

Judicial Oversight of Biometric Evidence and The Role of Polymer and Composite Technologies in Indian Criminal Trials

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Abstract

This paper critically looks at changes that have taken place in the role of forensic science in the remodeled Indian criminal justice system and how the modern law has deviated since the colonial laws. With the changing of reformatory model of justice to a more balanced one that suggests fairness and due process, the study lends weight to the increasing cases of clarity, consistency and control in the field of forensics. Among the main aspects that are analyzed in the research is the incorporation of recent achievements of science, such as those focused on polymer chemistry and the utilization of polymers to crime scenes and approximate techniques of the laboratories used in forensic science. The use of polymer materials and functional polymers has made number of improvements to the capabilities of forensic tools, the collection kits of DNA material to the technologies used in the analysis of finger prints all of which require the precise physical characteristics of the polymers being used in order to achieve the precision and reliability of the material required. The creation of more sophisticated polymer structure also facilitates the preservation of good samples and enhanced collection of trace evidence which is significant in the accomplishment of evidentiary excellence. This paper also examines how the law in regard to forensic science currently exists in comparison to the best practices experienced worldwide highlighting some of the main areas of concern including admissibility of expert evidence in the forensic laboratories. By so doing, it highlights international standards of evidence processing and the growing significance of circular and green polymer science to foster sustainable implementation of forensics technologies. The paper provides practical ideas to guide or offer institutional change with a practical view of ensuring that forensic evidence becomes more valid and open to scrutiny. The end result of the research study is the support of multidisciplinary reformism approach to research where science and law are built upon to provide a more just and technologically equipped justice delivery system in India

Keywords: Forensic evidence, indian justice system, legal framework, functional polymer, composites

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Received Date: August 01, 2025

Accepted Date: August 05, 2025

Published Date: August 15, 2025

Citation: Gaurav Kumar Sharma, Asha Rani Rawat. Judicial Oversight of Biometric Evidence and The Role of Polymer and Composite Technologies in Indian Criminal Trials. Journal of Polymer & Composites. 2025; 13(5): 141–152p.

INTRODUCTION

The current modernization of the Indian criminal justice system has been reflected in the development of forensic science, which is increasing the traditional forms of evidence scientifically with strong methods. Historically, criminal tests in India were highly dependent on pretext testimony, confession and circumstantial evidence which are naturally subjective and prone to human error. While the fingerprint analysis introduced during the colonial time marked the onset of forensic applications, recent decades have seen integration of advanced techniques such as DNA profiling, ballistic testing and biometric

identity. This change is not only operated by public outrage on flawed investigation in high-profile cases, but also by actively adopting more reliable evidence mechanisms by law enforcement. An important in this change is the role of often unseen ingredients polymer and overall materials, which produces the backbone of modern biometric and forensic technologies. These materials are necessary in developing durable, accurate and efficient equipment, from the Fingerprint scanner and DNA collection kit to the high sensitivity sensor used in the forensic lab. The reliability of biometric data collection, protection and analysis is closely associated with physical materials that support these processes, making the integrity of polymers and composites.

In today's courts, dependence on forensic evidence especially DNA analysis, ballistic report and biometric identity has become an important factor in giving accurate and fair decisions. DNA data has played a decisive role in cases of serious crimes such as rape and murder, offering a clear foundation that is often scientifically considered incompatible. However, this increasing dependence on scientific devices also increases concerns: the understanding of the judiciary, over equipped forensic laboratories overcrowding, and moral dimensions of evidence collection practices. These concerns highlight intensive constitutional stresses especially between articles 20 (3) and 21 which puts the right against self-induction and privacy against the need for effective criminal checks. Although the Supreme Court's decision in the *Selvi v. State of Karnataka* [1] sought to limit the use of involuntary scientific techniques, forensic evidence, especially a consistent and broad structure for biometric, is still developing. In practice, forensic technologies are sometimes considered infallible, especially in cases where physical evidence is rare. However, scientific impartiality that they provide, they should still be seriously examined under legal standards. The new *Bharatiya Sakshya Adhiniyam, 2023 (BSA)*, emphasizes the importance of such input, the importance of assessment, credibility and evaluation of clear weight. Since polymer and overall based forensic equipment become more sophisticated, ensuring that their standardization and reliability would be important for judicial acceptance.

