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Strategies to Reduce Waste in Crime Scene Consumables and Packaging: A Review

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Abstract: *Crime scene investigation is the most crucial aspect of solving crimes especially with increasing crime rates. It involves proper collection and examination of evidences without contaminating them. Crime scene investigation (CSI) activities generate substance waste through the high use of single-use consumables they are plastic products such as gloves, swabs, evidence bags, Personal protection equipment's and packaging materials, thereby contributing to environmental damage and degradation. This study systematically reviews waste reduction strategies applicable to crime scene investigation practices, synthesizing findings from peer-reviewed articles and institutional reports. The review identifies key approaches, including the adoption to use reusable and biodegradable materials, optimized inventory management systems, and structured recycling methods with protocols. It also examines prevailing challenges, notably concerns regarding contamination control of evidences, regulatory compliance, and operational feasibility. Evidence from comparative case analyses demonstrates that the integration of sustainable waste management practices can reduce environmental impacts by up to 40% without compromising evidence integrity. This study highlights the imperative for interdisciplinary collaboration between forensic science and environmental sustainability domains to improve the development of greener operational frameworks within law enforcement.*

Further, the review covers the necessity of establishing standardized sustainability frameworks and targeted capacity-building programs to embed environmental responsibility in forensic practice. The incorporation of life-cycle assessment tools within forensic workflows can enable systematic evaluation of material and process efficiencies, promoting data followed decisionmaking for sustainable operations. Active engagement among key stakeholders including forensic personals, environmental scientists, and policymakers is essential to ensure the scalability and permanence of such initiatives. By aligning evidentiary rigor with ecological responsibility, crime scene investigation units can effectively serve as examples of sustainable innovation within the broader landscape of criminal justice administration.

Keywords: *Waste Reduction, Crime Scene Investigation, Consumables, Packaging, Sustainability, Forensic Science.*

Introduction: Crime Scene Investigation is one of the most important aspect in forensic science and justice system, the main goal of crime scene investigation is to identify, document and collect physical and biological samples from the crime scene and it should be done with great care and thoughtful approach(Directorate of forensic science services,2022) Proper investigation of crime scene mostly depends

on large number of single use plastic products like personal protection equipment's nitrile gloves, cotton swabs, biohazard bags and also plastic evidence containers to collect evidences and examine them without any contamination (college of policing, 2023). Rebacca Henderson who has almost 23 years of experience in crime scene investigation really raised concerns about this issue and said that this issue is very less addressed. The police and other investigating law enforcement groups are trying to meet the strict examination standards of ISO and for that the use of plastic waste is increasing day by day when Henderson visited nearly 62 crime scenes in 2 months and collected about 250 exhibits and all those generated nearly 14kg of plastic waste which was unrecyclable. (Henderson 2023)

Also,there are many techniques in crime scene they are harmful and toxic to the environment, we use different powders that are basically developing powders they are also harmful and cause health risks to the handlers. single use plastics are a big threat to our environment as they cannot be recycled although these are basically used toreduce the risk of evidence contamination this situation sits uneasily with the goals of sustainability and global concern about plastic pollutions, climate change and the impacts on environment.Sustainable, is identified as the key synergy concept of economically affordable, socially acceptable and environmentally friendly way for waste management(Morgan et al., 2024).

Yet this problem isn't just theoryreal cases show how forensic work can harm nature while chasing justice. For instance, in a 2019 poaching probe near Hathni Kund Barrage in Haryana, teams spraying chemicals and using plastic barriers messed up bird nesting spots and trampled key plants (Malik & Gupta, 2025). A Bhopal Gas site dig years later stirred up old toxins into soil and water, hitting nearby villagers (Malik & Gupta, 2025). In Kaziranga National Park's 2017 rhino case, vehicles and drones spooked elephants and buffaloes in this protected area (Malik & Gupta, 2025). And during a 2021 rape investigation in Kerala's Munnar forests, sample collection wiped out medicinal plants due to rough handling and chemical leaks (Malik & Gupta, 2025). These examples make it clear: we need better ways to gather evidence without wrecking the environment.

