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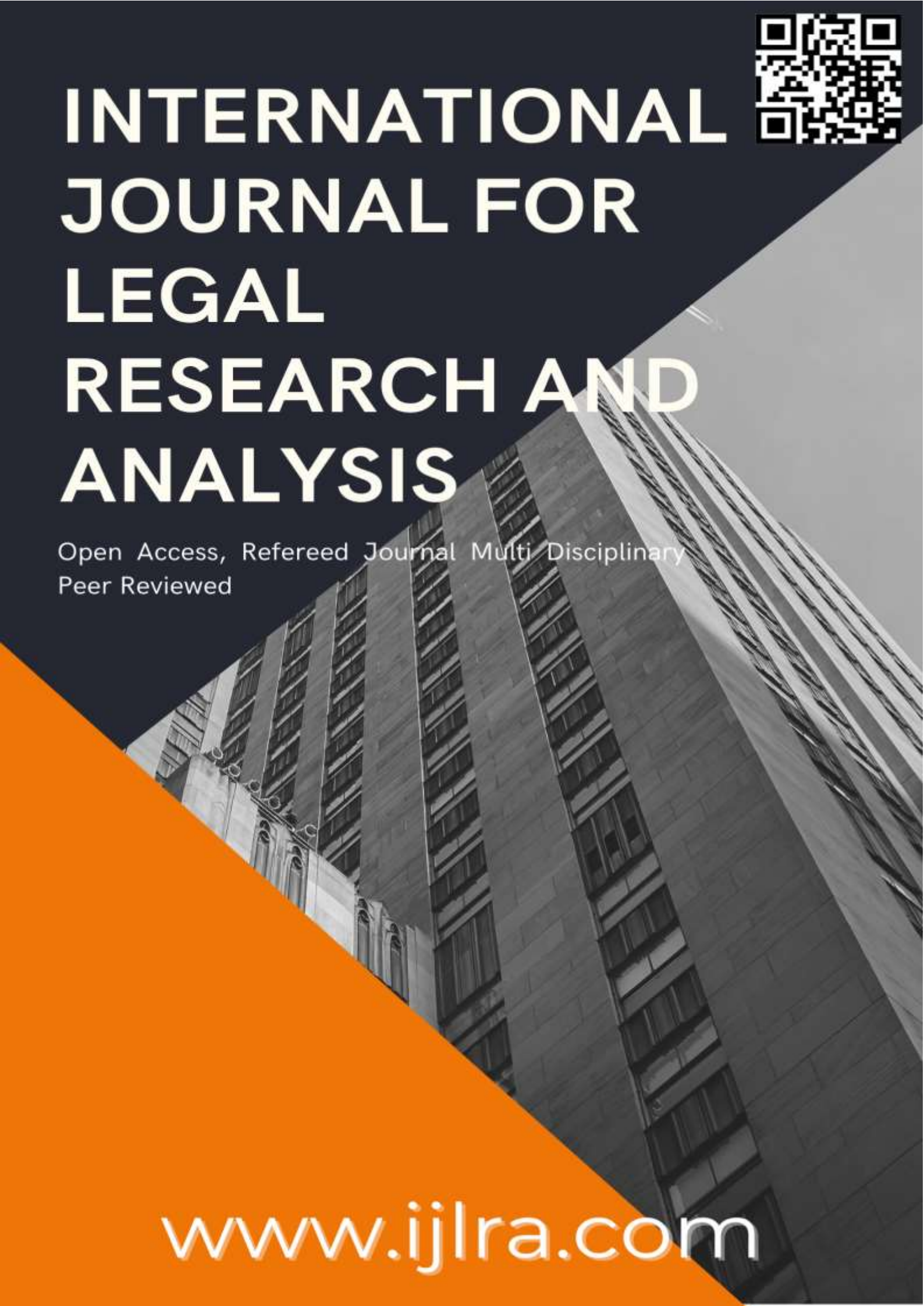