Use of these techniques in trial calls for overturning of certain contours on traditional criminal jurisprudence, which do not readily embrace science nor discount it unfairly. Amidst institutional modernization, building capacity within the judiciary, and setting up transparent standards for testing, accorded scientists and lab workers should have recourse to the places they are servicing: courts where their findings are being analyzed and looked into as evidence against an accused. Forensic science must continue to serve as a vital instrument in the history of forging justice, not as some shortcut to an unfair conviction; yet it must lead to truth and have its basis in scientific reliability and constitutional soundness [2].

Concept of Forensic Evidence

Forensic science has developed as a well-organized and continuously developing sphere, which is aimed at decreasing human error and limiting cognitive bias in justice delivery. The forensic opinions entrenched in scientific approach and using neutrality and objectivity in the manner in which they are presented contribute greatly towards truth seeking that is a critical component in the achievement of justice in court. An important role in this process is played by forensic evidence, which is usually provided by the independent expert. It is bias-free, provable and has scientific weight to support the process therefore making it a sensible instrument of the court. This kind of evidence is essential in proper identification of people and is vital in criminal as also civil legal cases [3].

In India, procedural laws are in place to govern court proceedings in which the forensic evidence has its role to play. Whereas the Criminal Procedure Code is an enactment according to which criminal cases are managed, the Indian Evidence Act comes up in the management of legal cases in all courts. Now, on or after 1st July, 2024, the Indian Evidence Act, 1872 and the Criminal Procedure Code, 1973 will be changed with the new enactments, i.e., the *Bharatiya Sakshya Adhiniyam (BSA)* and the *Bharatiya Nagarik Suraksha Sanhita (BNSS)* respectively. Indian criminal justice system currently utilizes a number of forms of forensic methods, such as:

- DNA Analysis whereby a unique genetic profile of a person is given.
- Fingerprint Examination, an old and basic forensic procedure that has built its reliability.
- Ballistics that would assist in identifying the use of guns and other related evidence.
- As the need of understanding cybercrime increases, Digital Forensics is the study related to retrieving and examination of data contained in electronic devices.
- Toxicology which determines drugs, chemicals or poisons present in bodily fluids in aid of investigations [4].

Research Methodology

This research is placed in a theorist point of view, including legal materials such as laws, constitutional provisions, judicial examples and detailed and structured examinations of official comments. The primary objective is to find out the implication of severe legal status and specific forensic techniques including DNA profiling, polygraph examination, fingerprint analysis and brain mapping within the structure of the Indian criminal justice system. The study not only assesses the existing statutory structure and case law, but also a comparative review of revoked legal provisions with the recently implemented criminal codes. Through a comprehensive review of relevant court decisions and legislative development, the research wants to evaluate the legal acceptance and procedural impartiality of these methods. By doing this, its purpose is to contribute to the broader discourse at the intersection of science and law; it gives information whether these techniques maintain or weaken the principles of justice and fixed process in contemporary criminal proceedings in India.

Role of Expert in taking Forensic Evidence

The new law still fails to define the term expert and it creates an ambiguity and uncertainty of interpretation. Based on the context an expert can be either a scientific as well as a non-scientific expert. Individuals who participate in the scientific assessment, especially, in legal matters are usually called the forensic experts. Nevertheless, the opinion of an expert is subjective to human mistakes and, hence, forensic testimony is not admissible as substantive evidences in any trial but merely supportive ones. Reducing the falsehoods in the judgment of experts is a major issue.

