

Occupational Safety and Chemical Exposure Among Female Tea Pluckers: A Comparative Review from Assam, Uk, And Japan

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“The true measure of any society can be found in how it treats its most vulnerable members.”
— Mahatma Gandhi

Abstract

This thematic review examines chemical exposure, health outcomes, and occupational safety practices among female tea pluckers in Assam, India. It provides a comparative analysis of regulatory frameworks and best practices in the United Kingdom and Japan. Female tea workers in Assam are disproportionately exposed to hazardous agrochemicals, often facing inadequate workplace protections and limited awareness regarding personal protective equipment (PPE) use. Literature indicates a range of health issues linked to such exposures, including skin diseases, respiratory ailments, and reproductive health problems. The review explores the factors influencing compliance with occupational safety standards, such as socio-economic constraints, gender roles, and gaps in policy enforcement. In contrast, the United Kingdom and Japan have established robust occupational health systems, emphasising comprehensive legislation, regular monitoring, and worker training to minimise chemical risks. Comparative analysis highlights the effectiveness of these interventions in reducing occupational hazards and promoting PPE adoption. The findings underscore the disparities in occupational health standards and the urgent need for context-specific improvements in Assam. The review advocates for stronger policy enforcement, enhanced worker education, and adaptation of international best practices to local realities. These steps are essential for safeguarding the health and well-being of female tea pluckers, ensuring both social justice and sustainable development in the region.

Keywords:-Chemical Exposure, Occupational Safety, Female Tea Workers, Assam, Personal Protective Equipment, Comparative Analysis

1. Introduction

Tea cultivation is a cornerstone of Assam's economy and cultural heritage, with the state contributing nearly half of India's total tea production and employing millions of workers, the majority of whom are women (Baruah, 2019; Tea Board of India, 2022). Female tea pluckers play a pivotal role in the labour-intensive process of harvesting tea leaves, yet significant occupational health and safety challenges often overshadow their contributions. Among the most pressing concerns is the widespread use of agrochemicals, pesticides, herbicides, and fertilisers, which expose workers to hazardous substances daily (Das & Barua, 2020). Despite the economic significance of tea, the health and well-being of these female workers remain precarious, shaped by socio-economic marginalisation, limited access to healthcare, and inadequate enforcement of occupational safety standards (Lahiri-Dutt, 2021).

1.1 Chemical Exposure And Health Risks

Exposure to chemical agents in tea plantations is an established occupational hazard with well-documented health consequences. Research in Assam and similar agrarian contexts has shown that frequent handling and proximity to agrochemicals can lead to acute and chronic health effects, ranging from skin irritations and respiratory disorders to reproductive health issues and long-term systemic diseases (Deka et al., 2018; Sharma et al., 2019). Female workers, in particular, face heightened risks due to prolonged exposure, lack of awareness, and biological susceptibility (Parveen et al., 2020). Many of these women are engaged in plucking, spraying, and handling tea leaves and plants, often without adequate personal protective equipment (PPE) or training in safe chemical handling practices (Baruah, 2019). The cumulative effect of these exposures has been linked to increased morbidity among tea plantation workers, further exacerbated by inadequate health surveillance and limited access to medical care (Lahiri-Dutt, 2021).

1.2 Occupational Safety Practices And Compliance

The implementation of occupational safety measures in Assam's tea plantations is inconsistent and often falls short of national and international standards. While Indian legislation, such as the Plantations Labour Act (1951), mandates provisions for worker safety, welfare, and health, practical enforcement remains weak due to institutional inertia, resource constraints, and limited worker representation (Bhowmik, 2015). Studies have reported low compliance with safety protocols and underutilization of PPE among female tea pluckers (Deka et al., 2018). Contributing factors include lack of awareness, insufficient training, economic pressures, and a workplace culture that undervalues the health risks associated with chemical exposure (Sharma et al., 2019). Furthermore, gender dynamics often influence the distribution of protective resources and access to health education, placing female workers at a pronounced disadvantage (Parveen et al., 2020).