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THE IMPORTANCE OF DNA EVIDENCE AND ITS UTILIZATION IN CRIME SCENE

AUTHORED BY - RISHIKA JHA & MS. SMEEKSHA PANDEY

Abstract

DNA Evidence is a powerful tool in criminal investigations, often seen as the "gold standard" for identifying perpetrators and proving innocence. However, a recent study overlooked that DNA is not foolproof. Factors like mistakes during evidence collection, overlooked samples, the absence of reliable witnesses and potential contamination can all compromise its accuracy. Human errors in the lab, inconsistent testing methods and subjective interpretations of results also raise concerns. There is a growing worry that investigators and jurors may rely too heavily on DNA without considering other evidence or understanding the statistical probabilities involved. Crime scene investigation is a critical element in the justice process and improvements in technology allow investigators to obtain more accurate evidence and solve cases more efficiently. The legal process is directly impacted by the caliber of evidence gathered and recorded at the site, which emphasizes the significance of crime scene forensics in guaranteeing a fair trial. This analysis emphasizes the need for stricter standards and ethical guidelines to ensure DNA evidence is used responsibly and reliably within the criminal justice system, balancing its potential benefits with the risk of wrongful convictions.

Introduction

Since its first application in 1987, DNA evidence has transformed forensic science and criminal investigation. It is now among the most effective instrument available for person identification, crime solving, and guarantees of justice. Except for identical twins, DNA, or deoxyribonucleic acid, is the hereditary material found in most other organisms including humans and most other entities having distinct genetic information that sets one individual from another. DNA evidence is biological material gathered from crime scenes—blood, hair, saliva, semen, or skin cells—that can be examined to either identify individuals or link suspects to criminal activity.[1] A new chapter in biological sciences began in 1950 when DNA was identified as the universal genetic material. Developed by Prof. Alec Jeffreys in 1985, DNA fingerprinting initially found

[1] National Institute of Justice, "DNA Evidence Basics," accessed March 2025.

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use in a civil immigration conflict in the UK. Its application in criminal investigations started with the 1986 Colin Pitchfork case, in which DNA profiling first helped to convict a killer. Indigenous DNA fingerprinting probes developed by scientists at the Centre for Cellular and Molecular Biology (CCMB), Hyderabad, brought DNA technology into India for forensic use in 1988. This success made India among the first few nations using sophisticated genetic technology for forensic purposes.[2]

Restricted Fragmentation Length Polymorphism (RFLP) was the first DNA fingerprinting technique applied. It worked by dissecting DNA and examining particular trends. Although RFLP was efficient, it presented difficulties since it needed big amounts of high-quality DNA around 10 nanograms. Often degrading DNA samples, environmental elements such as heat and humidity made analysis challenging.[3]

Polymerase Chain Reaction's arrival in 1990 fundamentally changed everything. PCR works like a "DNA photocopier," making tiny amounts of DNA much larger and easier to use. PCR can create billions of copies of the target DNA segment in hours even if the sample is degraded or in trace levels. This innovation solved the problem of insufficient or damaged samples and made DNA analysis much more accessible for forensic investigations.[4]

Short Tandem Repeat (STR)-based DNA analysis represented still another technological advance. STR profiling emphasizes repeating sequences in DNA that differ between individuals. It is quite sensitive and can yield findings even from somewhat deteriorated materials. For forensic use particularly in cases involving old or compromised biological evidence, this made DNA evidence more dependable and useful.[5]

By the 1990s, DNA fingerprinting was generally agreed upon as among the most accurate methods of identification. Events like the DNA Fingerprinting Congress during this decade advanced methods and broadened uses. Globally in criminal investigations, civil conflicts, and

[2] Ankit Srivastava, Abhimanyu Harshey, Tanurup Das, Akash Kumar, Murali Manohar Yadav, Pankaj Shrivastava, “Impact of DNA evidence in criminal justice system: Indian legislative perspectives” 12, Egyptian Journal of Forensic sciences, 51 (2022).
[3] Ibid.
[4] Ankit Srivastava, Abhimanyu Harshey, Tanurup Das, Akash Kumar, Murali Manohar Yadav, Pankaj Shrivastava, “Impact of DNA evidence in criminal justice system: Indian legislative perspectives” 12, Egyptian Journal of Forensic sciences, 51 (2022).
[5] Ibid.

