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SERICULTURE: PROSPECT TO ADDRESS THE GLOBAL CHALLENGES OF CLIMATE CHANGE AND MICROPLASTIC IN TEXTILE SECTOR

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ABSTRACT

The climate change and microplastic are the two important global concerns, which are well accepted by global fraternity. The textile industry is also having direct concern under the changing environmental condition and polluted environment. Some studies proclaim the negative effects of the sericulture on environment without considering the complete cycle of the sink and source. By looking into deep through pro-active research in soil-to-soil approach, it is possible to establish that sericulture is having the intrinsic capacity to reduce the global burden of the global warming as well as the microplastic pollution. Some initial attempts were already taken in this direction but the synchronised continuous attempts are essentially the need of the hour. In this study, the available research outputs and respective research gaps through systematic pro-active research and institutional pathways are discussed towards achieving the carbon neutrality and sustainability in silk production and sericulture research.
Keywords : Global warming, Microplastics, Sericulture, Silk, Mulberry.

Introduction

The increased emission of the greenhouse gases has accelerated the pace of global warming; consequently the effects of the climate change are more intense. Agricultural soil has been accounted for emission of the three major greenhouse gases i.e., carbon dioxide, nitrous oxide and methane (Kumar *et al*., 2016). Nitrous oxide accounts >70% of the global emission which majorly comes from agricultural soil (Kumar *et al*., 2020). Nitrous oxide concentration was ≈ 331 ppb in atmosphere in 2017. This is about 122% increases from the pre-industrial levels i.e., 1750 (WMO2019). The synthetic fertilizers and intercultural operations shared highest nitrous oxide emission (IPCC, 2014). The global nitrous oxide emission has increased three times since 1961 (1.44 Tg) to 2010 (4.25 Tg) (Fagodiya *et al*., 2017) and agriculture soil will become the highest source of nitrous oxide by 2030 (Zhao *et al*., 2020). The carbon dioxide from the silk production contributed from the utilization of the energy for sericultural operations, post cocoon operation and the maintenance and marketing requirements etc. The potential event for greenhouse gases trade-off among the different sectors of silk producing system was suggested in Figure 1. The carbon uptake during the photosynthesis and subsequent utilization into the growth and maintenance of the host plants through respiration indicated by the net primary production. The farm net primary production is the outcome of the gross primary production and respiration (Kumar *et al*., 2021). Some percentage of the photosynthate is secreted into the soil as rhizodeposition, which also can be considered as C sink based on the root depth and tillage operation. The tillage is also one of the important activities which is related to the efflux of soil entrapped carbon dioxide. As the host plant of the silks grows in the aerobic soil, thus the emission of the methane is not possible (Malyan *et al*., 2022). Even though, the methanotrophs are active in aerobic soil and consumes some amount of the atmospheric methane (Malyan *et al*., 2021). However, the applied farm yard manure is the output of livestock sector, therefore having methane emission credits due to enteric fermentation. Thus, it can be considered that the sericulture soil could be considered only for direct emission of carbon di oxide and nitrous oxide.

Synthetic textiles fibre: Fossil fuel is considered as one of the largest contributors for climate change and serves as a raw material for production of synthetic textile fibres such as polyester and nylon etc. Global production of the polyester is about >55 million tonnes (Textile Exchange, 2019) and hold first rank in production of the synthetic fibres. The nylon holds second rank in synthetic textile fibres production with a value of 5 million tonnes (Textile Exchange, 2019). Synthetic fibres are low-cost, durable, multipurpose and hold high performance.The textile industry contributes >10% of global carbon emissions. Approximately > 60 million tonnes synthetic fibre is consumed globally. The clothing and household textiles are the major (70%) use of synthetic fibres and safety wears, vehicles and machineries are the minor use

(Ryberg *et al.*, 2017). In 2018, EU alone consumed 3.66 million tonnes of synthetic fibres. EU meet out this demand through producing 2.24 million tonnes and import 1,78 million tonnes. The EU export during this year was 0.36 million tonnes. The global consumption of the crude oil for producing synthetic fibres is about 48 million tonnes per year (1% of crude oil production) (Ellen MacArthur Foundation, 2017; EIA, 2020).The Center for International Environmental Law (CIEL) estimates that if trends continue, plastics will account for 20% of oil consumption by 2050.