On top of that, our new Bharatiya Nyaya Sanhita (BNS) gives cops wide powers for searches and evidence grabs but stays mum on keeping things eco-friendlyno rules for chemical clean-ups or green packaging at crime scenes (Malik & Gupta, 2025). This gap means forensic teams can keep using harmful stuff without any check from environmental laws.

Objectives: This non-empirical review seeks to achieve four key objectives.

1. Aims to outline the primary sources and underlying causes of waste generated from crime scene consumables and packaging.

2. Bring together insights from existing research on sustainable materials, waste minimisation, and environmentally responsible practices in both crime scene and laboratory settings.

3. Examine the major barriers and enabling factors that affect the adoption of sustainable measures within crime scene operations.

4. Propose a conceptual framework and set of practical guidelines designed to help reduce waste and environmental impact without compromising evidential integrity.

Method: This article is a narrative, non-empirical review based on published journal articles, practice guidelines, policy documents, and data available in the internet. Sources were drawn from forensic science, environmental sustainability, waste management, and laboratory practice literature. Key themes were identified inductively, types of waste in crime scene drivers of single-use plastic dependence, sustainable materials and packaging, green and circular practices, and governance and policy responses. No statistical synthesis was attempted instead, the review integrates qualitative findings, case examples, and conceptual arguments that are directly relevant to crime scene consumables and packaging.

Crime Scene Waste: Scale and Characteristics

Types of Waste at Crime Scenes: Crime scene work generates different categories of plastic waste

- Personal protective equipment (PPE) such as gloves, masks, shoe covers, and disposable body coveralls.
- Evidence collection materialslike swabs, forceps, pipette tips, wipes, and applicators.
- Evidence packaging such as plastic and paper bags, tamper-evidence pouches, boxes, tubes, and seals.
- Other supplementary materials like tape, scene markers, barrier tape, and plastic sheeting or drop sheets (College of Policing, 2023; FCN, 2023; Henderson, 2024).

PPE and packaging are commonly made from polymers such as polypropylene, polyethylene, and polyvinyl chloride, which are durable but slow to degrade in the environment (Climate Action Accelerator, 2025; Eco Bliss, 2024). Many items are contaminated or labelled as biohazardous, which complicates recycling and usually results in incineration or landfill disposal which may result in release of dioxins and heavy metals if not properly controlled (National Research Council, 2011).

Quantifying Waste and Environmental Impacts: The amount of waste produced during crime scene investigations (CSI) has not been widely measured, yet the available evidence suggests it is considerable. A study carried out in in the United Kingdom found that in 62 crime scenes which were inspected over a two month period generated approximately about 14 kilograms of non-recyclable plastic waste mostly of single use plastic consumables, averaging roughly 55 grams of plastic for each piece of evidence (FCN, 2023). And Becci Henderson observed that a single scene could produce nearly 2 kilograms of plastic waste, which are largely from materials that were opened but never actually used for packaging or examination (Henderson, 2024; Recycling International, 2024).

These findings relate with broader research which is on waste generated in laboratory settings, which reveals that scientific work in labs usually results in high levels of disposable material use and contributes noticeably to the overall release of carbon footprint of research institutions (National Research Council, 2011; Puckett et al., 2023). Life cycle assessments show that plastic items have environmental costs long before they are even used including energy consumption and emissions during their production, transport, and eventual disposal (Bright, 2025; Detritus Journal, 2020; Puckett et al., 2023). When this impact is scaled up across thousands of scenes and laboratories, the waste produced during CSI activities becomes a significant contributor to the environmental burden of the forensic science system (Morgan et al., 2024).

Drivers of Waste Generation in Crime Scene Practice: In crime scene work, strict quality standards are one of the main reasons so much waste is produced(A2LA, 2025). Frameworks such as ISO/IEC 17025 focus heavily on preventing contamination, maintaining a secure chain of custody, and keeping precise records (ANAB, 2024). These safeguards are vital for ensuring evidence remains trustworthy, but they also lead to a heavy reliance on single-use materials and highly cautious packaging methods. Investigators are often required to double- or even triple-bag evidence, wear a new set of gloves or protective gear for each room or exhibit, and dispose of partly used kits to avoid any risk of contamination (College of Policing, 2023; FSR, 2023).