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even genealogies today, DNA evidence is applied.[6]

Using DNA starts with meticulous gathering of biological samples from crime sites. Prevention of contamination or degradation depends critically on proper handling and preservation. Forensic experts remove DNA from once gathered materials using organic or chelex extraction among other methods. The DNA is amplified following extraction using techniques including Polymerase Chain Reaction (PCR), which generates millions of copies of DNA segments for simpler study. Scientists then look at Short Tandem Repeats (STR), particular DNA areas where sequences are repeated, to produce a distinct genetic profile or "genetic fingerprint"[7]. Comparisons between cases and jurisdictions can be facilitated by storing profiles in databases such as Combined DNA Index System (CODIS) in the United States or like systems globally. Modern technologies let researchers examine even minute levels of DNA, including "touch DNA," left behind when someone handles an object. DNA evidence has many uses; it helps solve crimes by matching suspects' crime scene evidence with genetic profiles and can link unresolved crimes across national or international DNA databases. Furthermore, DNA evidence has been instrumental in reversing erroneous convictions by proving people's innocence and in cases involving missing persons or paternity conflicts in establishing family links.[8]

After being connected through blood samples to two murders carried out years ago, Colin Pitchfork became one of the first people found guilty in England in 1986 based just on DNA evidence. His conviction marked a turning point for forensic science globally.[9] Joseph DeAngelo, the Golden State Killer, was caught in 2018 after police used a public genealogy website to find his relatives through DNA. By building a family tree from these matches, investigators identified DeAngelo as a suspect, collected his DNA from discarded items, and matched it to evidence from the crime scenes.

Legal Framework

The laws governing DNA evidence are a complicated and dynamic field that strikes a balance between the need to uphold fair trials and safeguard individual rights and the potent powers of

[6] Ibid.
[7] Butler JM, “Advanced Topics in forensic DNA Typing: methodology” Academic press (2010).
[8] Innocence Project, “cases where DNA Evidence Exonerated Wrongfully Convicted individuals” accessed in March 2025.
[9] Supreme Court Judgments on DNA Evidence Use in Criminal Cases (India), accessed March 2025.

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forensic science. DNA evidence is becoming more and more acknowledged in India as an essential tool in criminal and civil cases, especially when it comes to issues like paternity disputes, investigations into sexual assault, and the identification of unidentified individuals. However, rather than being controlled by a single comprehensive rule, the use of DNA evidence is governed by a combination of legislative requirements, judicial precedents, and new policy initiatives.

The courts have the authority to accept expert views, including those pertaining to DNA analysis, as acceptable evidence under the Indian Evidence Act, 1872, which is currently known as Bhartiya Sakshya Adhiniyam. Expert witness is particularly permitted under Section 39 of the Act, which is crucial for assisting jurors and judges in comprehending the intricate technical details of DNA profiling. By allowing the collecting of biological samples from suspects for investigative purposes, the Code of Criminal Procedure, 1973 (CrPC), presently known as the Bharatiya Nagarik Suraksha Sanhita, further promotes the use of DNA evidence. Section 52 of the BNSS extends the use of Section 53 to include rape cases. Section 53 lets a doctor examine someone who is accused of a crime, including DNA analysis.

In India, DNA evidence has received strong judicial acceptance. If the methods used for DNA collection and testing are solid scientific practices and unaltered, the Supreme Court and many High Courts have consistently upheld the validity and probative value of DNA analysis. The significance of expert testimony has also been underlined by courts, which make sure that DNA evidence is presented in a way that non-experts can understand and that the prosecution and defence have access to all pertinent information and materials for cross-examination.