Waste management of synthetic fibres : The separate collection of the textile waste is not under practise, thus most of the synthetic textiles are collected as mixed waste. This induces the low recyclability of the synthetic fibres. According to a report only 0.06% of textile waste comes under the recycles and converted into new textile products (Textile Exchange, 2020). This recycled waste basically belongs to cotton-rich products (Textile Exchange, 2020). The recycling of the synthetic textile fibres is majorly absent. According to an estimate around 44 million tonnes of waste as textile plastic was generated which contributes 13% of the total plastic waste and puts textile industry into the top three plastic waste generating activities (Geyer, *et al*., 2017).

Synthetic fibres and Pollution: The synthetic textile fibres production and consumption have the direct effect i.e., climate change, water pollution, air pollution and being a part of the fossil fuels and long duration environmental pressure makes them unsustainable. The production of the synthetic fibre is energy intensive process and affects the environment in dual mode i.e., depletion of the resources as well as its persistent nature affects the natural resources negatively. Considering the fossil fuel and climate change, nylon bears the highest impact per kg production. Beton *et al.* (2014) estimated that under full life cycle condition, 1kg of polyester release more than 10 kg more CO_2 equivalent than cotton. Apart from this, the microplastics, which are not covered under life cycle analysis also affects the environment negatively. According to an estimation, 2-5x10^{-5} tonnes per year microplastics enters into the marine ecosystems (Sherrington, 2016; Ellen MacArthur Foundation, 2017). The synthetic fibers have been recognized as an important source of MPs / microfibres pollution, which account ~0.2-0.5 MTyear^{-1} of MPs into marine ecosystems (Eionet Report - ETC/CE 2022/1). According to the Eunomia and ICF (2018) about 13,000 tonnes year^{-1} (25 g person^{-1} year^{-1}) of textile microfibers are disposed to the surface water in Europe only. OECD (2020) estimated that drying and wearing of apparels may contribute upto 65% atmospheric MPs.

Synthetic fibre and Climate change: The synthetic fibres are persistent in nature, bear toxic chemicals and major fraction of the synthetic fibres are carbon. Thus, the global scientific fraternity is now focussing to estimate the impact of microplastics on greenhouse gases emission in aquatic as well as terrestrial ecosystem towards understanding the pace of global warming or the impact intensity of climate change due to microplastic pollution. The ban on the single use plastic in many countries across the globe surely slow the microplastic dumping into the natural resources but the effect of the already dumped microplastic needs to know for its ameliorative measures. The microplastic pollution and its adverse effect will continue to grow with the population in the absence of the effective alternative. However, another alternative still exists i.e., natural fibres such as cotton and silk which are having low to very low persistency into the environment. From silk production and consumption, the carbon dioxide (CO_2) is the most important GHG, followed by nitrous oxide (N_2O). Sericulture management, energy combustion activities are the main sources of CO_2 emission, whereas the emission of N_2O is mainly from turnover of nitrogen (N) in soil, application of N fertilizer and various industrial processes. The long-term carbon (C) storage at farmer fields and end products life span is the most important sink for the CO_2.

Prospect of silk: Silkworm utilizes the plant-based energy which is produced by the consumption of the atmospheric CO_2. Thus, the degraded carbon after use could not be counted as carbon emissions as in the case of biofuel. Additionally, the recycling of the silk is high in the present time so it may help to maintain its disposed-off pathways with increase in production. The methane uptake is done by soils as both the fibre produced under aerobic condition where methanotrophs play a significant role in consuming methane. However, the quantification of the methane uptake by the cotton and silk host plants needs to be done. However, the use of the synthetic chemicals which emits the nitrous oxide needs to be reduced drastically. The silk is a natural protein and some amount of the protein drains as a part of silk production process. The extraction of this N content and applied into the silk respective soil will surely reduce the utilization of the synthetic fibres. The production related greenhouse gases emission can also be addressed through effective implementation of the available technology. Thus, it is possible through successive research efforts to enhance the existing sustainable level of the silk and improve its net negative carbon status.