The Supreme Court of India in its recent ruling has expressed great concern with the procedural validity of forensic evaluations. In remarkably verdicts such as Anokhilal v. State of M.P. [5] and Rahul vs. (NCT of Delhi) [6], the question now lies on whether he or she should be concerned with the methods of forensics or applied in investigation. The first DNA-based exoneration of a death row convict in India (the third trial) was the Anokhilal case of March 19, 2024 (Madhya Pradesh). This leads India towards what might one day amount to an Innocence Movement in India. The case helps in highlighting the increased dependence on forensic science to enforce justice and the necessity of complying with international laws in dealing with injustice convictions.

Section 39 of the Bharatiya Saksha Adhinyam, 2023, resembles 45 of the Indian Evidence Act, 1872 and adds after the words any other field, extends the realm of expertise that is accepted. Nevertheless, the regulation does not go as far as defining the term expert, but the reference sounds like a person of special competence. Interest of the courts in the opinion of experts is normally on things such as science, foreign law, art, handwriting, and finger prints- topics that require the expertise of a specialist [7].

Forensic is not even mentioned in the Evidence Act, which further creates confusion in the qualification of the experts that keeps on coming up in front of other higher judges of India. The Supreme Court, in State of H.P. v. Jai Lal has defined the term especially skilled or expertise in Section 45 to consist either of study or formal education or specialist knowledge backed by years of practice. Therefore, an individual should also prove his/her competence and competency in the matter at hand to become an expert.

As held in State of Karnataka v. J. Jayalalitha [8], the expert does not act as a witness of facts but rather the court is guided by him by providing its expertise and advice informed by a good understanding of its facts. The judge has to balance these opinions in the light of the facts of the case and it is his independent decision and not blind decision of expert opinion that has to prevail.

In *Basheera Begam v. Mohd. Ibrahim* [9], the Court has restated the doctrine that expert evidence is neither binding nor conclusive. The likelihood of expert judgment being erroneous is not based on the suspicion of the expert integrity, but because there is likelihood of human interpretation to be faulty. As an example, fingerprints are considered to be very efficient, but handwriting identification is not so precise.

The case of *Sri Chand Batra v. State of U.P.*, the highest court acknowledged the evidence of an Excise Inspector as expert evidence in the light of capability of identifying illegal things by smell because he got field experience. Nonetheless, such subjective application lends much credence to judicial usurpation of powers that pose risks of fetishism, and thus wrongful imprisonment, and they dampen respect towards the judicial system.

Finally, an expert witness will give his/her opinions with reliability and rationality by providing an informative statement to give the court the chance to evaluate the results as well as the reasoning behind such results. Expert evidence can be quite advisory and then the courts that have to consider relevance and reliability should be able to make a decision independently [10].

The Role of Polymer and Composite Technologies in Indian Criminal Trials

The latest Indian criminal justice system has moved to integrate science and technology in the production of reliable and precise evidence. One of the technological tools that have taken a back seat in the construction of an infrastructure that facilitates the field of forensics investigation and biometric evidence gathering is the use of polymer and composite materials.

Polymers and composite materials can be utilized in biometric miscellany, fingerprints readers, DNA utilitarian apparatus and field kits. Polymers have a wide range of desirable physical properties, and so are well-suited to the storage, transport, and preservation of such sensitive biological material. To continue with the same example, the DNA evidence that is packaged within polymer jumpers and in hermetically sealed storage containers do not allow the trail to be degraded, which means that when the time to go to the court comes, such pieces of evidence will pass the court test of admissibility and validity. With the increase in the weight of the forensic equipment, composite materials are also now being employed in the structural design of such equipment because the resultant properties are lightweight and strong [11].

The use of functional polymers as part of modern bio sensing devices has found a place in real time crime scene analysis. Such sensors are proving to be sensitive and receptive to certain biological triggers, enhancing reliability and efficiency in the forensic practice. Furthermore there have been improvements in polymer chemistry that has made it possible to come up with tamper evident packaging and track able material usage, which has improved the chain of custody and integrity of evidence.