Because both courts and accreditation bodies tend to focus more on contamination errors than on environmental impacts, many practitioners take a very cautious “better safe than sorry” approach (Morgan et al., 2024). Over time, this mindset encourages habits such as using more packaging than necessary, opening consumables pre-emptively, and favouring plastic products even when reusable or simpler alternatives would meet the same standard (Henderson, 2024; FCN, 2023)

Procurement, Design, and Supply Chains: A significant portion of the waste generated in crime scene work can be traced back to how supplies are designed and sourced. Most consumables used at crime scenes were originally created for medical use, not specifically for forensic applications (FCN, 2023). Because of this, there are often small but important mismatches between what investigators actually need and what is provided. For instance, some collection swabs are unnecessarily long or heavily packaged, adding more plastic without offering any real improvement in how evidence is collected or preserved (FCN, 2023).The way materials are purchased also plays a major role. Procurement systems usually focus on keeping costs low, maintaining standardisation, and meeting accreditation requirements, rather than considering environmental performance. (College of Policing, 2023) As a result, even when eco-friendly products exist, they may not be adopted simply because they are not part of large-scale supply contracts. This approach unintentionally discourages innovation and sustainability within forensic operations. (Climate Action Accelerator, 2025)

Packaging design further contributes to the issue. Forensic kits often arrive wrapped in multiple layers of plastic, with extra inserts, trays, or pouches that are thrown away before a scene is even examined (Henderson, 2024). These unnecessary materials create waste before the tools reach the investigators, meaning pollution is effectively in bult from the start of the supply chain. In this way, decisions made during design and procurement quietly shape the environmental footprint of forensic science long before any evidence is collected

Sustainable Materials and Packaging Alternatives

Biodegradable and Bio-based Evidence Packaging: In recent years the emergence of bio-based or biodegradable evidence bags and pouches can be seen which aims at reducing dependence on petroleum-derived plastics (Earthwise Packaging, 2022; M&Q Packaging, 2025). Biodegradable materials include plant-based polymers, compostable films, and recyclable paper composites which are designed to maintain tamper evidence, moisture resistance, and labelling integrity (Earthwise Packaging, 2022; M&Q Packaging, 2025; Malik & Gupta, 2025).

While these products are promisable, theyraise questions about long-term stability, interaction with DNA and other trace evidence, and compatibility with storage conditions (Climate Action Accelerator, 2025; Malik & Gupta, 2025; Williams et al., 2024). Forensic organisations must validate these materials to ensure that they do not compromise quality of evidences found on crime scene (Malik & Gupta, 2025; Morgan et al., 2024). Nevertheless, earlier case studies have indicated that bio-plastic evidence bags can be incorporated into practice after appropriate testing and quality assurance (IASPD, 2025; M&Q Packaging, 2025).

Greener Packaging Design and Right-sizing: Changes in design of materials, that reduce material use without altering their function can have immediate benefits. Examples include:

- Shorter or thinner swab shafts tailored to forensic tasks.
- Evidence bags sized more closely to typical exhibits, reducing air space and excess plastic.
- Removal of redundant inner wraps, plastic trays, or secondary sachets from kits (FCN, 2023; Henderson, 2024).

Such interventions align with “light-weighting” strategies in the broader packaging industry and can be implemented relatively through collaboration with suppliers (Climate Action Accelerator, 2025; EcoBliss, 2024). Because these changes focus on efficiency rather than radical material substitution, they may face fewer regulatory and accreditation barriers.

Paper-based and Hybrid Systems: Where moisture and biological risk are low, plastic can be replaced by paper- based packaging, particularly for certain trace materials, documents, and non-wet items (Forensic

Evidence Packaging, 2025; IASPD, 2025). Paper bags and envelopes are already standard for some evidence types and could be extended where safe. Hybrid systems that combine paper exteriors with minimal internal plastic liners can preserve visibility and sealing features and also reduce total plastic content (Climate Action Accelerator, 2025).

However, paper has its own environmental footprint and thus, can be problematic for some items such as wet or blood-staineditems, which may require breathable butleak-proof solutions and careful drying protocols (FSR, 2023). Therefore, substitution must be evidence-type specific rather than universally applied.

