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## TOXICOLOGICAL EVIDENCE IN FORENSIC PHARMACOLOGY: LEGAL AND SCIENTIFIC INTERFACES IN CRIMINAL JUSTICE

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### Abstract

*A Comparative Legal and Scientific Analysis*

Jurisdictions: India | United States | United Kingdom

Toxicological evidence plays a pivotal role in forensic pharmacology, particularly in criminal investigations involving poisoning, drug-related offenses, and unexplained deaths. This research paper explores the scientific and legal dimensions of toxicological evidence, evaluating its admissibility, reliability, and application in criminal trials. Through an interdisciplinary approach encompassing case laws, statutory provisions, and comparative legal analysis across India, the United States, and the United Kingdom, this paper investigates how courts assess expert toxicological testimony, the impact of advancements in pharmacological testing, and challenges in interpretation. The study highlights real-world case studies, examines the evolving role of forensic toxicologists, and advocates for standardized protocols, enhanced cross-disciplinary training, and stronger legal safeguards to ensure justice.

**Keywords:** Forensic Toxicology, Criminal Justice, Expert Testimony, Daubert Standard, Evidence Law, Pharmacology, Postmortem Analysis, Chain of Custody, Legal Standards

### Introduction

Forensic pharmacology addresses the detection, interpretation, and legal implications of pharmaceutical substances in a forensic context. Toxicological evidence—derived from blood, urine, tissue, or hair analyses—serves as critical proof in criminal cases including homicides, suicides, accidental poisonings, sexual assaults, and drug-impaired driving. As forensic sciences evolve, the complexity and admissibility of toxicological data in judicial proceedings continue to expand.

The integration of toxicological evidence into legal contexts poses unique challenges. Courts

must interpret scientific findings, balance expert testimony, and adhere to evidentiary rules while maintaining principles of natural justice and due process. A foundational concern lies in ensuring that such evidence is scientifically valid, legally admissible, and presented comprehensibly to judges and jurors. With increasing reliance on complex chemical analyses and advanced detection instruments, rigorous scrutiny of laboratory protocols, expert qualifications, and potential for procedural error becomes essential.

In adversarial legal systems, expert testimony becomes a battleground for contesting forensic findings, especially in cases involving new or

controversial drugs, substances with delayed metabolism, and polydrug toxicity. This research provides comprehensive exploration of toxicological evidence from both doctrinal and empirical perspectives, assessing statutory frameworks, analyzing pivotal case laws, and highlighting comparative approaches across multiple jurisdictions.

## Scope and Methodology

### Scope of Study

This research investigates legal and scientific contours of toxicological evidence in forensic pharmacology within criminal justice systems. The jurisdictional focus examines India, the United States, and the United Kingdom, offering comparative perspectives on evidentiary standards and procedural frameworks. The study analyzes substantive laws relating to crimes involving toxic substances and procedural laws dealing with collection, analysis, and admissibility of toxicological evidence.

The research considers clinical toxicology and postmortem forensic toxicology, focusing on commonly litigated substances including narcotics, alcohol, prescription drugs, and poisons such as cyanide and arsenic. It examines the role and qualifications of forensic toxicologists, validity of laboratory techniques including GC-MS, LC-MS/MS, and immunoassays, and emerging scientific tools such as hair analysis, metabolomics, and synthetic drug detection. Case law analysis emphasizes landmark cases where toxicological evidence was pivotal, judicial scrutiny of expert testimony, chain of custody, and laboratory accreditation.

### Methodology

This study adopts a doctrinal-empirical hybrid approach integrating legal analysis with scientific evaluation. The methodology includes analysis of statutes, judicial precedents, and rules of evidence from selected jurisdictions, comparative legal analysis identifying points of convergence and divergence, and review of

scientific literature, laboratory manuals, and technical protocols. Critical review of criminal trials where toxicological evidence played decisive roles provides empirical grounding, while interdisciplinary framework bridges law and science by contextualizing legal doctrine within scientific parameters.

## Legal Provisions Governing Toxicological Evidence

Toxicological evidence is governed by statutory laws, evidentiary standards, procedural codes, and regulatory frameworks determining collection, admissibility, interpretation, and evidentiary value in criminal justice systems.