The use of DNA evidence in India is not without difficulties, despite its increasing acceptability. The absence of a thorough legislative framework devoted to DNA profiling is one of the main issues. Although they offer a starting point, Bharatiya Sakshya Adhiniyam and Bharatiya Nagarik Suraksha Sanhita do not cover important topics like forensic laboratory certification, testing process standardisation, or the long-term preservation and destruction of DNA evidence. The proposed DNA Technology (Use and Application) Regulation Bill aims to establish national and regional DNA databases, set stringent quality standards for laboratories, and define clear protocols for preservation and disposal of DNA profiles, is one piece of legislation that has been called for in response to this gap.

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The legal discussion around DNA evidence also revolves around privacy and consent. Article 21 of the Indian Constitution protects your right to privacy, meaning your personal life and information are safe. Article 20(3) protects you from being forced to say anything that might make you look guilty. Apart from situations where legal requirements permit mandatory collection during criminal investigations, these rights demand that DNA samples be obtained with informed permission. By enforcing stringent procedures for data access and retention and requiring the deletion of DNA data in instances of acquittal or release, unless a court rules differently, the new legislative framework aims to allay these worries.

Legal framework at international level

To guarantee the scientific validity of DNA testing while upholding human rights, a mix of judicial norms, ethical principles, and regulatory procedures have established the legal framework controlling DNA evidence on a global scale. The Frye and Daubert standards, which demand that DNA evidence be based on scientifically recognised procedures and be pertinent and trustworthy for the case at hand, are among the established admissibility requirements that courts across the world often adopt. By guaranteeing that only DNA tests that are supported by science are permitted into court, these guidelines aid in preserving the integrity of forensic evidence in both criminal and civil trials.[10]

Comparative legal studies show that the laws governing DNA evidence varied significantly between jurisdictions, particularly between European and non-European nations. European laws typically have more thorough frameworks that combine forensic science and human rights concerns, including specific guidelines for the gathering, storing, and use of genetic data. The European Convention on Human Rights (ECHR) helps ensure fair legal processes and protects people's right to privacy, which in turn shapes how justice and privacy are handled. It can be difficult to strike a balance between legal protections and technology advancements in certain non-European nations due to their less established or disjointed rules.[11]

Furthermore, there is a disconnect between scientific capacity and legal supervision as the quick growth of DNA technologies has surpassed regulatory advancements in many nations. This disparity highlights the necessity of ongoing legislation changes to handle new challenges

[10] National research council, “The evaluation of forensic DNA evidence” National Academies press, Washington DC (1996).
[11] Vol. 1 No. 2 (2022): The International Journal of Law in Changing World Issue 2 2022.

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including the use of artificial intelligence in forensic investigation, the use of novel genetic markers, and the moral ramifications of growing DNA databases. Harmonised rules that promote cross-border collaboration in criminal justice while protecting fundamental rights are being called for more and more in international discourse.[12]

Ethical considerations

DNA evidence raises several intricate and multidimensional ethical questions, including those of privacy, consent, accuracy, fairness, and misuse potential. This is a thorough explanation:

- **Privacy Concerns**

  DNA contains sensitive details about identity, health, and family, making privacy a major concern. Unauthorized access can lead to discrimination by employers or insurers, and DNA databases like CODIS risk racial bias and civil liberties violations, especially for innocent individuals.[13]

- **Informed Consent**

  It is important to Obtain clear consent before collecting or testing DNA is essential to protect privacy and individual rights. People must know how their DNA will be used, as collecting samples without consent or under pressure is unethical.[14]

- **Accuracy and Reliability**

  Strict quality control must be used when handling DNA evidence to avoid errors or contamination. Analytical errors may result in innocent people being acquitted or in erroneous convictions. Justice must be upheld by establishing strict guidelines for DNA testing methods and interpretation.[15]

- **Equitable Access**

  Fair access to DNA testing is essential, particularly for those who could have been unfairly convicted prior to the widespread use of DNA technology. Injustice may be sustained if such testing is denied.[16]

- **Potential Misuse**

  Targeting marginalised communities disproportionately, DNA information might be used for profiling or surveillance. These hazards must be addressed by ethical frameworks, which also guarantee that DNA evidence is applied equitably in criminal

[12] Ibid.
[13] Legal and Ethical Considerations in the Use of DNA Fingerprinting.
[14] Ibid.
[15] Ibid.
[16] Legal and Ethical Considerations in the Use of DNA Fingerprinting.