Looking at the fact that such scientific tools can easily be used due to the nature of science, it is necessary to have judicial oversight which will ensure that the evidence produced is of acceptable standards in terms of fairness and legitimacy. Due to the increased dependence of courts on biometric data and forensics, it is important to know how the technologies work. The application of polymer and composite technologies not only enhances the forensic validity but also that of the justice system that will be technologically engaged, scientifically more knowledgeable and constitutionally reasonable to do so [12].

- *Understanding polymer chemistry in biometric forensics*: The root of modern forensic technologies is polymer chemistry, which relates to the synthesis and behaviour of the macromolecule formed by repeating structural units. These polymers are fundamental for the development of important devices used in biometric evidence collection - from DNA collection kit to fingerprint scanner and sample storage container. Materials such as polyethylene,

polycarbonate and polystyrene are used in the manufacture of devices that demand sterility, flexibility and flexibility. In the forensic context, polymer chemistry contributes to the manufacture of biologically inactive surfaces, which are necessary to prevent contamination of sensitive biological samples such as blood, saliva or hair. The chemical stability of these materials ensures that the samples remain intact over time, thus maintaining their clear value when submitted to the court.

- *Polymer structures and physical properties in evidence integrity*: Structural properties of polymer-molecular loads, cross-linking, and crystallinity-determines their suitability for specific forensic applications. For example, the polymers with high tensile power and thermal resistance are ideal for devices coming into contact with various climatic conditions during the investigation of the region. Physical properties of polymer, such as permeability, elasticity and thermal stability, ensure that samples can be safely transported and stored without fall. In detecting fingerprints, polymer based film coatings are used to lift and preserve prints. These films are designed to increase the ridge visibility while maintaining the original details of the print. Similarly, polymer gloves and sample containers are engineered to get rid of DNA contamination, emphasis on the need for material accuracy in forensic workflows [13].
- *Functional polymers and their role in advanced forensic sensors*: New developments in functional polymers or materials that attempt to react in a certain biological or chemical way, has transformed forensic diagnostics. These polymers are used in biosensors capable of sensing very low concentrations of such things as the proteins in blood, drug traces or a residual of an explosive. These kinds of sensor promote the real-time capture of forensic samples in the crime scenes with minimum dependence on after-the-fact laboratory tests to conduct faster investigations. In addition to that, the sensitivity of functional polymers to any environmental change also makes them indicators of tampering or resolving of the samples, facilitating the judicial examination of the chain of custody and sample handling procedures. This is especially relevant where crimes that are of big names are involved as the credibility of the evidence is highly scrutinized.
- *Composite materials: enhancing durability and efficiency*: In addition to polymers, there are currently composite materials, which are a mixture of two or more materials that have different properties being increasingly used in constructing forensic equipment. The materials offer great strength to weight ratio and the ability to withstand heat, which is why they meet the needs of mobile forensic units, field kits, and storage. An example is the use of carbon fibre composites in lightweight tools to be used in forensic fields of work that need to be durable without interfering with portability. Polymers and composites have a synergetic relationship that makes the forensic infrastructure dependable even in the variable situations. Applied together with the high performance analytical devices, these materials enhance the quality and accuracy of data that is gathered in the course of investigations making such data even stronger in their admissibility within the framework of the Indian Evidence Law [14].
- *Sustainability and the role of green polymer science*: As the forensic technology grows in scale and application, it is required to address its environmental impact. Circular and green polymer science aims to reduce the ecological footprint of polymers used in forensic and biometric tools. The development of biodegradable and recycling polymers can ensure that increasing use of disposable forensic kits does not increase plastic waste. Green polymer initiative also focuses on reducing toxic by-products in the manufacture of forensic materials, aligning scientific progress with environmental responsibility. Judicial bodies in future, public law enforcement agencies may consider environmental norms when approved the mass procurement of forensic materials.

Therefore, there is reason to believe that despite being invisible in most cases, such materials are a part and parcel of the developing realm of criminal trials in India [15].

