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Forensic toxicology and its relevance with criminal justice delivery system in India

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Introduction

Toxicology is the study of the adverse effects of drugs and chemicals on biological systems. It is understood as that branch of science which deals with poisons, and a poison can be defined as any substance that causes a harmful effect when administered, either by accident or design, to a living organism.[1] Toxicology does embrace the study of deleterious effects of substance exposure not only to the human body but also to the environment and all other organisms existing in the environment.[2] Whereas, Forensic toxicology, is the use of toxicology and other disciplines such as analytical chemistry, pharmacology and clinical chemistry to cases and issues where those adverse effects have administrative or medico legal consequences, and where the results are likely to be used in court.[3] It is a thoroughly modern science, based on published and widely accepted scientific methods and practices, for both analysis of drugs in biological materials, and interpretation of those results. Many of the methods it employs have been derived from innovations in clinical medicine and academic laboratories throughout the world.[4] The application of this knowledge of drug presence (through forensic toxicology) in tissues is to meet the varied needs of the law. The interpretation of effects of drugs and their duration of action for the purpose of a medico-legal process is best referred to as forensic pharmacology, although there is overlap between these two scientific disciplines.[5]

The first comprehensive work on Forensic Toxicology was published in 1813 by Mathieu Orfila. He was a respected Spanish chemist and the physician who is often given the distinction of "Father of Toxicology." His work emphasized the need for adequate proof of identification and the need for quality assurance. It also recognized the application of forensic toxicology in pharmaceutical, clinical, industrial and environmental fields. The primary concern for forensic toxicology is not the legal outcome of the toxicological investigation, but rather the technology and techniques for obtaining and interpreting the results. Forensic toxicology is governed through various professional certifying and accrediting boards in various places such as- The American Board of Forensic Toxicology (ABFT) - and promotes professional development and education through major professional organizations, the Society of Forensic Toxicologists (SOFT), the American Academy of Forensic Sciences (AAFS), and international organizations such as The International Association of Forensic Toxicologists (TIAFT).

[1]Hodgson, E., Introduction To Toxicology, In A Textbook Of Modern Toxicology 3 (Third Edition, 2004), John Wiley & Sons, Inc., Hoboken, NJ, USA.
[2]Frederick W. Fochtman, Forensic Toxicology, in Legal Medicine 617 (7th Edition, 2007) (Ed. Shafeek S. Sanbar).
[3]Deepak Ratan & Mohd. Hasan Zaidi, Toxicology Division, in Forensic Science In India And The World, P. 578, (2008).
[4]The Forensic Toxicology Council, Briefing: What is Forensic Toxicology? (July 2010) Available At Http://Abft.Org/Files/WHAT%20IS%20FORENSIC%20TOXICOLOGY.Pdf
[5]Drummer, O.H., Forensic pharmacology and toxicology, in EXPERT EVIDENCE, 1-36 (2008) (ed. Ian Freckelton and Hugh Selby, Thomson Reuters).

Disciplines of forensic toxicology

Death investigation toxicology (Postmortem toxicology)

Postmortem forensic toxicology involves analyzing body fluids and organs from death cases and interpreting that information. Sudden unexpected and/or unexplained deaths become coroner's cases or fall under the jurisdiction of the medical examiner. Forensic toxicologists work with pathologists, medical examiners in helping to establish the role of alcohol, drugs and poisons in the causation of death.[6]

1. The toxicologist identifies and quantifies the presence of drugs and chemicals in blood and tissue samples. This is done using state of the art chemical and biomedical instrumentation capable of detecting small amounts of toxic materials, positively identifying them, and accurately measuring how much is present.
2. Accuracy, validity and reliability are essential, as this information is used in the determination of cause and manner of death.
3. Accurately establishing the appropriate cause and manner of death has serious implications for public health and public safety, and forensically reliable toxicology is an essential component of that process. Death investigation toxicology is performed by both public and private laboratories and many private forensic laboratories provide specialized expertise and services not available in government laboratories.[7]

Human performance toxicology

Human Performance Toxicology deals with the effects of alcohol and drugs on human performance and behavior, and the medico legal consequences of drug and alcohol use. This may include investigations of impaired driving, vehicular assault and homicide, drug facilitated crimes including sexual assault, and aircraft, motor vehicle and maritime collision investigations.[8] It can be referred to as behavioral toxicology.[9]

1. Forensic toxicologists perform analysis of drugs and alcohol in biological samples, typically blood and urine, but increasingly

[6]Legal Medicine, Supra note 2.
[7]Toxicology Council, Supra note 4 at 1-2.
[8]Ibid.
[9]Legal Medicine, Supra note 2.

in other matrices such as oral fluid, and hair, for the purposes of determining the timing, extent, and impairment resulting from different patterns of drug and alcohol use. The toxicologist uses those analytical methods that are found in many research and hospital laboratories to isolate drugs from complex biological samples, prepare them for analysis through extraction and purification, then determine the identity and amount of drug present.

