International Journal of Entomology Research
www.entomologyjournals.com
ISSN: 2455-4758
Received: 25-05-2025, Accepted: 24-06-2025, Published: 09-07-2025
Volume 10, Issue 7, 2025, Page No. 67-70

Silkworm performance and silk quality under combined industrial effluents and urban sewage water irrigation

Sanjay GB, Asiya Nuzhat FB*
Department of Studies and Research in Zoology, Tumkur University, Tumakuru, Karnataka, India.

Abstract
The viability of sericulture is intrinsically linked to the well-being of the silkworm, *Bombyx mori* L., and the nutritive value of mulberry leaves, its exclusive food source. This research investigates the impact of combined industrial effluent and urban sewage water irrigation on mulberry plants, focusing on the resultant physiological and economic characteristics of the FC1×FC2 bivoltine hybrid silkworm. Utilizing V-1 mulberry plants, the study employed effluent irrigation at various concentrations (25%, 50%, 75%, and 100%), with borewell water as a control to assess the silkworms' performance, evaluating crucial metrics such as larval weight, cocoon weight, shell weight, shell ratio, pupal weight, filament length, denier, and Renditta. The findings indicated a biphasic, concentration-dependent response. Specifically, lower effluent concentrations significantly improved larval development and silk production, potentially attributable to advantageous micronutrients present in diluted effluents. Conversely, exposure to 100% effluent concentration resulted in a marked reduction across all measured parameters, suggesting the presence of toxicological stressors. This study underscores the complex role of effluents, acting as both potential growth promoters and inhibitors in silkworm cultivation. It highlights the necessity for refined effluent management strategies and further investigation to pinpoint specific pollutants affecting sericulture, providing essential insights for enhancing silk production in regions impacted by effluent while simultaneously fostering environmentally sustainable sericulture practices.

Keywords: Sericulture, industrial effluent, urban sewage, bombyx mori, silk productivity

Introduction

The intricate interplay between environmental factors and biological systems is exemplified by the impact of industrial and urban effluents on the silkworm, *Bombyx mori L.*, an insect of significant economic importance in sericulture [1]. Sericulture, the practice of silk production through silkworm rearing, relies heavily on the health and productivity of these insects, which are directly influenced by their surrounding environment. *Bombyx mori*, a domesticated insect that has been cultivated for millennia to maximize silk fiber output, serves as a valuable insect model for research purposes because of its manageable size and ease of rearing [2, 3]. The unique ability of the silkworm to produce silk, composed mainly of fibroin and sericin proteins synthesized in the silk gland, has made it a valuable resource for both traditional textile production and emerging bio-based industries [4]. Silkworms are highly dependent on the nutritional quality of mulberry leaves, their sole food source, for their growth, development, and silk production [5]. Mulberry plants, known for their rapid growth and adaptability, are the cornerstone of sericulture, providing the necessary sustenance for silkworms to produce silk [6]. Industrial effluents and urban sewage water, as complex mixtures of pollutants, pose a significant threat to sericulture by disrupting silkworm physiology and potentially diminishing silk production, leading to economic losses for silk farmers [7].The health of silkworms and the quality of silk they produce are intrinsically linked to the health of the mulberry trees they feed on, making the quality of mulberry leaves a critical determinant of sericulture success [8]. Investigating the silkworm's response to these combined Industrial effluents and urban sewage water can provide insights into key economic traits of silkworms, helping ensure safer and more sustainable sericulture practices.

Material and methods

The study was initiated with the collection of combined industrial effluents and urban sewage water samples from Bhimasandra Pond near Tumakuru, Karnataka, and an area where agricultural practices commonly utilize such water sources for irrigation. This location was specifically chosen due to its direct relevance to agricultural practices involving effluent water, ensuring that the study's findings would be highly applicable to real-world scenarios. To ensure the representativeness of the samples, composite samples were collected from multiple points within the pond, integrating water from various depths and locations to account for potential stratification or localized variations in effluent composition.

In this study, V-1 mulberry plants were cultivated in pots and subjected to irrigation using various concentrations (25%, 50%, 75% and 100%) of a combined mixture of industrial effluents and urban sewage water. Control plants were irrigated with borewell water to establish a comparative baseline. This methodology enabled a detailed examination of how different levels of effluent exposure influence mulberry growth, which subsequently affected silkworm health and silk production.