Forensic Science and the Indian Criminal Justice System

The criminology in India with its introduction of the concept of forensic science has received a new legislative basis under the recently established Bharatiya Nyaya Sanhita (BNS), 2023 instead of the long-established Indian Penal Code of 1860. In spite of the fact BNS generally limits itself to

codification of substantive offences; it indirectly embraces the position of forensic tools with regard to the crimes, which cannot be committed without utilizing science-based inferences, such as crimes confined to cyberspace, sexual crimes, which also depend on the biological evidence, and high-tech frauds. This is a changing understanding of the importance of forensics both to prove intent and to make factual connection between the accused and the crime committed. Nevertheless, the procedures and evidence of forensic operation is silent in BNS and are left to be permeated by other procedural statutes [16].

The fact that this is not specific, although it might have a strategic purpose, can lead to inconsistencies in legal interpretation and arbitrariness of forensic investigations. The Bharatiya Nagarik Suraksha Sanhita (BNSS), 2023 on the contrary, initiates a more active course of action by repealing the CrPC, 1973. It enormously increases state power to take biometric and forensic samples, such as fingerprints, iris scans, voice records, and biological samples not only of a suspect or arrestee, but also bus-pass riders released on bail, so long as such taking can be justified as necessary and expedient. It is based on the Criminal Procedure (Identification) Act, 2022, and the provisions are weakened vis-a-vis the constitutional right under Article 21 of the constitution, particularly in the context of a weak data protection framework. Though these provisions seek to enhance the accuracy and effectiveness of investigations, they still are ambiguous and weakly guided due to which they allow such enumerated provisions as intrusive studies and violation of such tenets as consent and proportionality [17].

In the meanwhile, the BSA, 2023 is more organized in its outlook towards the admissibility of forensic and expert evidence. The expert confirms the legal weight of testimony - including scientific and electronic evidence such as DNA analysts, forensic scientists and cyber experts - and formally biometric equipment, forensic reports and digital surveillance data. Importantly, such evidences are only acceptable when its authenticity and integrity are installed properly. This clearly modernizes the structure, moving beyond the old and often unclear provisions of the Pre -Evidence Act. However, despite this advancement, the BSA does not launch specific proceptive benchmarks or scientific protocols for new technologies such as brain fingerprinting or AI-assisted forensic analysis-an omission that can obstruct stability and legal certainty in the future.

DNA Profiling: legal admissibility in india

The legal situation of DNA profiling in India now had reached a major turning point with the passing of the Bharatiya Nagarik Suraksha Sanhita (BNSS), 2023 as well as the implementation of the Bharatiya Sakshya Adhinyam (BSA), 2023. The BNSS has also provided a clear statutory support to investigative agencies that should now access biological material in form of DNA, fingerprints, and other biometrics of not only accused or persons under arrest, but also detained persons. This wide power is opposed to the narrower line of proceeding of the former Code of Criminal Procedure (CrPC). The BNSS is then further extended by section 51(4) which specifically acknowledges the evidential aspects of such forensic data when it comes to establishing identity and linking persons to crimes. Although such legislative trend raises the level of investigation effectiveness and the effectiveness of the procedure, it also causes fears in terms of voluntariness, necessity, and proportionality, especially when the evidence is gathered without any court approval beforehand [18].

Along a similar line, provisions are provided in the BSA that formally acknowledges scientific and electronic evidence that includes the use of DNA analysis therefore bringing India closer to international standards of evidence. But it does not go as far as the United States to fashion procedural tests and levels of scientific reliability like Daubert. The result of such an omission is a potential risk because, in the absence of codified standards of scientific credibility, the courts are now free to place inordinate trust in technically complex reports of forensic evidence, and apply scanty judicial standards to such proffers [19].

To this, burden should also be added the long-awaited regulation bill, the DNA Technology (Use and Application) Regulation Bill, 2019, that would establish a regulatory body, quality control, and regulate how DNA data was collected, stored and destroyed. Its pendency thus creates a major gap in regulation,

despite the fact procedural laws continue to make DNA collection and usage easier. The necessity of identification of clear-cut oversight was revealed during the Supreme Court case *Karandeep Sharma @ Razia @ Raju v. In State of Uttarakhand*(2025 INSC 444), the court ruled that a death sentence under POCSO was to be discharged because the forensic DNA expert was not recalled by the prosecution and because the chain of custody was not observed. According to the court, those lapses undermined the admissibility and the credibility of the DNA evidence [20].

