revealed that sewage water contains higher concentrations of total N, $PO_4$, K, Na, Fe, Mn, Zn, Cu, Ni, sulphates compared to borewell water whereas, Ca and Mg were found higher in borewell water. Similarly, soil pH, EC, OC, N, P, K, Fe, Mn, Zn were significantly higher in 100% raw sewage water irrigated plot. An overview of the study revealed that raw sewage water irrigated plot significantly improved the fertility status of the mulberry soil.

**Keywords:** Mulberry growth, raw sewage water, soil nutrient status, treated sewage water

## 1. Introduction
Mulberry foliage is the sole food for the silkworm (*Bombyx mori*, named after the mulberry genus *Morus.* As mulberry is a perennial crop can be maintained for many years, selection of land, recommended package of practices and water management are the imperial factors for producing quality leaf. Among these, irrigation water plays a significant role as one of the key inputs in mulberry cultivation. Mulberry leaf quality alone contributes 38.2% in successful silk production (Miyashita, 1986) [16], thus adequate supply of water and nutrients are essential in moriculture. Moisture content in mulberry leaves improves the palatability, ingestion, digestion and assimilation of nutrients in silkworms.

In Karnataka, about 95.0 percent of the mulberry region is under the irrigated condition,even though borewell water is a common source of irrigation in South India, its availability is getting scarce day by day due to quick groundwater depletion which often leads the farmers to fail to irrigate their mulberry gardens according to requirements (Anon. 2017-18) [4]. Water in the soil-plant system is a necessary medium for the distribution of nutrients through the plant, works as a solvent for biochemical reactions, represents as a medium of distribution for solutes, and helps in temperature regulation as well as a source of hydrogen in photosynthesis (Subbaswamy *et al.*, 1987) [17].

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 (Kalpana *et al.*, 2018) [12]. United Nation's Food and Agricultural Organisation (FAO) stated that nearly 10 per cent of agricultural land receives raw sewage or primarily treated sewage water globally which encloses around 20 million hectares.

The raw sewage water contains a high fertility load, it adds available nitrogen, phosphorous, potassium, iron, manganese, zinc, and copper to the soil, indicating their importance in suggesting the use of sewage water as an occasional grade low-cost fertilizer in agriculture. Sewage water will drastically cut back the price because of the substitution of chemical fertilizers. The impact of continuous irrigation with waste water will increase exchangeable cations to a large extent (Alghobar *et al.*, 2014) [3].

The raw sewage irrigation to mulberry significantly increased the soil pH (8.27), EC (0.216 milli mhos/cm), nitrogen (304.87 kg/ha), phosphorous (22.7 kg/ha) and potassium (456.35 kg/ha) compared with borewell water irrigation (Das *et al.*, 2003) [8].

The districts in Eastern Dry Zone (EDZ) of Karnataka such as Kolar and Chickaballapur mainly depend on rainfall and ground water sources due to lack of perennial water sources for crop production.

In 2014, the Karnataka government envisaged two projects *viz*., Koramangala-Challaghatta (KC) Valley project and Hebbal-Nagavara (HN) Valley project to supply treated waste water from Bengaluru to irrigation tanks in neighbouring districts of Kolar and Chikkaballapur in the view of recharging groundwater levels and making water available for irrigation. By considering above scope and problems the present study was conducted to evaluate the effect of treated sewage water on mulberry garden soil.

## 2. Material 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. 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. Before experiment, the soil samples were collected and analyzed for their chemical properties. 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. Before experiment the soil samples were collected and subjected for chemical analysis. The cultural practices were followed as per the recommended package of practices (Dandin *et al.*, 2003) [8]. 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. 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

**2.1 Chemical analysis of sewage water, treated sewage water and borewell water:** The raw and treated sewage water samples were collected from sewage treatment plant, GKVK whereas borewell water was collected from department of sericulture, GKVK and analyzed for their physio-chemical properties. The water samples were analyzed for anions like $CO_3$, $HCO_3$, Cl, $SO_4$ and cations like Ca, Mg, K, Na and also the heavy metals such as Ar, Co and Ni which causes toxicity to plants and also silkworms. The samples were analyzed by adopting Inductively coupled plasma – optical emission spectroscopy (ICPOES) instrument whereas pH, EC, N, P were analyzed by adopting the standard procedure (Subbaih and Asija, 1956; Jackson, 1973) [11].