Healthy, newly hatched silkworm larvae of the *Bombyx mori* species, specifically the FC1×FC2 double hybrid bivoltine race, were obtained from a chawki rearing centre in Tumakuru. Upon arrival, the larvae were randomly allocated into multiple treatment groups in triplicates, each group representing a distinct concentration of the combined industrial effluent and urban sewage water mixture. Throughout the larval development period, the silkworms were reared under meticulously controlled laboratory conditions, maintaining a constant temperature of 26±2°C and relative humidity of 75±2%, for silkworm growth and development [9]. The silkworms were fed with mulberry leaves from plants irrigated with different concentrations of industrial and sewage effluent water and control with borewell water. To ensure optimal nutritional intake and support healthy larval development, mulberry leaves were provided at regular intervals, throughout the rearing period, ensuring feeding conditions to meet their nutritional requirements during their growth stages [10].

To determine the comprehensive effects of exposure to combined industrial effluents and urban sewage water, a series of precise measurements were conducted on key traits influencing silkworm productivity and silk quality, encompassing larval weight, cocoon weight, shell weight, silk ratio, pupal weight, filament length, denier, and Renditta. During the fifth instar, a sample of larvae from each treatment group was carefully selected and weighed to determine the average larval weight, serving as an indicator of growth and development. At the completion of the larval stage, the weight of individual cocoons was measured to determine the average cocoon weight, a critical parameter reflecting the overall productivity of the silkworms [11].

Following cocoon harvesting, the pupae were meticulously weighed to ascertain the average pupal weight, which serves as another crucial indicator of the silkworms' overall health and development under the influence of the different effluent treatments; furthermore, after cocoon harvesting, silk filaments were reeled from a representative sample of cocoons from each treatment group, and the length of the individual filaments was measured to determine the average filament length, reflecting the silk productivity of the silkworms [12]. The thickness, or denier, of the silk filaments was also determined using standard techniques. Finally, the Renditta, which represents the number of cocoons required to produce one kilogram of raw silk, was calculated to assess the silk conversion efficiency of the silkworms. This comprehensive assessment of economic parameters provided valuable insights into the effects of the combined industrial effluents and urban sewage water on silkworm productivity and silk quality, which is vital for assessing the sustainability and economic viability of sericulture practices in effluent-affected areas [11]. The data was recorded and analyzed using statistical methods such as ANOVA to determine the significance of difference between the treatment’s groups.

Results

The present investigation meticulously examined the repercussions of combined industrial effluents and urban sewage water on the silkworm, revealing statistically significant alterations in larval growth dynamics and subsequent cocoon production efficacy. The data, subjected to rigorous one-way ANOVA and Tukey's HSD post-hoc analysis, unveiled a nuanced narrative of dose-dependent effects, wherein lower concentrations of the effluent-sewage admixture fostered enhanced larval development, while elevated concentrations precipitated detrimental outcomes [12]. Specifically, treatments involving 25%, 50%, and 75% concentrations of the effluent-sewage blend elicited a marked augmentation in precocoon parametrs like matured larval weight, cocoon weight, shell weight, and shell ratio, each registering statistically significant elevations ($p < 0.01$) when juxtaposed against the control group reared under standard conditions [13]. The matured larval weight demonstrated a significant, dose-responsive increase across the lower concentration treatments; specifically, the mean larval weight progressed from 15.67 ± 0.6 g in the control group to 16.18 ± 0.7 g, 17.94 ± 0.8 g, and culminating at 20.47 ± 0.9 g in the 25%, 50%, and 75% treatment groups, respectively. This suggests a stimulatory effect of certain components present within the diluted effluent-sewage mixture, potentially acting as nutrients or growth-promoting factors that augment the silkworm's physiological processes and assimilation efficiency [14].

Table 1: Cocoon parameters of silkworm *B. mori* FC1×FC2

Treatment	Matured Larval Weight (g)	Cocoon Weight (g)	Shell Weight (g)	Shell Ratio (%)	Pupal Weight (g)
Control	15.67 ± 0.6	1.87 ± 0.3	0.33 ± 0.1	17.64 ± 1.0	1.48 ± 0.2
25%	16.18 ± 0.7 **	2.03 ± 0.4 **	0.39 ± 0.2 *	19.21 ± 1.2 **	1.64 ± 0.3 **
50%	17.94 ± 0.8 **	2.14 ± 0.5 **	0.43 ± 0.2 *	20.09 ± 1.3 **	1.71 ± 0.4 **
75%	20.47 ± 0.9 **	2.39 ± 0.6 **	0.58 ± 0.3 *	24.26 ± 1.4 **	1.81 ± 0.5 **
100%	10.41 ± 0.5 **	1.17 ± 0.2 **	0.18 ± 0.1	15.38 ± 1.1 **	0.99 ± 0.2 **