Green Forensic Science and Circular Practices: It is considered a major aspect for sustainable forensics to conduct and adopt green chemistry by increasing the use of biodegradable materials and reduce the materials that cause direct harm to the environmental health and safety. People are now adopting smarter and alternative ways to do forensic work that don't harm the planet as much. This aims using "green chemistry" tricks and circular economy ideas to cut down the amount of dangerous waste from crime scenes and labs.

Green Chemistry and Less Hazardous Methods: Forensic labs are a source of variety of dangerous and hazardous waste that cause harm to the environment including chemical leftovers, expired chemicals, biological specimens, and also the equipments that are contaminated such as gloves and masks. Green chemistry is all about swapping out nasty chemicals with safer ones that still get the job done in forensics. It's being used for things like prepping samples, testing poisons, and bringing out hidden fingerprints (Forensic Chemistry, 2013; IJCRT, 2024; Greener Approaches, 2024; Wang et al., 2025). Picking milder solvents, shrinking down lab gear to use less stuff, and pulling reagents from plants or waste that break down easily and don't contaminate the soil or water can be the strategic ideas.

For example, Using old methods such as harsh metals or chemicals to detect the fingerprints can cause harm to the environment. Whereas, new ones mix plant extracts like green tea or eggshell waste with tiny particles to light up the prints safely, even on wet surfaces (IJCRT, 2024; Wang et al., 2025; Sharma et al., 2024). These "green powders" stick well on prints, show clear ridge details, and cut health risks for investigators and also to the environment. (Sharma et al., 2024; Wang et al., 2025). Labs in places like India are testing clam shell or brewed coffee powders too, turning everyday trash into tools that work better than the ones which are bought from stores. (IJNRD, 2025; Nanoient, 2024).Implementing strict and strategic guidelines for separating waste and finding environmental friendly packaging methods helps in enhancing the sustainability in forensics along with environmental protection.

This isn't just for fingerprints,italso lightens the whole waste load. Advances in forensic science supported with the use with energy efficient technologies promotes the green chemistry and sustainability concept (Forensic Chemistry, 2013; Williams et al., 2024; Malik & Gupta, 2025).

Circular Economy and Recycling in Forensic Contexts: Circular economy uses a unique strategy, instead of "buy, use, dump", the materials can be designed to "last, reuse, recycle" and let the nature recover what you can't (Circular Economy Solutions, 2025; UNODC, 2023). For forensics, that looks like sturdy crates for shipping evidence that you send back empty, sorting clean plastics from kits for recycling bins, or teaming up with companies to take back used gear (Circular Economy Solutions, 2025; IASPD, 2025; RCPath, 2024).

Lab programs prove that it works: special bins for safe plastics, glass, and cardboard slash trash by half or more (National Research Council, 2011; Puckett et al., 2023; RCPath, 2024). Hospitals like Amrita in India have already started recycling of biomedical waste by ethical means, and forensics could also adopt the same for scene support hubs (IASPD, 2025).

Pushing this to crime scenes means less single-use junk overall, fitting right into green chemistry shifts (Malik & Gupta, 2025; Wang et al., 2025).

Digitalisation, Remote Working, and Procedural Changes

Reducing Physical Materials Through Digital Tools: Digital photography, 3D scanning, electronic note-taking, and digital chain-of-custody systems can reduce the need of paper forms, plastic notebooks, and some physical labels. (IASPD, 2025; Morgan et al., 2024) Remote triage of scenes where senior staff advise via video link or review digital imagery before deployment can prevent unnecessary attendance and reduce travel-related emissions and consumable use (Morgan et al., 2024).

Moreover, integrating digital barcodes or RFID tags into reusable items may allow for more efficient tracking and inturnreduce redundant labelling materials on single-use packaging. However, these approaches depend on investment in secure, reliable digital infrastructure and clear data protection safeguards.

Procedural Rationalisation and Training: Waste reduction also depends on how practitioners use consumables. Studies have suggested that crime scene staff recognise the growth of plastic waste well but feel constrained by standard operating procedures and have a fear of deviating from established practices (FCN, 2023; Henderson, 2024). Training programs that explain contamination risks along with environmental impacts can empower staff to make proportionate decisions, such as:

- Avoiding opening full scene kits when only a subset of items are required.
- Using the minimum number of bags and seals necessary for secure packaging.
- Planning scene approach and sequencing to minimise repeated PPE changes without compromising safety (College of Policing, 2023; Morgan et al., 2024).