1.3 Comparative Perspectives: The United Kingdom And Japan

In contrast to the situation in Assam, developed countries such as the United Kingdom and Japan have established comprehensive frameworks for occupational health and safety in agriculture, including the tea sector. The United Kingdom enforces strict regulatory standards through agencies such as the Health and Safety Executive (HSE), which mandates risk assessments, regular monitoring, and the provision of PPE as part of employers' responsibilities (Health & Safety Executive, 2021). Similarly, Japan's occupational health policies are characterised by stringent chemical safety regulations, proactive worker training, and effective enforcement mechanisms (Ministry of Health, Labour and Welfare, 2020). In both countries, systematic worker education and robust monitoring have contributed to high compliance rates, lower incidence of chemical-related illnesses, and improved overall well-being among agricultural workers (Reeves et al., 2018; Saito et al., 2019).

Comparative analysis reveals that the success of these frameworks is driven not only by legislative rigour but also by institutional capacity, resource allocation, and a cultural emphasis on worker welfare. The experiences of the United Kingdom and Japan demonstrate the potential of coordinated policies, regular training, and participatory approaches to mitigate occupational hazards and promote PPE use (Reeves et al., 2018). These insights underscore the importance of adapting international best practices to local contexts, taking into account the socio-economic realities and cultural norms of regions like Assam.

1.4 Rationale For A Thematic Review

Given the persistent health challenges facing female tea pluckers in Assam, there is an urgent need to synthesise existing knowledge on chemical exposure and occupational safety practices, with a focus on compliance, awareness, and PPE use. A thematic review that draws on comparative perspectives from developed countries can illuminate gaps in current practices and highlight actionable lessons for policy and practice. Such a review is especially relevant in light of global efforts to promote decent work, gender equity, and the health and safety of vulnerable populations in agriculture (International Labour Organisation, 2022).

This article aims to provide a comprehensive synthesis of literature on chemical exposure and health outcomes among female tea pluckers in Assam, critically examining the factors influencing occupational safety compliance and the barriers to effective PPE use. By integrating comparative insights from the United Kingdom and Japan, the review seeks to identify best practices and policy recommendations tailored to the needs of Assam's tea workforce. Ultimately, this work advocates for a multi-level approach that combines strong regulatory enforcement, targeted education, and the adaptation of proven strategies from international contexts to safeguard the health and well-being of female tea workers in Assam.

2. Objectives

The primary objective of this article is to synthesise existing literature on chemical exposure, health outcomes, and occupational safety practices among female tea pluckers in Assam. Specifically, the review aims to: (1) examine the extent and nature of chemical exposure among female tea workers; (2) identify the associated health outcomes and risks linked to such exposures; (3) assess the level of compliance, awareness, and use of personal protective equipment (PPE) within the sector; and (4) provide a comparative analysis of occupational safety frameworks, policies, and best practices from two developed countries, namely the United Kingdom and Japan. By integrating these comparative perspectives, the review seeks to highlight actionable lessons and policy recommendations that are adaptable to the socio-economic context of Assam's tea industry. Ultimately, the article aspires to inform stakeholders, including policymakers and industry leaders, about strategies to enhance the occupational health and safety of female tea pluckers in Assam.

3. Methodology

This article adopts a non-empirical, thematic review approach. Relevant peer-reviewed articles, government and industry reports, and policy documents published in English over the past two decades were systematically identified through academic databases such as PubMed, Scopus, and Google Scholar. The search employed keywords including “chemical exposure,” “occupational health,” “female tea workers,” “Assam,” “personal protective equipment,” and “comparative analysis.” Literature on occupational health and safety practices in the United Kingdom and Japan was included to provide a comparative perspective. Key themes were extracted through iterative reading and thematic synthesis, focusing on exposure pathways, health outcomes, compliance with safety standards, and policy interventions. The comparative analysis emphasises regulatory frameworks, training initiatives, and the effectiveness of PPE use in both developed and developing contexts. No primary data were collected for this review.