One should also consider constitutional safeguards of these developments. In the case of Justice K.S. Puttaswamy (Retd.) v. Union of India [21], the Supreme Court held that privacy was a fundamental right under article 21. The implication of extraction of DNA sample, especially minus consent and before trial, entails immense concerns to the body autonomy, informational privacy and Article 20(3) protection against self-incrimination. In as much as Section 349 of the BNSS is reasonable in the context of investigative efficiency to carry out such collection, there is a serious argument to suggest that such collection is not justifiable on the account of constitutional tests of necessity and proportionality as set out in Puttaswamy judgment, more so when there exist no sound protections against the use, retention, and misuse of such data collected. Currently, the legislation has substantially shifted to the side of the state power, allowing it to collect very personal biological information without providing a sufficient mechanism of the defense of the rights of people. The admissibility of DNA evidence may be statutorily approved but until a separate, full-fledged law regarding DNA is passed into force, including the checks by the courts and data protection standards, the classes of such evidence will continue to be subject to the evaluation on the base of constitutionality [22].

The rise of biometric facial recognition

Facial recognition operated by Artificial Intelligence depends on biometric mapping to identify individuals by analysing the composition and placement of major facial features. This process begins with the digital capture of facial images, followed by a contour map that exposes important elements such as the eyes, nose and jaws. Advanced algorithms then convert these shapes into a digital template stored within a searchable database. These systems compare in many image banks, including the ID database released by the government, driver's license registries and publicly available social media photographs. When integrated with a modern CCTV system, such technology can identify real -time in both public places and private environment. As a result, surveillance capabilities are quite advanced, which enable quick, automated identity verification and monitoring. By widely adopting such biometric tools, it reflects increasing dependence on automatic decision making in place of human decision. However, the focus of scholars is limited to sociological effects especially on issues of social classification and exclusion, while legal and moral analysis is often ignored. It is important to address this difference to ensure moral implementation that aligns with the principles of justice and human dignity [23].

In the next few years, liberal democracies will face severe ethical dilemmas due to the usage of facial recognition. The fundamental values of such systems, the right to privacy, freedom, openness, and responsibility are incompatible with the real practice of biometrics monitoring. Although such technologies find their most frequent application in national security activities, border control, criminal inquiries, and business data gathering, they are incompatible with democratic principles to a certain extent.

The necessity to find the right decision concerning the required level of security without damaging civil liberties grows more and more. Governments need access to biometric data in order to prevent criminal behaviour and protect citizens, yet it cannot lead to violation of basic representations. In the last twenty years, nations, such as, Australia, United Kingdom, and United States have performed major legal reforms in a bid to enhance stronger counter terrorisms capacities. These legislations have widened the authority of law enforcement agencies and intelligence agencies extending them to predisposition of surveillance as well as collection of evidence [24].

Although they have enhanced the security measures of nations, these legal augmentations have brought about the apprehension of the overreach of the moral. Collecting of biometrics of people who are not suspected to have committed a crime is one of the most controversial practices. This casts doubts as to whether this can indeed be in harmony with the ideals of democracy. The question of ethics in the biometric data collection still attracts academic attention and popular discussion.

The need to employ powerful consent protocols and sophisticated privacy protections are emerging in the wake of bulging data volumes and complex applications. The cases of data misuse and unauthorized access, and in particular, sensitive information, have been increasing, and extra-strength protections are essential. Although the basic concepts of data security can still be applied, the conventional models of data security have to be developed in order to deal with the complexity of a modern and ever-changing interrelated technological world.