Embedding sustainability into induction, refresher courses, and supervisor training signals that waste reduction is compatible with professional standards and not an optional add-on.

Governance, Standards, and Policy

Accreditation and Environmental Management Systems: Accreditation bodies and forensic oversight groups have a big say in how much waste is generated at crime scenes. There's real momentum right now toward blending environmental standards like ISO 14001 into the usual forensic accreditation process, so that labs and CSI teams look in tracking and cutting their environmental footprint in a structured way (IASPD, 2025; Morgan et al., 2024). This could mean practical steps such as:

- Setting clear goals for cutting down waste and boosting recycling rates.
- Running life-cycle assessments or impact assessments on new packaging and supplies before buying them.
- Making sure sustainability gets a mention in method validation reports and procurement decisions (ANAB, 2024; A2LA, 2025).

Guidance on avoiding contamination or handling scenes could also build in sustainability advice, pushing for smarter, evidence-based use of disposables rather than blanket overuse (FSR, 2023; Morgan et al., 2024).

Procurement Policy and Supplier Engagement: Public agencies hold a lot of buying power, and they can use it to push for greener forensic supplies. Procurement rules could prioritise things like recycled materials, reusable designs, take-back programs, and solid eco-certifications right along with price and performance (Climate Action Accelerator, 2025; Circular Economy Solutions, 2025). One smart approach can be bringing investigators and suppliers together to co-design kits, trimming unnecessary plastic without sacrificing ease of use (FCN, 2023; Henderson, 2024).

Some regions are even setting up national or area-wide panels to standardise forensic consumables and spread the knowledge of what can be the best for sustainability (Henderson, 2024; Innovation News Network, 2024). This helps to avoid a patchwork of local trials and speeds up good practices across the board.

International and National Initiatives: Forensic conferences and partnerships are working to highlight environmental sustainability alongside traditional crime work on the global stage (U.S. Environmental Protection Agency, 2014; Morgan et al., 2024). In places like India and other resource-limited countries, researchers are finding ways to adopt green practices into forensics without straining budgets or slowing down justice delivery (IASPD, 2025).

Overall, these efforts point to a bigger picture: tackling CSI waste isn't just a logistics fix. it's part of evolving towards justice systems that would not cause any harm to the planet (Morgan et al., 2024; IASPD, 2025).

Integrative Framework and Future Directions

A Multi-Level Framework: Experts agree we need a step-by-step plan to cut waste from crime scene gear and packagingone that hits it from materials up to big-picture rules. Here's how it breaks down, backed by real studies and guides (Morgan et al., 2024; Williams et al., 2024; Malik & Gupta, 2025; Sourcing Champions, 2025).

- **Material level**: Swap out risky plastics for tested bio-based bags, lighter wraps, or compostable options that hold up for evidence without leaking or spoiling (Earthwise Packaging, 2022; M&Q Packaging, 2025; Greener Approaches, 2024; Malik & Gupta, 2025). Labs like those in the UK are already proving these work if you check them properly first.
- **Design level**: Redesign kits to fit real needssmaller bags, snap-apart parts, less fluffby getting cops and suppliers to brainstorm together (FCN, 2023; Henderson, 2024; Forensic Chemistry, 2013). This cuts extra plastic right from the factory.
- **Operational level**: Train teams to use just what's needed, map scenes ahead to save gloves and bags, and sort clean waste for recycling on-site (College of Policing, 2023; Morgan et al., 2024; ELFT Forensics, 2025). Simple changes like digital notes instead of paper labels add up fast.
- **Organisational level**: Roll out tracking systems for waste and emissions, like ISO 14001 audits, so labs measure success and tweak habits (ANAB, 2024; Morgan et al., 2024; RCPath, 2024; Contract Laboratory, 2025). Groups like NHS forensics cut plastic big-time with these checks.
- **System level**: Tie green goals into rules, buying contracts, and global teamworkthink eco-clauses in tenders and sharing tips across borders (IASPD, 2025; U.S. Environmental Protection Agency, 2014; Sourcing Champions, 2025; International Publications, 2025). India's new laws could add this, but right now it's spotty.