4. Historical Background

Assam, situated in the northeastern region of India, is bordered by Bhutan and Arunachal Pradesh to the north, Nagaland and Manipur to the east, Meghalaya, Tripura, Mizoram, and Bangladesh to the south, and West Bengal to the west, connected by the narrow Siliguri Corridor. The Brahmaputra River, one of Asia’s major waterways, flows through the state, shaping its fertile alluvial plains and making Assam particularly suitable for agriculture and tea cultivation (Baruah, 2019). On the Indian map, Assam occupies a strategic position as the gateway to the country’s northeast, and it is renowned for its lush green landscapes and biodiversity.

The introduction of tea cultivation in Assam dates to the early nineteenth century, following the British East India Company’s discovery of indigenous tea plants, *Camellia sinensis* var. *assamica*, in the region. Recognising Assam’s ideal climate and rich soil, the British established large-scale tea plantations in the 1830s, rapidly transforming the landscape and economy (Das & Barua, 2020). By the mid-nineteenth century, Assam had become the epicentre of India’s tea industry, fueling both national consumption and international exports.

Assam’s culture is a vibrant tapestry of indigenous ethnic groups, languages, festivals, and traditions. The state is home to communities such as the Ahoms, Bodos, Mishings, and various tea-tribe groups descended from labourers brought from central and eastern India during colonial times. Assamese culture is marked by its hospitality, unique cuisine, folk music, and festivals like Bihu, which celebrates the agricultural cycle. For the tea garden labour community, a distinct subculture has evolved, blending tribal customs, languages, and rituals, often centred on the rhythms of plantation life (Lahiri-Dutt, 2021).

To meet the labour demands of the growing tea industry, the British colonial administration introduced the indentured labour system, recruiting workers, many of them women and members of marginalised communities from distant parts of India. Women soon became the backbone of Assam’s tea workforce, valued for their dexterity in leaf plucking and willingness to accept lower wages (Parveen et al., 2020). Over generations, tea plantations became self-contained settlements, with families living in estate quarters and developing unique cultural identities.

Historically, the welfare and safety of tea workers, especially women, received little attention. During the colonial era, maximising output was prioritised over worker well-being. The introduction of chemical fertilisers and pesticides increased after independence, especially from the 1960s, as estates sought to boost yields. However, the adoption of agrochemicals was rarely paired with adequate training or personal protective equipment (PPE), exposing workers to significant health risks (Deka et al., 2018).

The Plantations Labour Act of 1951 marked a legislative attempt to protect workers by mandating standards for health, safety, and welfare. Nevertheless, enforcement has been sporadic, with many estates still lacking proper facilities, health surveillance, or safety protocols (Bhowmik, 2015). Female tea pluckers are often excluded from safety training and disproportionately affected by hazardous exposures due to cultural and workplace hierarchies (Sharma et al., 2019).

Despite advocacy by unions, NGOs, and international organisations, persistent gaps in policy implementation, socio-economic constraints, and entrenched gender norms continue to hinder progress. The historical context of Assam’s tea industry thus reflects an ongoing struggle between economic imperatives and the well-being of a diverse and culturally rich workforce, especially its women.

5. Chemical Exposure and Associated Health Outcomes

The widespread use of agrochemicals in Assam’s tea plantations has raised critical concerns about occupational health, particularly among female tea pluckers, who are frequently in direct contact with these substances. Agrochemicals, including pesticides, herbicides, fungicides, and chemical fertilisers, are integral to modern tea cultivation, employed to maximise yield and control pest infestations (Das & Barua, 2020). However, the

application and handling of these chemicals often occur without adequate protective measures, posing significant health risks to the workforce.