Limitation

The major issue with the silk is its low production and high cost. However, sericulture is an ideal occupation for employment generation and poverty alleviation and aligns with most of the objectives of the Sustainable Development Goal (SDG) set by the United Nations.

Conclusion

Based on the above discussion, it is well evident that the synthetic fibres are produced from the fossil fuels and do not bear any carbon sink during its production stage. However, the production of natural fibres including silk is a nature-based production and having intrinsic capacity to balance the carbon cycle. By collecting the more effective scientific information on the capacity of the silk towards maintaining the carbon cycle will be more effective for its promotion as a sustainable as well as eco-friendly alternative of the synthetic fibres.

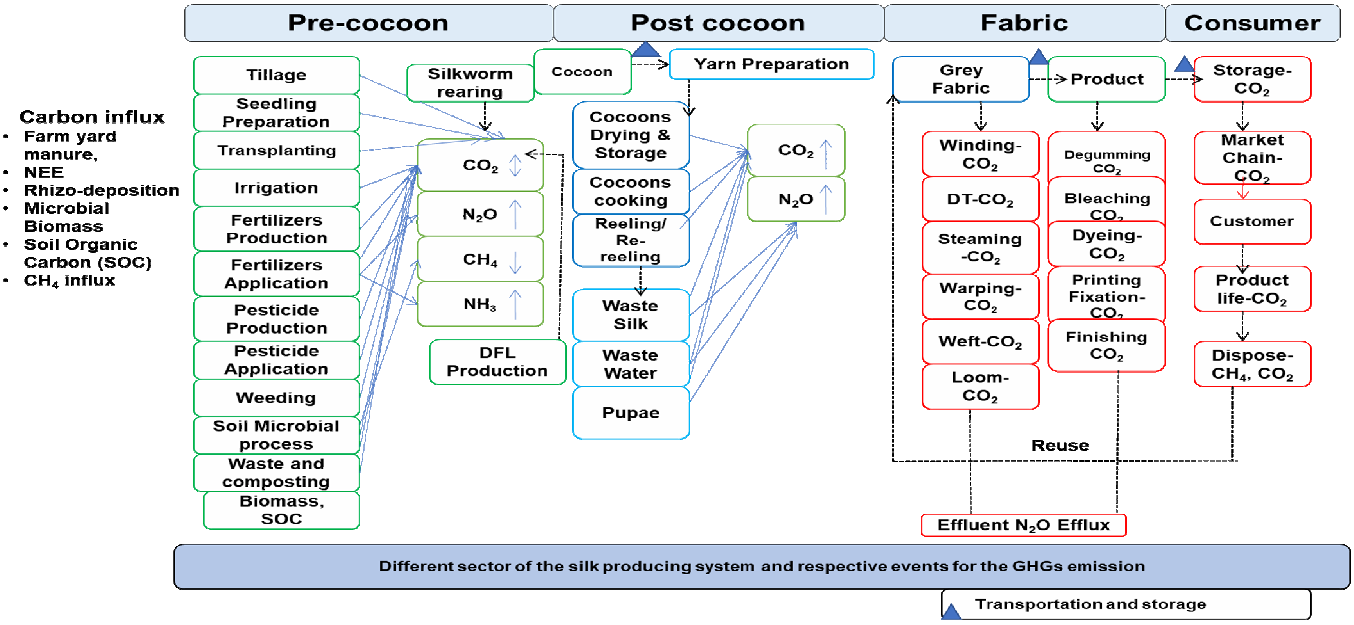

Fig. 1: The potential event for greenhouse gases trade-off among the different sectors of silk producing system.

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