### Indian Legal Framework

India's approach is rooted in the Indian Evidence Act 1872, Code of Criminal Procedure 1973, Indian Penal Code 1860, and relevant regulatory laws concerning narcotics, poisons, and pharmaceuticals. Section 45 of the Evidence Act allows courts to consider expert opinions on scientific matters including toxicology and pharmacology. Section 293 CrPC specifies that reports from government chemical examiners and forensic science laboratories are admissible without calling the expert unless demanded by court or accused.

Sections 53 and 53A CrPC permit collection of biological samples necessary for toxicological testing during investigation. The Indian Penal Code criminalizes negligent conduct with poisonous substances (Section 284), causing hurt by poison or stupefying substances (Section 328), and establishes frameworks for murder and culpable homicide cases where toxicological evidence determines cause of death. The NDPS Act 1985 provides framework for forensic identification and analysis of narcotics and psychotropic substances.

### United States Legal Framework

U.S. law regulates toxicological evidence through Federal Rules of Evidence, state laws, and constitutional principles. Rule 702 FRE allows expert testimony if knowledge helps the trier of

fact understand evidence and is based on reliable principles and methods under the Daubert Standard. Constitutional protections include Fourth Amendment protection against unreasonable search and seizure applying to biological sample collection, Fifth Amendment protection from self-incrimination, and Due Process Clause ensuring fairness in evidence gathering. Organizations including the American Board of Forensic Toxicology and Society of Forensic Toxicologists provide validated testing protocols and standards.

### United Kingdom Legal Framework

The UK incorporates toxicological evidence through the Police and Criminal Evidence Act 1984 governing collection and handling of biological samples, Criminal Procedure Rules 2015 Part 19 regulating expert evidence requiring independence and recognized methodologies, Human Tissue Act 2004 controlling removal, storage, and use of human biological material, and Misuse of Drugs Act 1971 establishing classification of controlled substances. The Crown Prosecution Service provides guidance on forensic toxicology while the Forensic Science Regulator's Codes of Practice ensure transparency and accuracy.

### Judicial Interpretation Through Case Laws

Toxicological evidence requires precise interpretation, strict procedural compliance, and expert validation. Judicial decisions across jurisdictions address admissibility, credibility, and probative value, navigating scientific and legal challenges.

### Indian Jurisprudence

*Mohd. Aman v. State of Rajasthan (AIR 1997 SC 2960)* held that mere recovery of poison is insufficient; there must be proof of administration, clear chain of custody, and expert confirmation of cause of death. This emphasized burden of proof in poison-related cases and importance of expert testimony.

*State of Himachal Pradesh v. Jai Lal (1999) 7 SCC 280* ruled that expert evidence is advisory

and courts must evaluate it within entire evidentiary chain, introducing the notion that toxicological reports require corroboration by other evidence including motive, opportunity, and witness testimony.

The *Sister Abhaya Case* (CBI Court, Thiruvananthapuram, 2020) demonstrated evolving reliability of forensic toxicology while highlighting risks of tampering and initial misreporting. The Court relied heavily on forensic reconstruction and chemical analysis despite earlier investigative lapses.

*Anil Phukan v. State of Assam (1993) 3 SCC 282* warned against relying solely on FSL reports without analyst testimony, reaffirming that oral examination of chemical examiner is essential under Section 293 CrPC unless the accused consents otherwise.

### United States Jurisprudence

*Daubert v. Merrell Dow Pharmaceuticals (509 U.S. 579, 1993)* established the Daubert standard for admissibility of expert scientific evidence under Federal Rule of Evidence 702. The judge serves as gatekeeper assessing testability, peer review, error rates, and general acceptance. This profoundly influenced how toxicological experts present findings, increasing scrutiny on methodology rather than conclusions.

*Kumho Tire Co. v. Carmichael (526 U.S. 137, 1999)* extended Daubert criteria to technical and specialized knowledge including forensic toxicology, solidifying the principle that methodology over opinion must guide court evaluation of toxicological evidence.

*Frye v. United States (293 F. 1013, D.C. Cir. 1923)* held that scientific evidence is admissible only if the method is generally accepted in its respective field. Though superseded by Daubert in federal courts, many states still use Frye, especially for toxicological innovations not yet peer-reviewed.

### United Kingdom Jurisprudence

*R v. Harris and Others ([2005] EWCA Crim 1980)* warned against over-reliance on one-sided

expert opinions, reinforcing that expert opinions must be balanced, current, and peer-evaluated especially in complex toxicology cases.