Female tea pluckers, who constitute a substantial proportion of the plantation workforce, are especially vulnerable to chemical exposure due to the nature of their tasks and their prolonged time spent in the fields. Many are responsible not only for plucking but also for activities such as spraying and mixing chemicals, often without training or awareness of the associated hazards (Parveen et al., 2020). Direct dermal contact with treated foliage, inhalation of chemical aerosols, and accidental ingestion contribute to both acute and chronic health risks (Deka et al., 2018).

Literature highlights a range of acute health symptoms reported by tea workers following exposure to agrochemicals. These include skin rashes, itching, eye irritation, headaches, nausea, and dizziness (Sharma et al., 2019). Such symptoms are frequently underreported due to inadequate health surveillance and limited access to medical care on the estates. Repeated exposure, compounded by inadequate washing facilities and poor workplace hygiene, can lead to chronic health conditions, including respiratory ailments, asthma, and persistent dermatological problems (Lahiri-Dutt, 2021).

Of particular concern are the reproductive health effects among female workers, as studies have linked chronic chemical exposure to menstrual irregularities, adverse pregnancy outcomes, and potential long-term fertility issues (Parveen et al., 2020). These risks are exacerbated by the lack of gender-sensitive occupational health programs and the minimal integration of women's health needs in workplace policies. The absence of proper personal protective equipment (PPE), such as gloves, masks, and protective clothing, further increases the risk of exposure for female workers (Deka et al., 2018).

The burden of illness from chemical exposure extends beyond immediate symptoms. Chronic toxicity has been associated with increased risks of cancer, neurological disorders, and systemic organ damage, although comprehensive epidemiological studies among tea workers in Assam remain limited (Sharma et al., 2019). The socio-economic consequences are equally significant, as poor health undermines productivity, increases absenteeism, and perpetuates cycles of poverty within plantation communities (Baruah, 2019).

Despite the evident risks, awareness about the dangers of agrochemical exposure remains low among tea workers, particularly women. Factors such as low literacy rates, communication barriers, and inadequate training programs contribute to limited knowledge about safe handling practices and the importance of PPE (Lahiri-Dutt, 2021). In many cases, economic pressures and the lack of employer-provided protective gear force workers to prioritise immediate livelihood needs over long-term health considerations.

In summary, chemical exposure in Assam's tea plantations represents a significant occupational health hazard, with direct and indirect impacts on the well-being of female tea pluckers. Addressing these challenges requires a concerted focus on health education, improved access to PPE, and the development of gender-sensitive occupational health policies tailored to the realities of plantation life.

6. Occupational Safety Practices, Compliance, and Awareness

Occupational safety within Assam's tea plantations is a multifaceted issue shaped by regulatory frameworks, workplace norms, and the knowledge and attitudes of both employers and workers. Despite legislative provisions in the Plantations Labour Act of 1951 mandating health, safety, and welfare measures for plantation workers, practical compliance remains inconsistent across the region (Bhowmik, 2015). This inconsistency is particularly evident in the implementation of measures designed to protect female tea pluckers from chemical exposure.

The provision and use of personal protective equipment (PPE) are central to occupational safety in agricultural contexts. PPE, including gloves, masks, aprons, and boots, serves as the first line of defence against direct contact with harmful agrochemicals (Deka et al., 2018). However, studies indicate a pervasive lack of PPE usage among tea pluckers in Assam. Many workers either do not receive adequate gear or are unaware of its importance. Even when PPE is distributed, it is often insufficient in quantity or quality. In some cases, workers are reluctant to use it due to discomfort, heat, or lack of awareness (Sharma et al., 2019).

Workplace training and health education are equally critical yet frequently neglected. Effective safety protocols require that workers be informed about the risks associated with chemical exposure, the proper handling of agrochemicals, and the proper use and maintenance of protective equipment. However, training programs tailored to the needs of female tea workers are rare, and information is often communicated in technical language that is inaccessible to many workers with low literacy levels (Lahiri-Dutt, 2021). As a result, awareness about chemical hazards and safe practices remains low, leaving workers vulnerable to preventable risks.