The use of biometric data spice with the smartphone usage, financial transactions, healthcare records and tax information pose severe threat to privacy. When facial identification equipment is associated with CCTV footage, audio recording and online activity, they can produce incredibly detailed profiles of individuals. This aggregation of data not only enhances monitoring capabilities, but also increases the risk of profiling of infiltration fulfils the immediate requirement of strong moral and legal investigation. The situation becomes even more complicated in ruling rule, where these devices are often used without democratic inspection. For example, in China, facial recognition is deeply inherent in public monitoring networks. Officers use it not only to identify petty criminals, but also publicly to implement social conformity by being considered "rude". This shows how uncontrolled monitoring can control freedom and behaviour. China's social credit system gives an example of possible misuse of such technologies. It evaluates citizen conduct through comprehensive data analysis, rewards analogy and punishing deviations. Low scores can result in travel restrictions, denying university entry, or excluded from desirable jobs. Although citizens have been promoted as a merit-based tool for betterment, the concerns are growing on its role in large-scale monitoring-especially of minority groups such as Uighurs. The scale and intensity of such programs raise immediate questions about discrimination, forced and erosion of fundamental human rights.

Strengthen Comparative Analysis with Global Forensic Standards

In this rapidly changing forensic science scenario, international standards are central in defining success, admissibility, and the usability of biometric evidence in the court of criminal cases. In India, to improve the judicial scrutiny of the such evidence, a more fortified comparative assessment should be made against the well-established international forensic principles. Countries like the United States, the United Kingdom, Germany among others have created a legal framework along with scientific procedures that govern the method with which biometrics including DNA, fingerprints, facial recognition and polymer based forensic materials are gathered and processed and even presented as evidence.

Such jurisdictions have tight quality controls and will tend to conform to international guidelines, including those of ISO/IEC 17025 or the Quality Assurance Standards for DNA Testing Laboratories of the FBI. Next, adoption of polymer and composite technologies which are used Notably in forensic reconstruction, trace evidence and modeling of ballistics are stringently tested by interdisciplinary peer reviews that make them scientifically accurate and legally admissible.

In opposition, the Indian jurisdiction does not have a universal benchmark in assessing sophisticated forensic on evidence which in many cases is obsolete in procedural laws. A well-developed principle of comparison will facilitate the adoption of the Indian judicial approach to the international best practices that minimise wrong convictions, fair trials, and judicial confidence in the high-tech forensic technologies. The use of such global standards would not only be able to increase the level of science being used in the Indian courts but also would help in keeping up with the latest technology such as polymer and composite based forensics applications that to be used responsibly and efficiently.

Practical Challenges and the Way Ahead

Forensic evidence is slowly but surely becoming a significant part in Indian criminal justice system that seeks scientific help to support the effective and fair administration of justice. Whereas the adoption of forensic science into the legal procedure is an unfinished process, the evolution is clearly in the direction of a more stringent, transparent, and scientifically competent use of such evidence. The interaction between the legal and the scientific spheres is enormous and can reach its fullest potential given the pinnacle of the technological development and the increased cooperation between the scientific professionals and the lawyers.

Forensic science does not just provide the means to either prove or disclaim any evidence, but it is also a critical factor in the determination of truth in complicated criminal cases. The path to proper implementation is, however, littered with a number of structural, procedural, and educational boxes.

The condition of forensic infrastructures in India is one of the most urgent questions. Most forensic laboratories, especially those on the state level, are chronically underfunded, have inadequate equipment, and sorely lack in trained staff. These constraints usually result in a delay of evidence analysis and reporting, and these results in a bottleneck in the judicial process. Despite the numerous efforts by both the central and the state governments to modernize the forensics as far as the various facilities are concerned, it is important to note that there is need to invest in the same over a period of time and even the policy making about the same should be long-term so that it can effectively cater to the rising need of the forensics services.

Also important is the competence of forensic analysts whose skills and judgment directly influence on the reliability of forensic results. There must be constant skills and training in the most relevant scientific methods so that the evidence delivered in the court is devoid of any errors and effective. The alliance with established foreign-based institutions might assist in eliminating the existing knowledge deficiency and approximate the current Indian forensic practice to contemporary worldwide practice.

