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Utilization of different waste water irrigation on mulberry sericulture: Review

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Abstract
Mulberry (*Morus indica* L.) belongs to the family moraceae, a fast growing, deciduous and perennial plant. It is the sole food plant of the silkworm (*Bombyx mori* L.) for silk production. Water is becoming the most important limiting natural resource nowadays and more than 70% of water is being utilized for irrigation. Shortage of surface and underground water could be partially overcome by reuse or recycling of waste water and its multiple uses are becoming more and more important to meet the increased demand of agricultural production. Poor water quality degrades soil quality, results in the accumulation of heavy metals and alteration of soil physical, physico-chemical and chemical properties and influences the soil health to a great extent. Studies by different authors on different soil properties, by the effect of different waste water on quality of soils, soil nutrient status, properties are reviewed in this paper.

Keywords: Mulberry, silkworm, different waste water, soil properties

1. Introduction
Mulberry is a deep rooted perennial deciduous herb belonging to the family Moraceae and high biomass producing foliage plant. It can be grown in a wide range of soil and climate both in tropical and temperate conditions. Mulberry varieties, environmental conditions, nature of soil, fertilizers, irrigation, maintenance of optimum plant population, suitable schedule of pruning and proper harvesting methods are some of the important factors that contribute to the higher leaf yield with good quality in mulberry leaf production. Among these factors, irrigation plays a pivotal role in enhancing the productivity and quality of mulberry leaves. According to (Miyashita, 1986) [27], the contributing factors for successful cocoon crop production are mulberry leaf (38.2%), climate (37.0%), rearing techniques (9.3%), silkworm breed (4.2%), silkworm seed (3.1%) and other factors (8.2%).
Southern peninsula of our country mainly depends on rainfall for its water source due to lack of perennial rivers as available in central & northern regions. Tamil Nadu state possesses 3.96% (1.3 crore ha) arable land, 6.08% (7.4 crores) population of the nation with per capita land of 0.208 ha, as against national level 0.32 ha and 46.89 lakh ha (36.0%) net sown area and 2.9% land unutilized. The state receives an average annual rainfall of 961.9 mm in 4 seasons (Anonymous, 2011) [6]. Nowadays, water scarcity is making agriculture increasingly dependent on the reuse of water which leads to search alternative sources of irrigation which could substantiate yield potential of crops and also serve as an alternative source for fresh water. Population leads to explosion of water crisis for irrigation by 2050. Waste water irrigation is an alternative practice for agriculture which helps for the conservation of water, recycling of nutrients in waste water, reducing the direct application of organic fertilizers and minimizing the contamination of water bodies (Vasudevan *et al.*, 2010; Thapliyal *et al.*, 2009; Hylander *et al.*, 2006) [40, 39, 18]. Irrigation water scarcity in tropical region during summer season coincides with peak crop water requirement period results in farmers interest to use recycling waste water as alternative water resource.
In this review, the importance of waste water irrigation, reuse of waste water for mulberry cultivation and effect on silkworm will be discussed.

1.1 Waste water
Waste water refers to all effluent from household, commercial establishments and institutions, hospitals, industries and so on. It also includes strom water and urban runoff, agricultural, horticultural and aquaculture effluent. Effluent refers to the sewage or liquid waste that is discharged into water bodies either from direct sources or from treatment plants.

Influent refers to water, wastewater or other liquid flowing into a reservoir, basin or treatment plant. (http://www.eschooltoday.com/wastewater/what-is-wastewater.html/) [44].

1.2 Types of Wastewater
Wastewater comes in three main types namely Black water, Graywater and Yellow water.

1.3 Black Water
This is wastewater that originates from toilet fixtures, dishwashers, and food preparation sinks. It is made up of all the things that you can imagine going down the toilets, bath and sink drains. They include poop, urine, toilet paper and wipes; body cleaning liquids, anal cleansing water and so on. They are known to be highly contaminated with dissolved chemicals, particulate matter and is very pathogenic.

1.4 Graywater
This is wastewater that originates from non-toilet and food fixtures such as bathroom sinks, laundry machines, spas, bathtubs and so on. Technically it is sewage that does not contain poop or urine. Greywater is treated very differently from blackwater and is usually suitable for re-use.

1.5 Yellow Water
This is basically urine collected with specific channels and not contaminated with either blackwater or greywater.