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investigations.[17]

- **Data Management and Regulation**

  Strong legal frameworks are necessary to control how DNA data is gathered, stored, used, and shared. The public's trust is preserved when data management practices are transparent. Regulations should guarantee non-discriminatory practices and contain sanctions for abuse.[18]

- **International Standards**

  International cooperation is required to standardise the use of DNA evidence across borders due to the global nature of migration and crime. These principles ought to uphold universal human rights while honouring various legal and cultural norms.[19]

- **Emerging Ethical Challenges**

  New ethical conundrums are brought forth by developments in DNA technology, such as gene treatment and ancestry testing. To address privacy hazards and potential misuse, ethical rules must be continuously evaluated and adjusted for these technologies.[20]

- **Balancing Benefits and Rights**

  DNA fingerprinting, while effective for solving crimes and identifying individuals, raises serious ethical concerns. Balancing its benefits with the protection of individual rights requires ongoing dialogue among scientists, legal experts, ethicists, and the public to ensure its responsible use.[21]

Challenges in implementation

The implementation of DNA evidence in forensic science faces several significant challenges, which can hinder its effectiveness and reliability in criminal investigations. These challenges can be categorized into issues related to sample quality, technical limitations, legal and ethical concerns, and procedural inadequacies.

1. **Sample Quality Challenges**

- Contamination: DNA samples are susceptible to contamination at various stages, from collection to analysis. Sources of contamination can include environmental factors, handling errors, or cross-contamination with other samples. Because of this

[17] Ibid.
[18] Ibid.
[19] Ibid.
[20] Legal and Ethical Considerations in the Use of DNA Fingerprinting.
[21] Ibid.

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contamination, DNA profiles may be mistakenly ascribed or excluded, producing misleading results.[22]

- Degradation: DNA samples can be weakened by environmental factors like heat, moisture, and sunlight. The trustworthiness of the data is compromised because degraded DNA frequently produces incomplete profiles that are challenging to evaluate.[23]
- Mixed Samples: Forensic cases often involve mixed DNA samples from multiple individuals, complicating the separation of individual profiles. This is particularly common in cases of sexual assault or shared objects, requiring complex analysis and interpretation that increases the risk of misinterpretation.[24]
- Limited Quantity: In many forensic scenarios, the available DNA is limited, especially when sourced from minute biological traces like hair or skin cells. Low-quantity samples are more prone to contamination and errors during amplification.[25]

2. Technical Limitations

- Data Analysis and Interpretation: The analysis of DNA data is fraught with challenges due to the complexity of genetic information. Current analytical software may have limitations that lead to misinterpretation of results. Moreover, human error during data processing can further compromise accuracy.[26]
- Statistical Significance: Calculating match probabilities in cases involving partial or mixed profiles requires sophisticated statistical methods. Inaccurate judgements regarding the strength of a DNA match may result from misinterpreting these statistics.[27]

3. Legal and Ethical Concerns

- Admissibility Issues: Courts may be hesitant to accept DNA evidence due to concerns over its collection and handling. Improper procedures, such as failure to maintain the

[22] Dr. Pratibha Tiwari, "Challenges and solution in DNA fingerprinting; sample quality, data analysis and interpretation" International Journal of Advanced Biochemistry Research (2024).
[23] Ibid.
[24] Ibid.
[25] Ibid.
[26] Dr. Pratibha Tiwari, "Challenges and solution in DNA fingerprinting; sample quality, data analysis and interpretation" International Journal of Advanced Biochemistry Research (2024).
[27] Ibid.