Further analysis of cocoon-related parameters revealed a similar pattern, with cocoon weight increasing significantly from 1.87 ± 0.3 g in the control group to 2.03 ± 0.4 g, 2.14 ± 0.5 g, and 2.39 ± 0.6 g in the 25%, 50%, and 75% treatment groups, respectively; this augmentation underscores the potential of diluted effluent-sewage mixtures to enhance silk production. The shell weight, a critical determinant of silk yield, also exhibited a statistically significant increase in the treatment groups, escalating from 0.33 ± 0.1 g in the control group to 0.39 ± 0.2 g, 0.43 ± 0.2 g, and 0.58 ± 0.3 g, respectively. Shell ratio, an important index of silk content, also followed the dose-responsive augmentation pattern, rising from 17.64 ± 1.0% in the control to 19.21 ± 1.2%, 20.09 ± 1.3%, and an impressive 24.26 ± 1.4% in the respective treatment groups.

Conversely, the treatment group exposed to 100% Concentration of the effluent-sewage blend manifested a stark reversal of the trends, exhibiting a precipitous decline in all measured cocoon parameters. The matured larval weight plummeted to 10.41 ± 0.5 g, cocoon weight decreased to 1.17 ± 0.2 g, and shell weight dropped to 0.18 ± 0.1 g, each registering statistically significant reductions when contrasted with the control group and the lower concentration treatments. Correspondingly, the shell ratio experienced a notable decrease, settling at 15.38 ± 1.1% within the 100% concentration treatment group; this decline provides compelling evidence of the deleterious impact of concentrated effluent-sewage mixtures on the silkworm's capacity to efficiently convert assimilated nutrients into silk protein, thereby underscoring the inherent toxicity associated with exposure to undiluted effluent-sewage.

Table 2: Cocoon parameters of silkworm *B. mori* FC1×FC2

Treatment	Filament Length (m)	Silk Filament Weight (g)	Denier	Renditta
Control	1051.12 ± 50.0	0.29	2.43 ± 0.1	6.44 ± 0.3
25%	1104.35 ± 55.0 **	0.32**	2.60 ± 0.1 **	6.34 ± 0.4 *
50%	1141.28 ± 60.0 **	0.36**	2.83 ± 0.2 **	5.94 ± 0.4 *
75%	1287.61 ± 65.0 **	0.43**	3.01 ± 0.3 **	5.55 ± 0.5 *
100%	902.34 ± 45.0 **	0.24	2.389 ± 0.1 **	4.87 ± 0.4 *

The data obtained from post cocoon parameters are in alignment with the patterns observed in the pre-cocoon phase and further substantiate the complex interplay between effluent concentration and silk production efficiency. Specifically, lower concentrations of the effluent-sewage mixture were associated with enhanced silk quality indices, while the highest concentration (100%) precipitated a decline in these metrics. The filament length, a direct indicator of silk thread continuity and processability, exhibited a significant increase in the 25%, 50%, and 75% treatment groups, escalating from a baseline of 1051.12 ± 50.0 m in the control group to 1104.35 ± 55.0 m, 1141.28 ± 60.0 m, and an impressive 1287.61 ± 65.0 m, respectively. This enhancement in filament length suggests that controlled exposure to diluted effluent-sewage mixtures may stimulate silk gland activity, leading to the production of longer and more continuous silk filaments. Similarly, the silk filament weight, a measure of the quantity of silk reeled from each cocoon, demonstrated a statistically significant increase in the lower concentration treatment groups, rising from 0.29 g in the control group to 0.32 g, 0.36 g, and 0.43 g in the 25%, 50%, and 75% treatment groups, respectively.

However, the 100% concentration treatment group deviated sharply from this trend, exhibiting a notable decrease in filament length (902.34 ± 45.0 m) and silk filament weight (0.24 g) when compared to the control group and lower concentration treatments, indicating the adverse effects of high effluent concentrations on silk production.

Collectively, the results underscore the complex interplay between environmental contaminants and silkworm physiology, revealing a biphasic dose-response relationship wherein controlled exposure to diluted effluent-sewage mixtures can stimulate silk production, while high concentrations exert detrimental effects. These findings align with observations in other biological systems, where undiluted industrial effluents have been shown to negatively impact growth and yield [15].