2. This can include performance enhancement which occurs following the use of stimulants, and impairment from recreational or prescription medication use and misuse.

Many blood alcohol and drug testing cases are performed in accredited private or academic forensic toxicology laboratories. Forensic toxicologists frequently testify in court to both their findings and to their interpretation. This type of testing may occur in public crime laboratories, but also may be a function of a health department in some states.[10]

Doping control

Governing bodies of most competitive and intramural sports have derived rules regarding performance enhancing drug use to protect the health and welfare of the amateur and professional athletes, to maintain a fair and even competitive standard, and avoid wagering fraud. This applies to both human and animal sports and athletes. International groups such as the International Olympic Committee (IOC), the World Anti Doping Agency (WADA), and the International Federation of Horseracing Authorities (IFHA) work to update and maintain these lists as patterns of drug use change. Forensic toxicologists in this field use many of the same high performance analytical methods to detect current and historical use of banned substances, including stimulants, anabolic steroids, and diuretics. This type of testing occurs in commercial and public accredited laboratories around the world, though there is also testing of high school, college and other athletes that occurs in private laboratories.

Forensic workplace drug testing

Use of drugs by people in the workplace has significant safety and economic consequences. Consequently, in many states, workers in safety sensitive positions are prohibited from using recreational drugs or taking certain medications without a prescription. Particularly, in recent years there has been increased emphasis on testing employees to make sure that they are not using drugs while on the job. This testing started with workers in sensitive situations or those who worked in dangerous environments, such as police officers, locomotive engineers, pilots, etc., but has since spread to many other occupations. However, the testing has to be done through some enforcing standards (that has to be made by legislation through forensic departments) that requires pre employment, random, and for cause drug testing, such as following an accident or a transportation collision. The majority of workplace drug testing is not covered directly by accreditation programs hence there are numerous examples of improper procedures and conclusions that have led to the termination of employees based on faulty drug testing.

Systematic toxicological analysis

Sampling is of the utmost importance for a successful systematic toxicological analysis (STA). The reliability and accuracy of any toxicological result is usually determined by the nature and integrity of the specimen(s) provided for analysis. Appropriate selection, sampling and proper storage of biological evidence are important, yet sometimes over-looked, steps in forensic toxicology, particularly when the results are to be used in the judicial system.[11] To address the issue of sampling for forensic toxicological analysis, selection of proper specimen, availability and recommendations of specimen types, amounts that should be collected and submitted to laboratories expected to perform STA, and criteria for ensuring quality assurance in sample collection is pertinent.[12] Generally speaking, STA involves the identification of a "general unknown", as opposed to the detection of common drugs or metabolites from a finite list.[13] In order to establish impairment from toxicological findings, a relevant substance must be identified within a relevant specimen. In forensic toxicology, the purpose of sampling is to provide a representative part of the whole that is suitable for screens and confirmations, affords reliable interpretation, and, when possible, allows for subsequent re-analysis, if required. Given this, it should be recognized that sampling is case-dependent.

Sampling includes

a. Selection of sample material suitable for analysis;

b. Sampling at the correct point of time;

c. Sufficient quantity;

d. Suitable sampling technique;

e. Adequate container;

f. Unique labeling;

g. Appropriate storage;

h. Packaging, transport or handing over of sample(s) with a request form;

i. Confirmation of receipt in the laboratory, intermediate storage until analysis is performed;

j. Storage mode and time of remaining material in storage;

k. Disposal of sample(s);

l. Complete documentation of all individual steps in the procedure (chain of custody).

Samples used in toxicology studies

Urine

A urine sample is quick and easy for a live subject, and is common among drug testing for employee of athletes. Urine sample do not necessarily reflect the toxic substances unless the subject was influenced by it at the time of the sample collection.[14] Urine is a valuable specimen for both ante mortem and post mortem drug testing

[10]Drummer OH, Gerostamoulos J., Postmortem drug analysis: Analytical and Toxicological aspects, 24(2) Therapeutic Drug Monitoring, 199-209 (2002).

[11]Sarah Kerrigan. Sampling, Storage And Stability In Clarke's Analysis Of Drugs And Poisons, (4th Ed.) Pharmaceutical Press, London, UK. Eds. A.C. Moffat, M.D. Osselton and B. Widdop (in press). [hereinafter SARAH]

[12]SARAH, Supra note 12 at 335.

[13]Levine B., Principles of Forensic Toxicology, American Association For Clinical Chemistry, Washington, (2006) [hereinafter LEVINE]; The Bullention Of International Association Of Forensic Toxicologist, TIAFT-Bulletin vol. XXIX (1), (1999), Available at http://www.tiaft.org/_test12/tiaft_bulletin [hereinafter TIAFT]

[14]Toxicology Division, *Supra* note 3 at 578-79.