1.6 Uses for recycled water
Recycled water is most commonly used for non-potable (not for drinking) purposes, such as agriculture, landscape, public parks, and golf course irrigation. Other non-potable applications include cooling water for power plants and oil refineries, industrial process water for such facilities as paper mills and carpet dyers, toilet flushing, dust control, construction activities, concrete mixing, and artificial lakes. (https://www3.epa.gov/region9/water/recycling/) [45].

2. Physico-chemical properties of different waste water
2.1 Sewage water
The sewage water normally has a high turbidity and appears grayish. Sewage water comprises of nitrites, phosphates, sulphates, carbonates and chlorides of calcium, magnesium, sodium, potassium and iron. Besides, some trace quantities of some toxic metals like copper, chromium, zinc, manganese, lead and nickel may also present.

2.2 Tannery waste water
The tannery waste water was brown, turbid, and had an offensive odour. The pH of the waste water was found to be in acidic range. The physical parameters studied in the waste water namely total hardness, total suspended and dissolved solids were at higher level. The chemical parameters namely COD, BOD, carbonate, bicarbonate, calcium, magnesium, chloride, potassium, nitrite, sulfur, and chromium, is found to be much above the permissible limits. Tannery waste water was unpleasant odour and acidic with high BOD, COD, organic particulate matter, increased total hardness, high TDS. Tannery waste water has a high TSS, TDS, total hardness, carbonate and bicarbonate than the permissible limits. BOD, COD, Cl, Na, K, Ca, Mg, SO3, N and No3 are also increased along with chromium, nickel zinc and cadmium (Babyshakila and Usha, 2009) [7].

2.3 Paper mill waste water
Paper mill waste water is light brown in colour, pH shows alkaline nature, SS, BOD, COD are the parameters from the treated waste water is higher in concentrations compared to Indian standards. Paper mill was brown with unpleasant smell and increase BOD and COD level in the waste water. pH value of the waste water was about 7.9-8.5 with high electrical conductivity of 1.24-1.92 dSm-1.The Paper mill waste water contained considerable amount of total solids suspended and total dissolved solids from (2420-2560 mgL-1), (436-526 mgL-1) and (1908-2124 mgL-1) in different seasons respectively (Deepak Arora *et al*., 2014) [35].

2.4 Sugar factory waste water
The sugar and distillery industry untreated effluent containing high temperature, EC, TH, free inorganic ions, CO2, TSS, TDS, TS oil and grease (Chaurasia and Tiwari, 2012) [9].

2.5 Textile waste water
The textile waste water was characterized by the presence of colour with objectionable odour, high electrical conductivity, high TSS, TDS values, alkaline pH, high BOD and COD, low DO, high amounts of chlorides and sulphates, nitrates and also showed the presence of heavy metals, oil and grease (Vigneshpriya,2015) [41].

Textile waste water with pH, EC, TDS, BOD, COD, sodium, chlorides, potassium, calcium, magnesium, sulfates, and trace metals are very high in concentration compared to the standards prescribed by the WHO (Sathiyaraj, *et al.*, 2017) [32].

3. Effect of waste water on different agricultural crops
3.1 Sewage water
(Khan *et al.*, 2010) [22] investigated that the effect of treated sewage waste water and equivalent basal fertilizer on growth, yield and nutrient quality of sorghum (*Sorghum bicolar* L. moench) under field conditions. Treated waste water significantly increased plant height, stem thickness, number of grains/panicle, grain weight/ panicle and 1000 grain weight of sorghum, while basal fertilizer only elevated grain/ panicle compared to control.

3.2 Tannery waste water
(Babyshakila and Usha 2009) [7] studied the effect of tannery effluent on the biochemical parameters of Vigna radiata and concluded that effluent could be used for effective plant growth in a lower concentration.

(Hussain *et al.*, 2010) [19] opinioned that tannery effluents caused a reduction in germination, growth of sunflower parameters along with other parameters like chlorophyll content, protein and carbohydrate content.

Vegetative growth parameters like plant height, branching, root dry weight and shoot dry weight of Chrysanthemum plants was promoted by tannery waste at lower ratio which can be successfully utilized in planting medium for production of Chrysanthemum flowers (Singh *et al.*, 2011) [36].

(Zereen *et al.*, 2014) [43] studied that the effect of tannery waste water on growth and yield of sunflower (*Helianthus annuus L.*) showed that tannery waste water are not fit for irrigation due to presence of higher level of minerals and heavy metals was adversely effected from seedling stage to maturity leading to reduce biomass and seed production as compared to control.