The other principle of effective forensic science is putting in place and following clear standard operating procedures (SOPs) and mechanisms of quality control. Forensic practice that has been standardized increases the reliability of the results and makes it admissible in court. India has also improved on this front and engaged in the process of coming up with standards similar to those that have been developed by the FBI on DNA testing laboratories. Still, the increased consistency of approach in different areas of forensics is also an admirable objective.

A significant and often unseen obstacle for effective integration of forensic science in the Indian legal system is a lack of scientific literacy within the legal fraternity. Judges, lawyers and law enforcement officers often face challenges in explaining complex scientific data, especially in areas associated with specialized subjects. This disconnect may cause a misinterpretation of important forensic evidence. Many forensic techniques depend on rapidly advanced material science - which includes areas such as polymer chemistry and polymer physics and principles - there is an urgent need to strengthen forensic literacy among legal professionals. Appointment of scientific advisors for testing related to technical evidence and integrating forensic awareness in legal education can greatly improve the process of making judicial decision making.

Looking forward, the future of forensic science in India promises a lot. Field which study the relationship between brain function and criminal behavior, are likely to emerge as special branches of evidence. With these developments, the role of polymer materials in forensic investigation is becoming increasingly important - especially in applications associated with sensor development, fingerprint lifting and functional polymer used in DNA sample protection. Physical properties of polymer, including durability, elasticity and chemical resistance, make them ideal for making forensic equipment and packaging that maintain sample integrity.

This scientific speed has been further intensified by the enactment of three recent laws that outline the important role of forensic evidence in Indian criminal proceedings. These laws make the initial participation of forensic experts mandatory in serious crime investigation and strengthen the need to follow the valid laboratory protocol. Increasing dependence on forensic technology including monitoring devices, drug detection kits and technical applications of polymer structures in material analysis is an important step towards embedding science within the structure of justice.

However, legislative support alone for permanent improvement is insufficient. Pressure is required to expand the cadre of trained forensic experts and establish a broad, right-email training programs. Additionally, institutional capacity should be increased without compromising the privacy and freedom of individuals. To preserve public belief, a strong mechanism must be applied to prevent malpractices, including tampering with forensic samples. Using circular and green polymer sciences can also support sustainable practices environmentally in the use of forensic materials, aligning technological progress with moral responsibility.

Establishing an independent forensic Lokpal to ensure accountability and transparency will further strengthen public belief. Since forensic science continues to develop in India, it enhances the emergence of a more sophisticated and just legal scenario one where science, physics and polymer applications contained in subjects such as science, physics and polymer applications, make meaningful contributions to fairness, truth and constitutional integrity in search of justice.

CONCLUSION

The passage of India's new criminal laws in 2023 leads to an important procedural change, especially in the areas of investigation and evidence management. However, with the progressive development that appears, the legal system continues to struggle with challenges of standard and institutional failure especially in its interface with forensic science. While the intention behind these reforms is to encourage the integration of scientific equipment, especially in Section 349 of Bharatiya Nagarik Suraksha Sanhita (BNSS), the absence of an arbitrary concerns and violations arises about the existence of obviously defined regulatory standards, control mechanisms and scientifically valid protocols.

A particularly disturbing aspect is a continuous dependence on scientifically controversial techniques such as polygraph tests and brain mapping. Despite repeated judicial criticisms about their clear value, such methods remain under the guise of search utility, reflecting a blurred range between the valid process and the search campaign. Compiling the issue, the Bharatiya Sakshya Adhinyam (BSA) accepts the role of forensic evidence, but the expert fails to establish a strong acceptance criteria or minimal threshold for testimony. This regulator leaves a wide place for vacuum discretion, misuse and possible abortion of justice.

In addition, the use of forensic materials and equipment such as DNA protection kits, fingerprint sensors and biometric storage systems and upgraded polymer materials requires strict quality assurance. If not regulated, the integrity and erosion of evidence or technical failure due to inferior materials can compromise the fairness.

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