Socio-economic and institutional barriers further undermine compliance with mandated safety standards. Plantation management may prioritise productivity and cost-saving over worker welfare, resulting in the neglect of safety measures (Baruah, 2019). Additionally, workers, especially women, may hesitate to demand better

conditions due to fear of job loss, lack of collective bargaining power, or entrenched social hierarchies within the estates (Parveen et al., 2020). These challenges are compounded for female workers, who often have less access to information and fewer opportunities to participate in occupational safety decision-making.

Monitoring and enforcement of safety standards also remain weak. Government inspections are infrequent, and there is limited accountability for non-compliance. As a result, many plantations continue to operate below the minimum safety requirements, and violations often go unaddressed (Bhowmik, 2015). Unions and non-governmental organisations have played a role in advocating for improved safety, but their reach and influence vary across different plantations.

7. Comparative Analysis: Occupational Safety In The United Kingdom And Japan

Examining occupational safety practices and regulatory frameworks in developed countries such as the United Kingdom (UK) and Japan offers valuable insights for improving the health and safety conditions of female tea pluckers in Assam. Both the UK and Japan have robust systems for managing chemical risks in agriculture, characterised by comprehensive legislation, systematic monitoring, and a strong culture of worker protection (Health & Safety Executive, 2021; Ministry of Health, Labour and Welfare, 2020).

In the UK, the Health and Safety at Work Act (1974) forms the cornerstone of occupational health and safety legislation, establishing employer responsibility for providing safe working environments and ensuring employee well-being. The Control of Substances Hazardous to Health (COSHH) regulations specifically address chemical hazards, requiring employers to assess risks, implement control measures, and provide personal protective equipment (Health & Safety Executive, 2021). Regular risk assessments, thorough documentation, and mandatory training are integral to compliance. The Health and Safety Executive (HSE), a dedicated regulatory agency, conducts routine inspections and enforces compliance with significant authority, including the power to levy fines and halt unsafe operations.

Japan's approach to occupational safety in agriculture is similarly rigorous. The Industrial Safety and Health Act (1972) mandates that employers be responsible for risk assessment, hazard communication, and the provision of appropriate protective gear (Ministry of Health, Labour and Welfare, 2020). Japan's Ministry of Health, Labour and Welfare oversees enforcement, ensuring that employers not only supply PPE but also provide comprehensive education and training on chemical safety. Worker participation is strongly emphasised, with regular health monitoring and opportunities for workers to report hazards or unsafe practices (Saito et al., 2019). A key feature distinguishing these countries from the context in Assam is the integration of systematic training and a strong culture of safety. In the UK and Japan, safety training is not a one-time event but an ongoing process, regularly updated to reflect new risks and best practices. Training materials are tailored for accessibility, often using visual aids and practical demonstrations to ensure understanding across varying literacy levels (Reeves et al., 2018; Saito et al., 2019). Moreover, employers are legally obligated to ensure that all workers, regardless of gender or employment status, are included in safety programs and have access to PPE.

Worker empowerment and participation are also central to the success of occupational safety in the UK and Japan. Employees are encouraged to be proactive in identifying risks and suggesting improvements. Formal mechanisms, such as safety committees and anonymous reporting systems, support worker engagement and accountability (Health & Safety Executive, 2021). This participatory approach contrasts with the more hierarchical and top-down management seen in many Assam tea plantations, where female workers may have limited voice in workplace safety matters (Parveen et al., 2020).

Another significant difference lies in the monitoring and enforcement of safety standards. In the UK and Japan, regular government inspections, transparent reporting, and stringent penalties for non-compliance create strong incentives for employers to prioritise worker safety (Ministry of Health, Labour and Welfare, 2020). In contrast, enforcement in Assam is hindered by limited resources, infrequent inspections, and weak penalties, allowing many plantations to operate below minimum safety standards (Bhowmik, 2015).