### 2.2 Soil analysis

After experiment, the soil samples that are collected from different treatments under each replication at 60 DAP were shade dried, sieved and analyzed for their physio-chemical properties. The soil pH, EC, OC, available N, P, K, Fe, Mn, Cu, Zn and heavy metals such as Ar, Co and Ni were analyzed by adopting the standard procedure (Subbaih and Asija, 1956; Jackson 1973; Lindsey and Norwell, 1978) [11, 15].

**2.3 Statistical analysis:** The data recorded on various parameters were subjected to Fisher's method of Analysis of Variance (ANOVA) and interpreted according to Gomez and Gomez (1984).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.

## 3. Results and Discussion

Chemical composition of raw sewage water, treated sewage water and borewell water such as pH, electrical conductivity, carbonates, bicarbonates, total phosphorous(P), total potassium (K), total nitrogen (N), calcium (Ca), magnesium (Mg), sulphates, chlorides, sodium, iron, manganese, copper, magnesium, arsenic, cobalt, nickel were analyzed and the results are tabulated (Table-1).

**3.1 Irrigation water quality:** Among different irrigation waters, raw sewage water contains higher concentrations of total nitrogen (53 mg $L^{-1}$), total $PO_4$ (1.31mg $L^{-1}$), total K (7.31 mg $L^{-1}$), sodium (1.02 mg $L^{-1}$), iron (1.21 mg $L^{-1}$), manganese (0.33 mg $L^{-1}$), zinc (0.19 mg $L^{-1}$), copper (0.16 mg $L^{-1}$), nickel (0.04 mg $L^{-1}$), sulphates (2.6 mg $L^{-1}$) whereas, calcium (14.21 mg $L^{-1}$), magnesium (2.10 mg $L^{-1}$) concentrations were found higher in borewell water. The carbonates and heavy metals such as arsenic, cobalt and nickel were in below detection level range in raw sewage water, treated sewage water and also borewell water. The Electrical conductivity, sodium adsorption ratio and residual sodium carbonates are the basic criteria for evaluating the irrigation water quality and all these values found under little or no hazard category so the water can be used safely for irrigation.

**Table 1:** Physio-chemical characterization of raw sewage water (RSW), treated sewage water (TSW) of GKVK STP and borewell water (BW) of GKVK

| 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

**3.2 Raw and treated sewage water irrigation on soil pH, EC and OC status:** Before conducting the experiment the soil samples were collected at the experimental site and anayzed for its chemical properties and the data is presented in the table-2. After irrigation with raw and treated sewage water significantly altered the soil pH, EC of V1 mulberry plots (Table 3). The ideal soil pH for growth and development of mulberry plants was recorded in 100% treated sewage water irrigated plot (7.48) and 100% raw sewage water irrigated plot (7.45) whereas higher OC content (0.56%) in soil was exhibited in 100% raw sewage water irrigated plot.

The reason for decreased soil pH in raw and treated sewage water irrigated plots may be due to decomposition of organic matter and production of organic acids in soils (Khai *et al.*, 2008) [14]. The EC is one of the attribute which influences soil stability, soil structure and water availability to plants. Further Alawsy *et al.* (2018) [2] opined that increase in EC is mainly due to contamination of sewage water with large quantities of dissolved salts. Similarly, Das *et al.* (2003) [8] observed that increased organic carbon in raw sewage irrigated plot is due the formation of anaerobic situation which increases the soil organic carbon by two and half folds.