The silk gland within silkworm larvae produces silk proteins, primarily composed of fibrous fibroin and aqueous sericin [16]. Fibroin protein, which constitutes the major component, is assembled in the silk gland lumen [17]. A study elucidates the relationship between the diet of silkworms and their metabolic characteristics [18]. The attainment of superior silk quality is fundamentally dependent on the provision of a nutritional profile characterized by a synergistic combination of proteins and an ample supply of micronutrients [14]. Being a monophagous organism, silkworms depend solely on the mulberry leaf to obtain all the nutrients necessary for their development [12]. The yield of silk is closely related to the nutritional properties of the mulberry leaves consumed by silkworms. Looking ahead, the economic viability of silk production is threatened by the expenses, accessibility, and resources required for silkworm cultivation and silk processing [19]. The nutritional condition, environmental factors, and feeding of silkworms have a substantial impact on their capacity to digest, absorb, and convert nutrients into body matter [20].

Discussion

This study provides a nuanced understanding of how combined industrial effluents and urban sewage water affect the silkworm Bombyx mori L., revealing a complex, concentration-dependent response; the data suggest that while diluted mixtures may enhance silk production, potentially acting as a nutritional supplement, concentrated effluents have detrimental effects on silkworm development and silk quality, likely due to toxic components overpowering any potential nutritional benefits.

The observed increase in larval weight, cocoon weight, shell weight, and shell ratio in silkworms exposed to lower concentrations of the effluent-sewage mixture suggests a possible fertilizing effect, mirroring how silkworm feces can act as an organic compost to fertilize mulberry trees, enhancing their nutritional value and subsequently benefiting the silkworms that feed on them [21]. It is plausible that certain components present in the diluted effluent-sewage mixtures, such as trace elements and organic compounds, may act as micronutrients, promoting growth and silk production, when mulberry leaves are the sole food source [22]. This highlights the importance of selecting silkworm strains appropriate to specific geographical and environmental conditions to optimize silk production [14].

The decrease in cocoon and silk quality at higher concentrations can be attributed to the toxic effects of pollutants present in industrial effluents and urban sewage, which can disrupt the silkworm's physiological processes, including digestion, nutrient absorption, and silk protein synthesis. Specifically, heavy metals, pesticides, and other organic pollutants can interfere with enzyme activity, disrupt hormonal balance, and damage cellular structures, ultimately leading to reduced growth, increased mortality, and impaired silk production.

The silkworm, Bombyx mori an economically significant insect in silk production, has been extensively cultivated throughout sericulture's history [23]. Like many species, Bombyx mori has been selectively bred by humans from a wild ancestor; however, in contrast to other animals, silkworm strains' genetic stocks have been preserved in public research facilities for centuries [24]. Furthermore, studies show that rearing silkworms with bio-foliar-enriched mulberry varieties resulted in the highest cocoon weight, shell weight, shell ratio, effective rate of rearing, silk filament length, filament weight, denier, renditta, non-breakable filament length, and silk yield [25].

Conclusion

In synthesis, our investigation elucidates a biphasic response of Bombyx mori to combined industrial effluents and urban sewage, demonstrating that while controlled exposure to diluted concentrations may stimulate silk production, higher concentrations exert detrimental effects on larval development and silk quality. These findings underscore the importance of responsible waste management and highlight the need for further research to identify and mitigate the specific pollutants responsible for the observed toxicity, thereby safeguarding sericulture and promoting sustainable practices in wastewater management. It can adapt to fluctuating environmental conditions, suggesting a genetic adaptability that could be harnessed for breeding programs aimed at enhancing tolerance to environmental stressors. Further research should focus on identifying specific pollutants responsible for the observed toxicity, assessing the long-term effects of effluent exposure on silkworm genetics and physiology, and developing strategies to mitigate the negative impacts of industrial effluents and urban sewage on sericulture.