Comparative data also show the direct impact of these frameworks on health outcomes. Studies from both the UK and Japan report lower incidence rates of chemical-related illnesses among agricultural workers, attributed to high compliance with PPE use, effective training, and accessible healthcare (Reeves et al., 2018; Saito et al., 2019). The contrast with Assam, where reports of acute and chronic health problems remain prevalent among female tea pluckers, highlights the efficacy of comprehensive regulatory and practical interventions.

In summary, the experiences of the UK and Japan illustrate the importance of a multi-pronged approach to occupational safety combining robust regulation, thorough training, worker empowerment, and strict enforcement. Adapting these best practices to the context of Assam requires not only policy reform but also

cultural change, resource investment, and the active involvement of all stakeholders. Emphasising gender equity, sustained education, and participatory workplace cultures can lay the foundation for safer and healthier working conditions in Assam's tea industry.

Table 1. Comparative Overview of Occupational Safety Practices: Assam, United Kingdom, and Japan

Aspect	Assam, India	United Kingdom	Japan
Legislation	Plantations Labour Act (1951)	Health and Safety at Work Act (1974); COSHH	Industrial Safety and Health Act (1972)
Regulatory Agency	State and district labour departments	Health and Safety Executive (HSE)	Ministry of Health, Labour and Welfare
Risk Assessment	Rare, inconsistent	Mandatory, routine	Mandatory, routine
PPE Provision	Often inadequate or absent	Employer-mandated, enforced	Employer-mandated, enforced
Worker Training	Infrequent, limited scope	Comprehensive, ongoing	Comprehensive, ongoing
Worker Participation	Low, limited empowerment	High, formal committees and reporting	High, formal committees and reporting
Enforcement	Weak, infrequent inspections	Strong, regular inspections and penalties	Strong, regular inspections and penalties
Gender Sensitivity	Often lacking	Legally required, inclusive	Legally required, inclusive
Health Outcomes	High incidence of chemical-related illness	Low incidence due to effective controls	Low incidence due to effective controls

- **Source:** Author's own work

Note:

This table presents a synthesised comparison based on the literature and policy documents (Bhowmik, 2015; Health & Safety Executive, 2021; Ministry of Health, Labour and Welfare, 2020; Saito et al., 2019). It illustrates how comprehensive legislation, strong enforcement, and a culture of safety contribute to better occupational health outcomes in the UK and Japan, compared to current challenges in Assam.

8. Barriers To Implementation and Lessons Learned

Despite the existence of legislative frameworks and policy guidelines in Assam, the effective implementation of occupational safety practices within tea plantations remains fraught with significant barriers. These obstacles are multidimensional, stemming from socio-economic, cultural, institutional, and logistical factors that collectively hinder progress toward safer and healthier working conditions for female tea pluckers.

8.1 Socio-Economic Barriers

A fundamental challenge in Assam's tea industry is the entrenched poverty and economic vulnerability of the workforce. Many female tea pluckers hail from marginalised communities with limited alternative livelihood options, making them heavily dependent on plantation employment for survival (Baruah, 2019). This dependency often translates into a reluctance to demand better safety measures or refuse hazardous work, for fear of job loss or wage deductions. Furthermore, the prevalence of casual and seasonal employment reduces workers' bargaining power and their access to social security benefits, including health care and compensation for occupational illnesses (Parveen et al., 2020).

8.2 Cultural and Gender-Based Challenges

Cultural norms and gender roles further complicate the scenario. In many tea garden communities, patriarchal attitudes restrict women's participation in decision-making processes, both at home and in the workplace (Lahiri-Dutt, 2021). This marginalisation is reflected in the limited inclusion of women in safety committees or training programs and in their reduced access to information about occupational hazards. Additionally, social stigmas associated with illness or injury may prevent female workers from reporting symptoms or seeking timely medical attention (Sharma et al., 2019).