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chain of custody or inadequate preservation methods, can lead courts to reject forensic evidence altogether.[28]

- Privacy and Ethical Considerations: The use of genetic information raises ethical questions regarding privacy and potential misuse. Ensuring that DNA evidence is handled ethically is crucial for maintaining public trust in forensic science.[29]

4. Procedural Inadequacies

- Lack of Standardization: There is often a lack of standardized protocols for interpreting DNA evidence across different jurisdictions. Variations in database systems and analysis protocols can hinder effective collaboration between agencies.[30]
- Training and Resources: Many forensic laboratories lack adequate training and resources for personnel handling DNA evidence. This deficiency can lead to errors in collection, analysis, and interpretation.[31]

Case laws

1. Priyadarshini Mattoo case [Santosh Kumar Singh v. State through CBI (2010)][32]

The Priyadarshini Mattoo case is a significant legal case in India that highlights issues with the criminal justice system, particularly when influential individuals are involved. Priyadarshini Mattoo, a 25-year-old law student, was found raped and murdered in her home in New Delhi on January 23, 1996. The accused, Santosh Kumar Singh, was the son of a senior IPS officer, J.P. Singh. The initial investigation was marred by allegations of police inaction and evidence tampering, partly due to the accused's influential family background.

In 1999, the trial court acquitted Santosh Singh, citing the benefit of doubt despite acknowledging he was likely the perpetrator. The judge criticized the police for inaction and potential influence by the accused's father. However, the CBI appealed the acquittal in the Delhi High Court in 2000. After years of delay, the case was expedited in 2006 due to public pressure Sections 376 and 302 of the Indian Penal Code were used by the Delhi High Court to find Santosh Singh guilty of rape and murder on October 17, 2006. The court sentenced him to death on October 30, 2006, relying on strong circumstantial evidence, including DNA tests,

[28] Ibid.
[29] Ibid.
[30] Dr. Pratibha Tiwari, "Challenges and solution in DNA fingerprinting; sample quality, data analysis and interpretation" International Journal of Advanced Biochemistry Research (2024).
[31] Ibid.
[32] (2010) 9 SCC 747.

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eyewitness accounts, and injuries on the accused that matched the crime scene.

Santosh Singh appealed the death sentence in the Supreme Court. On October 6, 2010, the Supreme Court upheld the conviction but commuted the death sentence to life imprisonment, citing mitigating factors. The case highlights the challenges faced by the Indian justice system, particularly when dealing with influential defendants. It demonstrates the impact of public pressure and media scrutiny on the judicial process. The reversal of the acquittal by the High Court was seen as a landmark decision, emphasizing the importance of proper investigation and evidence handling.[33]

2. Kunhiraman vs. Manoj (1991) DMC 499 (Vilasini v. Kunhiraman) [34]

The case of Vilasini v. Kunhiraman involves a dispute over paternity and maintenance. An unmarried woman named Vilasini got pregnant and gave birth to a child named Manoj. She claimed that Kunhiraman, a wealthy bachelor and her neighbor, was the father. Pregnancy and delivery were kept secret due to societal pressures. Vilasini filed a petition under Section 125 of the Code of Criminal Procedure for maintenance for her child, alleging Kunhiraman as the father. Kunhiraman denied paternity.

Vilasini testified that she had sexual relations only with Kunhiraman, who promised to marry her. Kunhiraman denied these claims but could not provide evidence of Vilasini's immoral character or suggest another father. The Chief Judicial Magistrate found Kunhiraman to be the putative father and ordered him to pay maintenance for Manoj. DNA testing was done at the Centre for Cellular and Molecular Biology (CCMB), Hyderabad, as part of Kunhiraman's appeal of this ruling. These tests confirmed Kunhiraman as the biological father of Manoj. Despite initial reservations about the reliability of the DNA test conducted in India, Kunhiraman's objections were dismissed, and the DNA evidence was deemed conclusive.