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because it is a relatively uncomplicated matrix.[15] The amount required for sampling is 50 ml or total amount.[16] It is considered as the best specimen for comprehensive drug and poison screening is urine.[17]

Blood

Blood provides unique advantages over other matrices in terms of the wide variety of analytical methodologies available. A blood sample of approximately 10 ml is usually sufficient to screen and confirm most common toxic substances. A blood sample provides the toxicologist with a profile of the substance that the subject was influenced by at the time of collection; for this reason, it is the sample of choice for measuring blood alcohol content in drunken driving cases. For cases of poisoning where gaseous or volatile substances are involved, samples of brain, lungs and blood must be collected immediately using gas-tight containers, and if possible, tarred, cooled glass containers.[18] Maintaining a frozen fraction of blood may help ensure better analyze stability in later re-analyses.

Hair

Hair has been used in variety of toxicology settings to provide a history of drug exposure and has therefore found applications in workplace drug testing, in monitoring of persons on probation or on parole for drug use, in insurance testing to verify the truthfulness of statements made by applicants relating to whether they use drugs or are smokers, in drug-facilitated sexual assault and in other types of criminal case- work.[19] Hair is capable of recording medium to long-term or high dosage substance abuse. Chemicals in the bloodstream may be transferred to the growing hair and stored in the follicle, providing a rough timeline of drug intake events. However, testing for drugs in hair is not standard throughout the population. For eg- If two people consumed the same amount of drugs, the person with the darker and coarser hair will have more drug in their hair than the lighter haired person when tested. This raises issues of possible racial bias in substance tests with hair samples.[20] Approximately 100-200 mg of hair should be collected from the vertex posterior on the back of the head by cutting as close to the scalp as possible, ensuring that it is clearly marked which end is closest to the scalp and appropriately securing the hair into a bundle with a rubber band, twist tie, or string. The hair sample may then be placed into aluminum foil, an envelope, or plastic collection tube and stored at room temperature until analysis.[21] Therefore concluding that, hair is considered as one of the most useful specimens for STA, when there has been a significant delay between suspected exposure to a drug or poison and reporting to law enforcement.

Oral fluid

The use of oral fluid is gaining importance in forensic toxicology for showing recent drug use, e.g. in clinical settings or investigation of driving under influence of substances. It can be collected non-invasively, conveniently and without invasion of privacy and is most commonly collected fluid from the oral cavity for the determination of drugs.[22] The use of oral fluid is gaining importance in forensic toxicology for showing recent drug use, e.g. in clinical settings or investigation of driving under influence of substances. It is composed of many things and concentrations of drugs typically parallel to those found in blood. Sometimes referred to as ultra filtrate of blood, it is thought that drugs pass into oral fluid predominantly through a process known as passive diffusion. Drugs and pharmaceuticals that are highly protein bound in blood will have a lower concentration in oral fluid.

Vitreous humor

It is one of the post-mortem specimens. The availability of autopsy specimens in postmortem toxicology allow for a more flexible analytical approach to the analysis, although some specimens have more value than others when specific drugs or poisons are involved in the death. The fact that vitreous humor resides in an anatomically isolated and protected area of the body (behind the lens of the eye), coupled with its good stability as a biological fluid, makes this specimen more resistant to putrefactive changes than other postmortem specimens. All available vitreous fluid from each eye should be collected separately.[23] Vitreous humor is particularly useful for postmortem analysis of glucose, urea nitrogen, uric acid, creatinine, sodium and chloride. These are important analyses for the evaluation of diabetes, degree of hydration, electrolyte imbalance, postmortem interval and the state of renal function prior to death.[24]

Gastric contents

Gastric content is a potentially valuable specimen for analysis in postmortem and clinical cases. Oral ingestion remains the most popular means of exposure to drugs and poisons. Therefore, gastric contents are essential for screening tests. All of the available sample should be collected without the addition of a preservative. Undigested pills and tablets should be separated and placed into plastic pillboxes for analysis. After opening the abdominal cavity, the stomach should be tied off and then removed, subsequently emptying the contents into a container and documenting the total amount. Suspicious items such as tablet remnants and herbal matter etc. should be isolated, dried (e.g. on cellulose tissue) and stored separately.[25] Gastric contents are non-homogeneous and should be homogenized prior to sampling.

Tissues

Tissue samples collected in postmortem investigations generally provide supplemental information to the toxicologist to assist in interpretation of their results. In STA, analysis of the correct tissue

[15]Toxicology Division, *Supra* note 3 at 578-79.

[16]G. Skopp, Heidelberg; L. von Meyer, München, Appendix D of the GTFCh Guideline for Quality Control in Forensic Toxicological Analyses , Recommendations for sampling postmortem specimens for forensic toxicological analyses and special aspects of a postmortem toxicology investigation, 2004, 5 June.