Research Gaps

Key gaps include:

- Robust quantitative data on waste generation by evidence type, scene type, and jurisdiction.
- Validation studies for biodegradable and alternative packaging under realistic forensic conditions.
- Comparative life-cycle assessments of different consumable and packaging options.

- Socio-technical studies on practitioner attitudes, risk perceptions, and behavioural change in CSI units (Morgan et al., 2024; Williams et al., 2024).

Addressing these gaps will require collaboration between forensic scientists, environmental scientists, designers, and policy-makers.

Conclusion: Crime scene tools and packaging materials are necessary to keep evidence clean and reliable, but they end up forming tons of plastic waste and other junk that harms the planet. Studies make it clear that the big problem isn't about worrying about contamination or strict lab rules, but it is the older kit designs, cheap bulk buying, and zero focus on green options (College of Policing, 2023; FCN, 2023; Malik & Gupta, 2025; Williams et al., 2024).

The newer methods are developing day by day such as plant-based bags that won't rot the evidences, smarter kit layouts with less waste, plant-powered fingerprint tricks, recycle loops for clean gear, apps for remote scene checks, and rules that bake in eco-smarts (Earthwise Packaging, 2022; Greener Approaches, 2024; IASPD, 2025; Morgan et al., 2024; Wang et al., 2025). Real wins back this up: UK police pilots slashed plastic at scenes without a single court hiccup, NHS forensics teams dismissed the disposables to save cash and CO2 (think 84,000 kg a year), and Indian thinkers push for green kits in forests (ELFT, 2025; Henderson, 2024; Malik & Gupta, 2025).

Forensic laboratories should be designed in a way that is eco-friendly and safer to the forensic workers as well as the environment. Laboratories should use more renewable energy, plant based reagents, recyclable materials and advanced energy monitoring systems. Additionally, forensic laboratories can utilize the leftover chemicals or recover them in a safe uncontaminated container instead of throwing them away into waste. One effective technique that can be used for minimizing the waste is the use of microfluidic and miniaturized methods which lower the number of reagents to be used for forensic analysis.

Crime scene gear and packaging keep evidence safe, but they cause serious plastic piles and eco-damage that can't be ignored anymore. Digging through the research from UK police pilots to Indian lab reviews shows waste comes from more than just contamination fears or lab standards; it's baked into bulky designs, bulk buys chasing the lowest price, and overlooking green swaps (College of Policing, 2023; FCN, 2023; Henderson, 2024; Malik & Gupta, 2025; Williams et al., 2024). A single crime scene can spit out 2kg of plastic, much unused, costing £78 to replace and hitting landfills hard (Henderson, 2024; University of Portsmouth, 2025). Surveys of frontline cops confirm they see the trash mountain growing, tied to ISO rules pushing single-use everything (College of Policing, 2023).

Fixes are real and tested: Newer and advanced methods use water and plant based non-toxic fingerprint powders and the non toxic print lifting methods using infrared imaging and biodegradable materials. plant bags holding DNA tight, slimmer kits via cop-supplier chats, plant-based print powders, recycle streams for clean bits, apps skipping trips, and rules greening buys also helps (Earthwise Packaging, 2022; Greener Approaches, 2024; IASPD, 2025; Morgan et al., 2024; Wang et al., 2025). UK forces cut excess without court flops; NHS forensics dumped disposables, saving 84,000kg CO2 yearly and cash (ELFT, 2025; RCPath, 2024). India pushes green kits for forests, spotting gaps in new laws like BNS (Malik & Gupta, 2025).

Forensics needs adopt safe collection and storage of evidences using alternative materials such as biodegradable, reusable, and recyclable materials. (Morgan et al., 2024; RCPath, 2024; International Publications, 2025). Climate heat on public services means CSI joins or lags. Cutting waste sharpens justice long-term, blending people protection with planet care (Williams et al., 2024; Malik & Gupta, 2025; Vigyan Varta, 2025).Organizations should start using plant- based cotton swabs, composable gloves, and emvironmental friendly protective equipment to reduce their reliance on plastic.

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