**Table 2:** Chemical properties of the soil at the experimental site prior to experimentation

| Chemical properties | Before experiment |
|---|---|
| Soil pH | 7.95 |
| Electrical conductivity($dSm^{-1}$) | 0.29 |
| Organic carbon (%) | 0.51 |
| Available nitrogen (kg/ha) | 222.34 |
| Available phosphorous(kg/ha) | 29.15 |
| Available potassium (kg/ha) | 172.30 |
| Fe (ppm) | 12.61 |
| Mn (ppm) | 11.75 |
| Cu (ppm) | 3.89 |
| Zn (ppm) | 6.46 |
| Arsenic (ppm) | nd |
| Cobalt (ppm) | nd |
| Nickel (ppm) | 0.21 |

**Table 3:** Influence of raw and treated sewage water irrigation on soil reaction, electrical conductivity and organic carbon of V1 mulberry garden soil at 60DAP

| Treatments | Soil reaction (pH) | Electrical conductivity ($dSm^{-1}$) | Organic carbon (%) |
|---|---|---|---|
| $T_1$ (100% BW) | 7.82 | 0.31 | 0.50 |
| $T_2$ (25% TSW + 75% BW) | 7.64 | 0.32 | 0.51 |
| $T_3$ (50% TSW + 50% BW) | 7.62 | 0.32 | 0.51 |
| $T_4$ (75% TSW + 25% BW) | 7.62 | 0.33 | 0.53 |
| $T_5$ (100% TSW) | 7.48 | 0.34 | 0.56 |
| $T_6$ (100% RSW) | 7.45 | 0.35 | 0.56 |
| F-test | * | * | * |
| S.Em.± | 0.043 | 0.004 | 0.003 |
| CD @ 5% | 0.132 | 0.013 | 0.010 |

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

**Table 4:** Influence of raw and treated sewage water irrigation on macronutrient status of soil in V1 mulberry garden at 60 DAP

| Treatments | Available N (kg/ha) | Available P (kg/ha) | Available K (kg/ha) |
|---|---|---|---|
| $T_1$ (100% BW) | 244.54 | 33.97 | 187.18 |
| $T_2$ (25% TSW + 75% BW) | 246.25 | 35.58 | 194.09 |
| $T_3$ (50% TSW + 50% BW) | 248.25 | 37.67 | 197.23 |
| $T_4$ (75% TSW + 25% BW) | 252.40 | 37.99 | 197.25 |
| $T_5$ (100% TSW) | 259.33 | 40.77 | 203.08 |
| $T_6$ (100% RSW) | 265.25 | 42.08 | 206.33 |
| F-test | * | * | * |
| S.Em.± | 2.271 | 0.518 | 1.377 |
| CD @ 5% | 6.847 | 1.562 | 4.152 |

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

**Table 5:** Influence of raw and treated sewage water irrigation on micronutrient status of soil in V1 mulberry garden at 60 DAP

| Treatments | Fe (ppm) | Mn (ppm) | Cu (ppm) | Zn (ppm) |
|---|---|---|---|---|
| $T_1$ (100% BW) | 14.30 | 12.43 | 3.63 | 7.05 |
| $T_2$ (25% TSW + 75% BW) | 15.38 | 13.34 | 3.96 | 7.61 |
| $T_3$ (50% TSW + 50% BW) | 16.63 | 13.71 | 4.12 | 7.78 |
| $T_4$ (75% TSW + 25% BW) | 16.67 | 13.80 | 4.49 | 7.87 |
| $T_5$ (100% TSW) | 18.15 | 15.48 | 4.57 | 8.66 |
| $T_6$ (100% RSW) | 18.76 | 16.01 | 5.68 | 9.03 |
| F-test | * | * | NS | * |
| S.Em.± | 0.430 | 0.434 | - | 0.126 |
| CD @ 5% | 1.296 | 1.310 | - | 0.381 |