(Sumangala Rao *et al.*, 2014) [38] conducted experiment that the effects of tannery wastewater on different agricultural crops like wheat, jowar, maize, black gram, green gram, red gram, lentil and horse gram concluded the increase in waste water concentration showed decrease in seed germination and shoot elongation.

3.3 Paper mill waste water

(Dutta and Boissya 1999) [16] revealed that at lower concentration of effluent resulted in beneficial impact on general health of the crops whereas, higher concentrations of the paper mill effluent has deleterious effect on the growth of crop. Investigation showed that the growth and production of rice, mustard and pea was found maximum at a concentration of 30, 40 and 50% effluent respectively.

3.4 Sugar factory waste water

Sugar factory waste water was pH, electrical conductivity, COD, chloride, hardness, calcium, magnesium, sulphate and TDS were relatively high in the sugar factory waste water and severely affected seed germination. In paddy, gradual decrease in the percentage seed germination and germination value with sugar industry waste water concentration. The untreated sugar industry waste water could possibly lead to soil deterioration and low productivity (Sajani Samuel 2011) [33].

(Doke *et al.*, 2011) [17] assessed physico-chemical parameters of treated waste water effluents from a sugar industry and determined the effect of various concentrations of effluent on seed germination, germination speed, peak value and the germination value of Mung (*Vigna angularis*), Chavali (*Vigna cylindrica*) and Jowar (*Sorghum cernum*) seeds.

(Vinoda kumar, 2014) [26] studied the fertigation response of Abelmoschus esculentus L. (Okra) with sugar mill effluent in two different seasons with 5%, 10%, 25%, 50%, 75% and 100%. Study revealed that fertigant had significant effect on WHC and bulk density of the soil in both seasons. Fertigation with 100% sugar mill effluent concentration decreased moisture content, WHC, BD and pH, and increased EC, OC, Na+, K+, Ca2+, Mg2+, TKN, PO4, SO4, Fe2+, Cd, Cu, Pb, Mn and Zn in the soil used for the cultivation of A. esculentus in both seasons.

3.5 Reeling waste water

(Jimilee M Garcia, 2015) [21] reported that reeling water can also be used as an alternative source for organic fertilizer sampling in the nursery and tested the different parameters in mulberry varieties using reeling waste water and tap water. The length of shoots, root-shoot ratio (length) and sprouting % have significant interaction effect.

3.6 Textile waste water

(Kumari *et al.*, 2007) [34] investigated the impact of various concentrations of the effluent of textile mill on seed germination, seedling growth and pigment content of the Arachis hypogea. The effluent caused toxicity to the seedlings at higher concentrations. Undiluted effluents had an inhibitory effect whereas 25 per cent effluent had a growth promoting effect which was significantly better than control thus effluent can be used for irrigation purpose at 25 per cent dilution for beneficial cultivation.

(Yousaf *et al.*, 2010) [42] investigated the effect of textile and paper industry effluents on different varieties of soybean (Glycine max) and observed maximum seedling length in 60% effluents.

(Albino and Murugan, 2010) [4] recommended the use of textile mill effluent after proper treatment at a concentration of 25% or lower as it could enhance the growth of Black gram.

(Khan *et al.*, 2011) [23] conducted experiments to evaluate the impact of textile factory effluents of different dilutions on germination and certain physiological parameters in three leguminous crops i.e. Pisum sativum, Lens esculentum and Cicer arietinum. Crops reacted differently to the effluent imposition and thus can be inferred that the effect of textile factory effluent was crop specific depending upon the concentration and the stage of growth.

(Jeeva Anbuselvam *et al.*, 2016) [20] analyzed that Effect of Textile Waste Water Irrigation on Seed Germination, Plant Growth, Biomass, and Crop Yield in Green Gram Seeds (*Vigna radiate* (L) Under Plating Technique and Pot Experiment. Concluded that seed germination was well in all concentration, Chlorophyll a, b and protein content in the leaves are higher in 100% followed by 75%, 50% and 25%.

4. Effect of different waste water on mulberry and silkworm growth

4.1 Sewage water

(Bongale *et al.*, 2000) [8] reported that cocoon yield was increased by irrigated the garden with sewage waste water, which due to the presence of high amount of phosphorus and potassium in soil. Leaf chlorophyll, protein, nitrogen, phosphorus and potassium contents were higher in sewage irrigated gardens compared to the bore well irrigated mulberry gardens.

(Debashish *et al.*, 2003) [31] reported that the use of raw sewage water directly in the mulberry garden without dilution with fresh water is harmful to soil health, plant growth, leaf yield and leaf quality of mulberry as well as cocoon crop.