*R v. T* ([2010] EWCA Crim 2439) ruled that mathematical methods lacking sufficient scientific foundation render evidence inadmissible, highlighting dangers of pseudo-scientific methods in forensic disciplines including toxicology.

### Challenges in Toxicological Evidence

While toxicological evidence plays crucial roles in criminal justice, its application faces scientific, legal, procedural, and ethical challenges affecting credibility, admissibility, and interpretive accuracy.

#### Scientific and Technical Challenges

Toxicological results, especially in postmortem cases, are inherently complex. Presence of a substance does not always establish causality of death, intent, or precise dosage and timing. Postmortem redistribution complicates dose estimations as drugs redistribute from tissues into blood after death, leading to artificially elevated concentrations. Drug interactions and metabolites in multiple drug ingestion cases alter pharmacokinetics of individual drugs.

Modern methods like GC-MS, LC-MS/MS, and ELISA offer high sensitivity but face limitations including false positives due to cross-reactivity and false negatives when substances fall outside testing panels. Sample degradation and contamination remain problematic as biological samples are prone to degradation without prompt refrigeration or preservation, leading to decomposition of volatile substances, microbial activity producing ethanol in dead bodies, and contamination during collection or testing.

#### Legal and Evidentiary Challenges

Maintaining unbroken and documented chain of custody from collection to analysis is essential for admissibility. Breaks may give rise to allegations of tampering, mishandling, or fabrication, leading courts to exclude

toxicological evidence. Expert witness qualifications require relevant educational background, experience with specific tests, and impartiality, yet lack of standardized credentialing particularly in India and some U.S. states leads to inconsistencies in expert testimonies.

Jurisprudential disparities affect uniformity as courts vary in admissibility thresholds. The Daubert standard requires scientific validity and peer-reviewed methods, Frye demands general acceptance in scientific community, while Indian courts under Evidence Act Section 45 provide broad discretion without always scrutinizing methodology. Prosecutors may place excessive reliance on toxicological reports while neglecting circumstantial evidence, or conversely, absence of toxicology may unjustly weaken prosecution.

Defence attorneys often lack the technical expertise to effectively challenge toxicological findings, resulting in limited cross-examination and undermining adversarial rigor. When forensic reports are accepted without analyst presence under CrPC Section 293, defence loses opportunity to test evidence in open court.

#### Ethical and Regulatory Challenges

Obtaining biological samples raises ethical issues regarding consent and bodily autonomy. Compulsory testing may infringe on privacy rights under Article 21 (India), Fourth Amendment (U.S.), and Human Rights Act (U.K.). Many jurisdictions lack central accrediting authority for toxicology labs. In India, forensic labs operate under state governments or police departments with varying standards, while ABFT accreditation remains voluntary in the U.S.

Experts may be subconsciously biased toward the commissioning side, usually prosecution, resulting in overstating conclusions, ignoring alternate hypotheses, or adapting reports to fit narratives. Media trials often misrepresent toxicological evidence in high-profile cases, creating pressure on forensic analysts,

influencing juror perceptions, and undermining public trust in forensic science.

The Sister Abhaya case exemplifies how absence of original toxicological samples and conflicting reports from multiple agencies severely weakened evidentiary trails. Questions of tampering, delayed reporting, and lack of transparency demonstrate how procedural flaws in toxicological evidence obstruct justice even decades after crimes.

### Relevance and Significance

Growing reliance on forensic science in criminal justice necessitates comprehensive understanding of how toxicological evidence impacts judicial outcomes. Observable increases in crimes involving toxic agents—from date-rape drugs to intentional poisonings—make toxicological evidence central to criminal investigations and prosecutions. Cases involving fentanyl-laced substances have surged, making precise forensic analysis matters of life and liberty.

Toxicological evidence being technically complex means courts rely on forensic experts to interpret data and findings. This study clarifies legal principles governing expert admissibility and scrutiny of conclusions, relevant for judges, prosecutors, and defense attorneys. Advancements in analytical instrumentation increase possibilities of contamination, false positives, and flawed methodologies potentially leading to wrongful convictions or acquittals.

Despite critical roles, many countries lack standardized forensic protocols. Indian Forensic Science Laboratories face chronic underfunding with often delayed or contested reports. With advent of digital drug trafficking through dark web markets and designer drugs including synthetic cannabinoids, law enforcement must constantly adapt toxicological testing techniques. This research bridges law and science, fostering interdisciplinary thinking among legal scholars, forensic scientists, and policymakers while identifying procedural

lapses and inconsistencies to offer legislative and procedural recommendations.