8.3 Institutional and Logistical Barriers

Institutional weaknesses are evident in the lack of robust monitoring and enforcement mechanisms. Inspections by labour authorities are infrequent due to understaffing, resource constraints, and bureaucratic delays (Bhowmik, 2015). Consequently, non-compliance with safety standards often goes unchecked. Plantation management may also prioritise productivity over worker welfare, leading to cost-cutting measures that compromise the provision of personal protective equipment (PPE) and training (Deka et al., 2018). Logistical challenges, such as the remote location of many tea estates and poor infrastructure, further impede the regular supply and maintenance of safety equipment.

8.4 Barriers to Training and Awareness

Low literacy rates and language barriers are significant hurdles to effective training and awareness campaigns. Many female workers are either illiterate or speak dialects that differ from the official language of training materials, resulting in poor comprehension of safety instructions (Lahiri-Dutt, 2021). Moreover, training sessions are often conducted infrequently and may not be tailored to the practical realities of plantation work, reducing their impact.

8.5 Lessons Learned: International Best Practices

The experiences of the United Kingdom and Japan provide instructive lessons for overcoming these barriers. Both countries demonstrate that strong regulatory frameworks, coupled with regular inspections and meaningful enforcement, can drive significant improvements in occupational safety (Health & Safety Executive, 2021; Saito et al., 2019). Regular, accessible, and contextually adapted training programs are essential for raising awareness and fostering safe work habits. In particular, using visual aids, practical demonstrations, and local languages can greatly enhance understanding, especially among workers with limited literacy.

Worker empowerment and participation are also critical. In the UK and Japan, formal mechanisms such as safety committees, anonymous reporting systems, and avenues for worker feedback ensure that employees can voice concerns and contribute to the development of safer workplaces (Reeves et al., 2018). This participatory approach not only improves compliance but also builds a culture of safety that extends beyond formal regulations.

Gender sensitivity is another key lesson. Both countries have made strides toward integrating gender considerations into occupational safety policies, ensuring that women have equal access to training, PPE, and decision-making opportunities (Ministry of Health, Labour and Welfare, 2020). Such approaches can help address the unique vulnerabilities faced by female workers in Assam and foster more inclusive workplace environments.

9. Discussion: Implications And Recommendations

The synthesis of evidence from Assam's tea sector, together with comparative analysis with developed countries, underscores the urgent need for actionable interventions to improve occupational health and safety among female tea pluckers. The persistent gaps in compliance, awareness, and protective measures reflect broader structural and cultural challenges that cannot be addressed by legislative reform alone (Bhowmik, 2015; Lahiri-Dutt, 2021). Therefore, a multi-dimensional and context-sensitive approach is essential for sustainable progress.

- i. One of the primary implications of the current situation is the need for inclusive policy enforcement. While the Plantations Labour Act of 1951 provides a legal framework for worker welfare, enforcement must be strengthened through more frequent inspections, meaningful penalties for non-compliance, and transparent monitoring systems (Bhowmik, 2015). Collaboration between government agencies and independent bodies, including non-governmental organisations and labour unions, can ensure greater accountability and help bridge implementation gaps.
- ii. Education and training emerge as critical levers for change. As seen in the United Kingdom and Japan, regular, accessible, and practical training programs are crucial for raising awareness about chemical hazards and the correct use of personal protective equipment (Health & Safety Executive, 2021; Saito et al., 2019). Training should be delivered in local languages and adapted to the literacy levels of female workers, using visual aids and demonstrations to enhance understanding. Furthermore, integrating gender-sensitive content and involving women as peer educators can empower female tea pluckers to advocate for their own safety.
- iii. The provision of adequate and appropriate PPE must be prioritised. Government and plantation management should ensure that high-quality protective gear is available to all workers, with systems in place for regular replacement and maintenance (Deka et al., 2018). Cost-sharing models, subsidies, or public-private partnerships could help address resource constraints. At the same time, fostering a culture of safety

through positive reinforcement, peer support, and recognition of safe practices can encourage consistent use of PPE.