(Bongale and Krishna, 2000) [8] investigated the effect of sewage and bore well water irrigation on quality of Mulberry (*Morus indica*. L.) Leaf samples were analyzed for total N and chlorophyll, soluble protein, sugar, calcium and magnesium. It was concluded that sewage water irrigated gardens were associated with significantly higher values of leaf chlorophyll, protein, nitrogen, phosphorous and potassium contents compared to bore well irrigated mulberry gardens.

(Ambika *et al.*, 2013) [5] conducted the pot culture experiment with four mulberry varieties *viz*., V1, S36, S13 & M5 treating with sewage and bore well water to study the influence of sewage water on diversity and population of microflora of rhizosphere soil. They concluded that a significant reduction in fungi population and percentage root colonization with AM fungi in the mulberry varieties treated with sewage water, besides a change in fungal diversity and the bacterial population was significantly higher on sewage water treatment, though similar groups of bacterial colonies were found in both the treatment.

(Rabin Chandra Paramanik, 2015) [29] stated that domestic sewage water irrigation can be done to the mulberry garden only when water scarcity arise or better alternatively to the bore well irrigation. In Mulberry varieties ((S-54 and M5), morphological traits such as plant height, number of shoots/plant, number of nodes/meter length, leaf yield, shoot yield and biological yield/plant. Physiological traits like photosynthetic rate, transpiration rate, water use efficiency and total chlorophyll content and biochemical traits, i.e. total protein, sugar, starch and amino acid contents in both the genotypes were found increased in sewage water compared to bore well water.

4.2 Spent wash

(Chandraju *et al.*, 2012a) [12] CSR19, Kolar gold and CSR2xCSR4 varieties of silkworm were reared using M5 variety of mulberry leaves cultivated by different proportions of spentwash irrigation. Influence of SW irrigated M5 Mulberry leaves on the yields of different varieties of cocoons of silkworms at their respective maturity was investigated. It was found that the yields of CSR19, Kolar gold and CSR2xCSR4 were high in case of Mulberry leaves irrigated with 33% SW than raw water and 50% spentwash irrigations [the percentage yield was maximum in the case of Kolar gold (26%) and minimum in CSR2xCSR4 (21.87%) and moderate in CSR19 (25.6%)]. This concludes that the diluted (33%) spentwash irrigated mulberry leaves is most suitable for the rearing of the above varieties of cocoons, which elevates the economy of the farmers.

(Chandraju *et al.*, 2012b) [13] observed that the parameters of cocoons produced by CSR-2, CSR-2 x CSR-4 and CSR-4 rearing the silk worms using M5 variety of mulberry leaves cultivated by irrigation in 33% SW were maximum and moderate in 50% SW and minimum in RW irrigations. It concludes that, in 33% SW irrigation the plants are able to absorb maximum amounts of nutrients (NPK) both from the soil and the spentwash resulting high yield and enhance the nutrients in plants leaves which in turn influence the better growth of silk worms containing higher proportion of silk proteins yields spinning of long silk threads in cocoons resulting in increased weight of cocoons, minimizes the cost of cultivation, and increase the parameter values of cocoons resulting in high silk production, this elevates the economy of the farmers, since cultivation of mulberry is made without using fertilizer.

(Chandraju *et al.*, 2013) [11] reported that the nutrient uptake in V-1 variety Mulberry plants were largely influenced in case of both 33% and 50% spent wash irrigation than raw water, but 33% distillery spent wash showed more uptakes of nutrients when compared to 50% Spent wash in V-1 variety Mulberry plant due to the maximum absorption of nutrients by plants at more diluted spent wash.

4.3 Tannery waste water

(Chikkaswamy and Rabin Chandra Paramanik, 2014) [14] tested the various concentrations of tannery effluent (10, 30, 50, 70, 90 and 100%) for the mulberry cuttings sprouting and biomass production of mulberry seedlings. The 10% of tannery effluent treatment showed best growth and leaf biomass of mulberry varieties.

5. Effect of different waste water on soil properties

5.1 Sewage water

(Rana *et al.*, 2010) [30] conducted studies of soil characteristics affected by long term application of sewage water at Rohtak city. Soil analysis revealed that organic carbon, phosphorus, calcium and magnesium content were high in sewage irrigated soils compared to tube well irrigated soils. The soil pH decreased by 0.38 units as a result of sewage water irrigation. The continuous application of untreated sewage effluent for last 35 years resulted into significant accumulation of nutrients and heavy metals in soils.