### Recommendations and Best Practices

To mitigate challenges and enhance reliability of toxicological evidence in criminal justice, several remedies and best practices should be implemented:

- Establish standardized accreditation and external audits for toxicology laboratories under NABL in India and ISO internationally
- Mandate dual confirmatory testing for crucial evidence to minimize analytical errors
- Ensure transparency in expert methodology and disclosure of error margins
- Provide technical training for judges and lawyers to enhance scientific literacy
- Encourage interdisciplinary collaboration between law and science communities
- Establish ethical oversight committees for forensic laboratories
- Strengthen legal aid framework ensuring defense can afford independent expert testimony
- Implement digital chain of custody systems preventing tampering or misplacement

### Future Directions

The future of forensic toxicology lies in continued technological evolution. Mass spectrometry and liquid chromatography have revolutionized toxicology, allowing detection of new psychoactive substances and improving sensitivity and specificity of tests. Microfluidic devices for rapid on-site testing and biosensors offer potential solutions for faster and more efficient toxicological analysis, reducing time between evidence collection and court hearings. Artificial intelligence may play growing roles in improving data analysis,

recognizing patterns in toxicological data, and predicting substance effects on human biology.

Establishment of global and national standards remains essential. International accreditation bodies such as ISO/IEC 17025 must enforce uniform standards in toxicology laboratory procedures ensuring consistency in quality control and result validity. Standard operating procedures for sample collection, storage, and transportation are necessary to safeguard against contamination and tampering. Enhanced training and education at all levels from forensic toxicologists to law enforcement officers is crucial, with forensic toxicologists staying abreast of emerging drugs including designer drugs and synthetic substances.

Ethical concerns regarding toxicological evidence use must be addressed through strengthened legal frameworks. Informed consent for toxicological tests, especially in non-consensual testing scenarios, should be scrutinized to safeguard individual rights. Legal provisions regarding chain of custody and evidence integrity must be clearly defined to avoid tampering and ensure admissibility. Ethical review boards in forensic toxicology should regularly monitor cases involving sensitive data.

Criminal tactics evolution and emergence of new drugs require forensic toxicology to continually adapt. Synthetic opioids like fentanyl leading to increasing overdose deaths necessitate new detection methods. Toxicological analysis of electronic devices including e-cigarettes and drug delivery systems will become more prominent. Cross-border cooperation and data sharing through international collaborations and databases for identifying new substances can facilitate quicker and more accurate responses to emerging threats.

### Conclusion

Toxicological evidence in forensic pharmacology plays an indispensable role in criminal justice, serving as a cornerstone in

solving crimes, establishing cause of death, and proving criminal intent. However, toxicology in legal contexts is fraught with challenges related to reliability of scientific methods, ethical considerations, and legal implications of toxicological data. The research synthesizes findings demonstrating that toxicological evidence provides scientific backbone of many criminal investigations, offering critical insights into cause of death, criminal intent, and defense in wrongful accusations.

Despite clear importance, integration with law remains problematic due to reliability of scientific methods vulnerable to accuracy issues, contamination, and misinterpretation; heavy dependence on experts to interpret complex findings leading to misapplication; ethical issues surrounding informed consent, privacy, and potential misuse; and legal challenges including chain of custody failures, improper documentation, and malfeasance undermining credibility.

Each jurisdiction—India, the United States, and the United Kingdom—brings unique challenges and contributions. India faces lack of standardization in forensic practices and insufficient training impeding development of robust protocols. The U.S. and U.K. benefit from more standardized methods, though concerns about bias, expert qualifications, and ethical violations remain. The future of forensic toxicology is poised for remarkable advancements, yet scientific, legal, and ethical communities must ensure these advances serve justice.

Toxicological evidence will continue playing pivotal roles, but for effectiveness and equity, significant strides must be made in scientific accuracy, ethical practice, and legal clarity. The intersection of forensic science and law must evolve to meet challenges of modern-day criminal investigations through continuous improvements in technology, training, and ethical oversight. Only through such comprehensive reform can toxicological evidence truly fulfill its promise as an instrument

of justice while protecting the rights and dignity of all individuals involved in the criminal justice process. References

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