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

**Table 6:** Influence of raw and treated sewage water irrigation on heavy metal status of soil in V1 mulberry garden at 60 DAP

| Treatments | Arsenic (ppm) | Cobalt (ppm) | Nickel (ppm) |
|---|---|---|---|
| $T_1$ (100% BW) | nd | nd | 0.13 |
| $T_2$ (25% TSW + 75% BW) | nd | nd | 0.28 |
| $T_3$ (50% TSW + 50% BW) | nd | nd | 0.33 |
| $T_4$ (75% TSW + 25% BW) | nd | nd | 0.33 |
| $T_5$ (100% TSW) | nd | nd | 0.34 |
| $T_6$ (100% RSW) | nd | nd | 0.36 |
| F-test | - | - | NS |
| S.Em.± | - | - | - |
| CD @ 5% | - | - | - |

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

**3.3 Raw and treated sewage water irrigation on soil macro and micro nutrient status**

Significant improvement in soil fertility was noticed with regard to macro and micronutrient status of mulberry soil except for the micronutrient Cu (Table 4). After treatment, 100% raw sewage water irrigated plot recorded the highest available NPK content in soil (265.25 N, 42.08 P and 206.33 K kg/ha) whereas, the least NPK content (244.54 N, 33.97 P and 187.18 K kg/ha) was recorded in 100% borewell water irrigated plot at 60 DAP. Among different treatments, 100% raw sewage water irrigated plot registered the maximum availability of Zn, Fe, and Mn (9.03 ppm, 18.76, and 16.01 ppm respectively) whereas, the lowest micronutrient content was in 100% borewell water irrigated plot. The Cu micronutrient was found non-significant among different treatments.

The increased available NPK and micronutrients over the initial value in soil in all the treatments could be due to the raw and treated sewage water irrigation which are rich in macro nutrients, gets accumulated in soil and thus inturn increase the native nutrients present in soil (Dubey *et al*., 2006) [9]. Further, Kaushik (2002) [13] stated that the sewage water contained high rate of detergents with sodium tri-polyphosphates (STPP) which gets washed along with the dirty water and increased the phosphorous content in sewage water.

The results are comparable with the findings of Chikkaswamy *et al.* (2014) [6] who reported that increased micronutrient content with the application of raw sewage water, this could be due to immobilization, precipitation and fixation of micronutrients from the sewage sludge.

**3.3 Raw and treated sewage water irrigation on heavy metal status of soil**

The heavy metal accumulation in soil has shown non-significant increase in 100% raw

sewage water irrigated plot registering the maximum availability of Ni (0.36 ppm) whereas, the lowest concentration was in 100% borewell water irrigated plot with 0.13 ppm of Ni at 60 DAP (Table 6). However the heavy metals such as arsenic and cobalt were in below detection level range in raw sewage, treated sewage and borewell water as well as in soil.

Similar results are also reported by Chandrakala *et al*. (2009) [5] the mulberry soils irrigated with Vrishabhavathy stream water which is polluted with domestic and industrial wastes from Banglore city, showed higher content of nickel in summer season (60.01 ppm), followed by winter (51.3 ppm) and rainy season (41.8 ppm).

Alabdi *et al.* (2018) indicated that the critical limits of cobalt (50 mg/kg) and nickel (100 mg/kg) in soil. However, the concentration of heavy metals did not reach the critical limits, long term sewage irrigation may cause the heavy metal accumulation in soil and ultimately it deteriorates the soil quality.

**4. Conclusion**

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 development. Thus irrigating mulberry with raw and treated sewage water increased the soil nutrient status of the soil. Utilizing the sewage water for irrigation of mulberry gardens will helps to reduce the dependence of sericulturists on fresh water sources and also helps to reduce the fertilizer cost to the farmers. However long term irrigation of raw sewage water containing higher concentration of heavy metals and poor irrigation water quality may deteriorates the soil health and fertility. Therefore, it is concluded that primarily treated sewage water can be used for irrigation after checking irrigation quality standards and raw sewage water shouldn't be used for irrigation unless water scarcity arises**.**

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