The High Court of Kerala upheld the trial court's decision, affirming Kunhiraman as the father and maintaining the order for him to pay maintenance for Manoj. The court noted that Kunhiraman failed to provide evidence of Vilasini's immoral character or suggest another possible father, supporting Vilasini's claims. This case highlights the use of DNA evidence in establishing paternity and the legal obligations of putative fathers towards their children, even in the absence of a legal marriage. It demonstrates how modern forensic techniques can be

[33] Nidhi N Anand, "Media trial in India and case analysis of Priyadarshini Mattoo case with respect to media trial" II, II, Indian journal of integrated research in law (2022).
[34] (1991) DMC 499

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pivotal in resolving paternity disputes and ensuring justice for children and their mothers.[35]

3. Naina Sahni Tandoor Murder Case[36]

In the 1995 Naina Sahni Tandoor Murder Case, her husband, Sushil Sharma, a Delhi-based youth leader for the Indian National Congress, brutally murdered Naina Sahni. On the night of July 2, 1995, Sushil Sharma, a youth Congress leader, became consumed by suspicion and jealousy over his wife Naina Sahni's alleged extramarital relationship with Matloob Karim, a fellow party member and her former love, confronted her at their residence. In a fit of rage, he shot Naina multiple times, killing her instantly. Panicking and desperate to conceal the crime, Sushil wrapped her body in a bedsheet, placed it in his car, and drove to a nearby restaurant called Bagia. There, he attempted to destroy the evidence by burning her body in the restaurant's tandoor (a traditional clay oven used for cooking. He brutally cut Naina's arms below the elbows and legs below the knees in order to fit the body inside the tandoor. Keshav Kumar, the restaurant manager, was forced to assist him commit this heinous deed. The intense heat and smell from the burning body attracted the attention of the restaurant staff and nearby residents, prompting the police to investigate. Initially, the post-mortem report suggested that Naina had died due to burn injuries, but a second, more thorough autopsy revealed that the actual cause of death was the gunshot wounds inflicted by Sushil Sharma, which was crucial in establishing the murder charge. Sushil fled the city but surrendered to the police nine days later. After a lengthy trial, he was convicted and sentenced to death in 2003, while Keshav Kumar received a seven-year rigorous imprisonment sentence for his role in aiding the crime. The case is infamous not only for its gruesome nature but also for highlighting the importance of forensic science and the role of a second autopsy in uncovering the truth. It remains one of the most sensational murder cases in India, reflecting the dark consequences of jealousy and the lengths to which a perpetrator may go to cover up a crime.[37]

4. Swami Premanand Case 1997[38]

The Swami Premananda case of 1997 is one of the most infamous criminal cases in India, involving the conviction of Swami Premananda, a self-styled godman, for multiple counts of rape, murder, and other offenses. Born Prem Kumar in Sri Lanka, he fled to India during the

[35] Suraj Kumar, "The age of DNA: Unravelling Mysteries and Impact on Justice Delivery" 12, 8, International Journal of Science and Research (IJSR) (2023).
[36] 2006 (12) SCC 421, AIR 1999 SC 1926
[37] 2006 (12) SCC 421, AIR 1999 SC 1926
[38] AIR 2005 SUPREME COURT 2132

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Sri Lankan Civil War and established the Premananda Ashram in Tamil Nadu. The case came to light in 1994 when Arul Jyothi, a girl living in the ashram, escaped and reported that she had been raped by Premananda and was pregnant. Investigations revealed further allegations of sexual assault on 13 women, molestation of two others, and the murder of an ashram resident named Ravi, who had attempted to expose the crimes.

The trial was held in the Pudukkottai Sessions Court under Judge R. Banumathi. The evidence presented included DNA samples linking Premananda to the pregnancy of Arul Jyothi and the remains of the murdered victim found buried on the ashram premises. Despite defense arguments led by senior advocate Ram Jethmalani, which claimed police brutality and mishandling of evidence, the court found Premananda guilty. In August 1997, he was sentenced to double life imprisonment and fined ₹67.3 lakh for 13 counts of rape, molestation, and murder. The court also ruled that his sentences would run consecutively rather than concurrently—a rare decision—and denied any possibility of remission or amnesty.