Reference

1. Yuan SZ, Sun Y, Chang W, *et al*. The silkworm (Bombyx mori) gut microbiota is involved in metabolic detoxification by glucosylation of plant toxins. Communications Biology, 2023, 6(1).
2. Chen B, Du K, Sun C, *et al*. Gut bacterial and fungal communities of the domesticated silkworm (Bombyx mori) and wild mulberry-feeding relatives. The ISME Journal,2018:12(9):2252.
3. Ashraf H, Qamar A. Silkworm Bombyx mori as a model organism: A review. Physiological Entomology,2023:48(4):107.
4. Yokoi K, Tsubota T, Jouraku A, Sezutsu H, Bono H. Reference Transcriptome Data in Silkworm Bombyx mori. Insects,2021:12(6):519.
5. Lalfelpuii R, Ghatak S, Sarathbabu S, *et al*. Influence of Micronutrients on the Food Consumption Rate and Silk Production of Bombyx mori (Lepidoptera: Bombycidae) Reared on Mulberry Plants Grown in a Mountainous Agro-Ecological Condition. Frontiers in Physiology, 2019, 10.
6. Rahman M, Islam SMS. Studies on Food, Health and Environmental Perspectives in Mulberry (Morus spp.) – A Review. Journal of Bio-Science, 2021, 163.
7. Reddy R, Jiang Q, Aramwit P, Reddy N. Litter to Leaf: The Unexplored Potential of Silk Byproducts. Trends in Biotechnology,2020:39(7):706.
8. Shen X, He J, Zhang N, *et al*. Assessing the quality and eco-beneficial microbes in the use of silkworm excrement compost. Waste Management,2024:183:163.
9. Krishnaswami S. Improved method of rearing young age (chawki) silkworm’s central silk board (Govt. of India-Ministry of Textiles) Bangalore.
10. Łochyńska M, Frankowski J. The Effects of Silkworm Excrement Organic Fertilizer on the Hemp Yield. Journal of Natural Fibers,2021:19(3):847.
11. Riaz M, Bukhari R, Sudan K. Growth rate pattern and economic traits of silkworm (Bombyx mori L.) under the influence of inorganic and organic supplementation diet. International Journal of Fauna and Biological Studies,2021:8(1):5.
12. Pavankumar S, Bali K, Chanotra S. Ascendancy of Organic Based Nutrients for Boosting Rearing Performance of Silkworm (Bombyx mori L.). International Journal of Current Microbiology and Applied Sciences,2020:9(7):1665.
13. Riaz M, Bukhari R, Sudan K. Growth rate pattern and economic traits of silkworm (Bombyx mori L.) under the influence of inorganic and organic supplementation diet. International Journal of Fauna and Biological Studies,2021:8(1):5.
14. Lalfelpuii R, Ghatak S, Sarathbabu S, *et al*. Influence of Micronutrients on the Food Consumption Rate and Silk Production of Bombyx mori (Lepidoptera: Bombycidae) Reared on Mulberry Plants Grown in a Mountainous Agro-Ecological Condition. Frontiers in Physiology, 2019, 10.
15. Hussain A, Mustafa A, Waqas R, Ashraf I, Akhtar MFUZ. Effect of textile wastewater on growth and yield of wheat (Triticum aestivum L.). Soil & Environment,2017:36(1):28.
16. Yokoi K, Tsubota T, Jouraku A, Sezutsu H, Bono H. Reference Transcriptome Data in Silkworm Bombyx mori. Insects,2021:12(6):519.
17. Li Z, You L, Zhang Q, Ye Y, Tan A. A Targeted In-Fusion Expression System for Recombinant Protein Production in Bombyx mori. Frontiers in Genetics, 2022, 12.
18. Qin D, Wang G, Dong Z, Xia Q, Zhao P. Comparative Fecal Metabolomes of Silkworms Being Fed Mulberry Leaf and Artificial Diet. Insects,2020:11(12):851.
19. Reddy R, Jiang Q, Aramwit P, Reddy N. Litter to Leaf: The Unexplored Potential of Silk Byproducts. Trends in Biotechnology,2020:39(7):706.
20. Murali S, Singh S. Studies on Nutrigenetic Traits of Silkworm (Bombyx mori L.) for Determining Growth and Development for Identifying Parental Breeds for Breeding under Subtropical Region of North West India. International Journal of Environment and Climate Change, 2021, 26.
21. Shen X, He J, Zhang N, *et al*. Assessing the quality and eco-beneficial microbes in the use of silkworm excrement compost. Waste Management,2024:183:163.
22. Chen B, Du K, Sun C, *et al*. Gut bacterial and fungal communities of the domesticated silkworm (Bombyx mori) and wild mulberry-feeding relatives. The ISME Journal,2018:12(9):2252.
23. Yuan SZ, Sun Y, Chang W, *et al*. The silkworm (Bombyx mori) gut microbiota is involved in metabolic detoxification by glucosylation of plant toxins. Communications Biology, 2023, 6(1).
24. Cappellozza S, Casartelli M, Sandrelli F, Saviane A, Tettamanti G. Silkworm and Silk: Traditional and Innovative Applications. Insects,2022:13(11):1016.
25. Kumar D, Kumar R. Impact of Novel Bio-Foliar on Natural Cocoons and Silk Quality. Journal of Natural Fibers,2015:12(5):419.