(Kharche *et al.*, 2011) [25] conducted studies about the effect of sewage water irrigation on soil properties, essential nutrient and pollutant element status of soils and plants in a vegetable growing area around Ahmednagar city in Maharashtra. The results showed that an appreciable increase in organic carbon; available N, P, K, micronutrients; and soil micro flora was recorded in the sewage irrigated soils over that of well irrigated soils. Long term application of sewage water resulted in the accumulation of heavy metals in the surface soil. The mean content of Fe, Mn, Zn, Cu, Cd, Cr and Ni in the soils irrigated with sewage water was 1.05, 1.24, 3.98, 1.51, 2.10, 1.62, 1.24 times as compared to their content in the well irrigated soils.

(Mollahoseini, 2013) [28] conducted field experiment from 1981 to 2010 to assess the long term effect of municipal wastewater irrigation on soil properties of semiarid region of Iran. The results showed that using of wastewater increased the soil organic carbon from 0.60 to 1.10 per cent at soil depth of 0 to 20 centimeter and soil reaction at soil depths of 0-20 and 20-40 cm decreases from 7.9 to 7.8 and 8.2 to 7.9, respectively.

(Mohammed A. Alghobar *et al.*, 2014) [1] result showed that the soil parameters are significantly affected by application of sewage water irrigation. Irrigation with sewage water increased the concentrations of pH, electrical conductivity, total N, total P, K, Ca, Na, SO4 and Fe, in soils irrigated by sewage water grown grass crop compared to the control treatment.

(Vikash Agrawal *et al.*, 2014) [2] Investigated that use of sewage waste water for irrigation helps in better crop growth with increased fertility status of the soil. Application of sewage waste water increases total N, P, K and organic carbon content of soil & increases the yield of crops compared to irrigation with ground water.

(Arshdeep Kaur and Naveed Najam, 2016) [24] Stated that sewage waste water improve the physicochemical properties of the soil like soil fertility, soil nutrients, water holding capacity.

5.2 Tannery waste water

(Alvarez bernal *et al.*, 2006) [3] observed that irrigation with tannery waste water to the agricultural land over 25 years, soil had significantly increased the electric conductivity and increased the micronutrients in the soil. Concluded that continue application of tannery waste water for long duration leads to increase sodicity and salinity that could deteriorate soil and affected the future crop production.

5.3 Paper mill waste water

(Singh *et al.*, 2013) [37] Application of paper wastewater resulted in an increase of pH value, ranging from 6.2-7.6; the electrical conductivity of saturated extracts was found to be 0.6-1.7 dS m (-1), and exchangeable sodium percentage (ESP) ranged from 7.8-11.1% in soils. Similarly, an increase in the organic carbon, available nitrogen, phosphorus and potash content of soils was observed when irrigated with wastewater.

5.4 Sugar factory waste water

(Renu daulta *et al.*, 2014) [15] resulted that Sugar mill waste water improve the soil properties as well as soil becomes toxic due to presence of higher concentration of sulfur and potassium, declines the soil characteristics. Finally, affected the soil parameters like electric conductivity, Organic carbon, sulfur and potassium.

5.5 Spent wash

(Chandraju *et al.*, 2011) [10] Studies the characteristics of experimental soils such as pH, electrical conductivity, the amount of organic carbon, available nitrogen (N), phosphorous (P), potassium (K), sulphur (S), exchangeable calcium (Ca), magnesium (Mg), sodium (Na), DTPA iron

(Fe), manganese (Mn), copper (Cu) and zinc (Zn) were analyzed and found that the soil composition is fit for the cultivation of plants, because it fulfils all the requirements for the growth of plants.

6. Conclusion

Recycling of waste water is alternative source for cultivation of agricultural crops. In Sericulture, we can use the different waste waters like *reeling waste water, spent wash, industrial waste water* are rich in essential nutrients for growth and development of mulberry and silkworm rearing parameters. Especially, in reeling waste water used for cultivation of mulberry its shows the positive response in length of shoots, weight of shoots, root-shoot ratio (length) and rooting percentage. In spent wash irrigation for mulberry plants were shown maximum growth in the case of 33% and moderate in 50% spent wash and minimum in raw water irrigations. In 33% spent wash irrigation the plants were able to absorb maximum amounts of nutrients both from the soil and the spent wash resulting good yields. In industrial waste water irrigation with lower concentration helps the plant can tolerate and gives better stimulation of growth can be observed. However, its utility in India is not much exploited by the industrialists, which can also effective recycling system.

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