The Madras High Court upheld his conviction in 2002, and the Supreme Court rejected his appeal in 2005. Prior to his death from liver illness in 2011, Premananda maintained his innocence during his incarceration in Cuddalore Central Prison. The case is notable not only for its gruesome details but also for exposing the exploitation committed under the guise of spirituality. It highlighted the vulnerability of women and orphans in such institutions and underscored the importance of rigorous legal and investigative processes in cases involving influential figures.[39]

Future Potential

The future of DNA evidence in India is promising, with proposed legislation like the DNA Technology Regulation Bill aiming to establish national and regional DNA data banks for solving crimes, identifying missing persons, and managing disasters. The Bill also proposes a regulatory board to oversee DNA labs, ensuring accuracy, ethical standards, and data protection, which would make DNA evidence more reliable and widely accepted in courts.[40]

DNA evidence in India has broad applications beyond crime-solving. It helps reunite missing children with families and identify unknown bodies, addressing the country's large numbers of missing persons and unidentified remains. DNA technology also supports wildlife conservation by tracking endangered species and combating poaching. In agriculture, DNA advances enable

[39] AIR 2005 SUPREME COURT 2132
[40] The DNA Technology (Use and Application) Regulation Bill – 2019 introduced in Lok Sabha,

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the development of disease-resistant, high-yield crops, improving food security and resilience. These uses show DNA's transformative impact across social, environmental, and scientific sectors.[41] [42]

Technological advancements are making DNA testing in India faster and more accessible, helping to reduce case backlogs. Indigenous solutions from institutions like CSIR-CCMB have lowered costs and reliance on imports, expanding nationwide access to DNA fingerprinting. These innovations are improving forensic standards and the quality of DNA analysis across the country.[43]

For DNA evidence to be fully integrated into India's legal system, increasing awareness and providing specialized training for judges and legal professionals is crucial to boost confidence in its reliability. Courts are gradually recognizing DNA evidence as highly probative, especially in serious crimes like rape and murder, but acceptance still faces hurdles such as limited forensic infrastructure, procedural gaps, and lack of uniform standards. Legislative reforms, technological advancements, and judicial education together can help DNA evidence become a transformative tool in crime-solving and justice delivery across India.[44]

Conclusion

In conclusion, crime scene investigation is a critical part of modern forensic science and the criminal justice system, relying on systematic protocols to preserve evidence integrity and transform speculation into definitive conclusions about guilt or innocence. The legal framework is complex, blending constitutional rights, state regulations, and evidence-handling protocols. Investigators must conduct thorough, respectful, and scientifically rigorous investigations to maintain evidence credibility and admissibility.

Technological advancements, especially in digital forensics, introduce new challenges that require constant adaptation of legal frameworks. Effective crime scene management-identifying the scene, collecting and securing evidence, and reconstructing events-is crucial, as

[41] Rina Chandran," India's DNA data law seen to harm minorities and hurt privacy" (2021).
[42] The DNA Technology (Use and Application) Regulation Bill – 2019.
[43] Manpreet Dhillon, Mandira Narain, Prabhat Mishra, Deepa Kansara, Nupur Chowdhury and P. Puneeth, "THE DNA TECHNOLOGY (USE AND APPLICATION) REGULATION BILL, 2019: A CRITICAL ANALYSIS" ILI Law Review (2021).
[44] Rina Chandran," India's DNA data law seen to harm minorities and hurt privacy" (2021).

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courts give great weight to physical evidence. Proper training of officers is essential to prevent disturbance or destruction of clues, and the effectiveness of investigations depends on methods applied at the scene.

The "chain of custody" and exclusionary rule are vital for maintaining evidence integrity and preventing constitutional rights violations. Forensic science's role is indispensable, with courts increasingly relying on scientifically validated evidence. With digital forensics posing special challenges, legal frameworks must adapt to privacy and warrant concerns. Ultimately, the success of criminal investigations depends on rigorous scientific methods and adherence to legal standards, ensuring a fair and just process.

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