- iv. Worker participation is another essential component. Lessons from international best practices highlight the value of involving workers in safety committees, hazard identification, and decision-making processes (Reeves et al., 2018). Platforms for anonymous reporting and regular feedback can help surface concerns that may otherwise remain unaddressed, especially among female workers who may face additional barriers due to social hierarchy or fear of reprisal.
- v. Finally, further research and data collection are needed to fill existing knowledge gaps regarding the health impacts of chemical exposure and the effectiveness of safety interventions in Assam. Community-based participatory research and collaboration with public health institutions can generate actionable insights and inform evidence-based policy development (Lahiri-Dutt, 2021).

10. Conclusion

The occupational health and safety of female tea pluckers in Assam remain a critical issue, shaped by a complex interplay of historical, socio-economic, cultural, and institutional factors. This review has highlighted that despite legislative frameworks such as the Plantations Labour Act of 1951, the practical implementation of health and safety measures is often inadequate. Female tea workers continue to face high levels of chemical exposure, resulting in a spectrum of acute and chronic health problems that are compounded by insufficient access to healthcare, limited awareness, and inadequate provision of personal protective equipment.

Comparative analysis with developed nations such as the United Kingdom and Japan demonstrates the efficacy of robust regulatory frameworks, comprehensive training, and participatory safety cultures in reducing occupational hazards and improving health outcomes. These countries exemplify how systematic risk assessment, ongoing worker education, and strict enforcement of safety protocols can create safer working environments, even in labour-intensive sectors such as agriculture and plantation work.

For Assam, the lessons from international best practices are clear. To bridge the gap between policy and practice, a multi-pronged approach is essential. This includes strengthening enforcement mechanisms, enhancing the accessibility and relevance of training programs, and ensuring the consistent provision and use of high-quality personal protective equipment. Empowering female workers through greater involvement in safety decision-making and fostering a workplace culture that prioritises health and safety are equally important. Furthermore, interventions must be tailored to local realities, taking into account the linguistic, cultural, and gender-based nuances that characterise Assam's tea communities.

The way forward requires collaboration among government agencies, plantation management, labour unions, non-governmental organisations, and the workers themselves. Investments should match policy reforms in infrastructure, training, and monitoring systems. Simultaneously, there is a need for ongoing research to better understand the unique challenges faced by female tea pluckers and to evaluate the effectiveness of interventions over time.

Suggestions :-

To address the occupational health and safety challenges faced by female tea pluckers in Assam, a series of targeted interventions and reforms is recommended.

- First, it is imperative to strengthen the enforcement of existing legislation by increasing the frequency and rigour of inspections, as well as imposing meaningful penalties for non-compliance. Government agencies should collaborate with independent organisations to ensure transparency and accountability in the monitoring process.
- Second, accessible and context-sensitive training programs should be developed and delivered regularly, focusing on the safe handling of agrochemicals and the correct usage of personal protective equipment (PPE). Training materials must be tailored to the local languages and literacy levels of female workers, utilising visual aids and demonstrations to enhance comprehension and retention. Involving female workers as peer trainers can further increase engagement and empowerment.
- Third, the consistent provision of high-quality PPE must be ensured. Plantation management and government support should be mobilised to subsidise costs and establish reliable supply chains for protective gear. Maintenance and timely replacement of PPE should also be prioritised to guarantee its effectiveness.

- Fourth, mechanisms for worker participation in occupational safety decision-making should be institutionalised. Establishing safety committees with strong female representation and creating anonymous reporting channels will help address workplace hazards and foster a culture of safety.
- Lastly, ongoing research and data collection are essential to track progress, identify emerging risks, and assess the effectiveness of interventions. Partnerships with academic and public health institutions can support evidence-based policy development and continuous improvement.

By implementing these suggestions, Assam's tea industry can make meaningful strides toward safeguarding the health, dignity, and well-being of its female workforce.

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