[17]LEVINE, *Supra* note 14.

[18]Appendix D, *Supra* note 17.

[19]Nakahara Y (1999) hair analysis for abused and therapeutic drugs, J. Chromatogr B Biomed Sci Appl 733: 161-180; Kintz P et al., Hair analysis for drug detection. Ther Drug Monit 28: 442-446 (2006).

[20]Toxicology Division, *Supra* note 3 at 579.

[21]Levine, Supra note 14; Tiess D (2003) Asservierung, Exhumierung, Thanatochemie. In: Madea B, Brinkmann B (Hrsg.) Handbuch gerichtliche Medizin, Bd. 2, Springer, Berlin, Heidelberg, New York.

[22]Crouch DJ, Oral fluid collection: The neglected variablein oral fluid testin, Forensic Sci Int, 165-173 (2005).

[23]TIAFT, *Supra* note 14.

[24]Coe JI, Postmortem chemistry of blood, cerebrospinal fluid, and vitreous humor. Leg Med Annu 1976: 55-92 (1977); Coe JI, Postmortem chemistry update. Emphasis on forensic application. Am J Forensic Med Pathol 14: 91-117(1993).

[25]Appendix D, *Supra* note 17 at 5.

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specimen may be vital to the identification or confirmation of an unknown causative agent. When tissues are sampled they should be collected quickly and placed immediately into airtight containers. Liver, kidney, brain, lung and spleen are the most frequently collected postmortem tissues.

Application of forensic toxicology

This area of forensics has evolved to mean the study of illegal drugs and legal ones such as alcohol. It has been already discussed above that forensic toxicology can identify poisons and hazardous chemicals which can be used in interpreting the outcome or the real situation. The chemical makeup of each substance is studied and they are also identified from different sources such as urine or hair. Forensic toxicology deals with the way that substances are absorbed, distributed or eliminated in the body the metabolism of substances. When learning about drugs and how they act in the body, forensic toxicology will study where the drug affects the body and how this occurs. While there are many uses for forensic toxicology testing, the most familiar one to most people is likely to be drug and alcohol testing. This type of testing is commonly performed in the transportation industry and in workplaces. Another use is for drug overdoses, whether these are intended or accidental. People who drive with a blood alcohol concentration over the accepted legal limit can also be accessed through toxicology testing. Another application of forensic toxicology relates to sexual assault that involves the use of drugs. Various drugs are used today for the purposes of rendering the victim unable to fight the attacker, who then proceeds to sexually assault the victim. Through toxicology testing, a victim can find out what drug was given and can then be treated accordingly.

There are a lot of substances and poisons in our world many of which impact how we function in work and society. Forensic toxicology is also applied in cases of post-mortem investigations where toxicology is required to establish if an excessive intake of the drug occurred and, if so, whether this contributed to death. Forensic toxicology testing allows forensic scientists to identify substances and determine a pattern of use. Suicidal, homicidal and accidental cases of poisoning are common in India and in other countries. With the availability of various agents like pesticides, insecticides, drugs, chemicals the probability of the misuse of the same is happening. The substances of preference for poisoning are aconite, strychnine, calotropis, oleander, copper, mercury, arsenic etc. The forensic toxicology laboratory, thus, analyzes body fluids and tissues to determine the presence of these substances. Toxicologists conduct the analysis, issue reports on their findings, and provide court testimony to interpret the test results.

Law governing forensics in India

Arising out of a growing concern over the burgeoning incidence of poisoning worldwide, coupled with a lack of public awareness about its seriousness, the government has incorporated provisions regarding the abuse of poison and admissibility of the reports of medical examinations into the Indian legislation. It is dealt below in following parts:

Criminal offences in Indian panel code (IPC)

In India mostly poisons are used for robbery and suicidal purposes. For eg- Datura is used by that sect of the thugs who poisoned wayfarers. Even today the poisoning and robbing of travelers was of frequent occurrence in India. Therefore, the administration of a poison is a criminal offence whenever-

I. It is with intent to kill,
II. With intent to cause serious injury,
III. Used recklessly even though there is no intent to kill,
IV. For stupefying to facilitate a crime, eg., robbery or rape,
V. To procure an abortion,
VI. To annoy the victim,

To throw poison on another person with intention to injure him.[26]

Different sections of Indian penal code related to poisons are as follows:

I. Sec. 272 I.P.C.- Punishment for adulterating food or drink intended for sale;
II. Sec. 273 I.P.C.- Punishment for selling noxious food or drink;
III. Sec. 274 I.P.C.- Punishment for adulteration of drugs in any form with any change in its effect knowing that it Will be sold;
IV. Sec. 275 I.P.C.- Punishment for knowingly selling adulterated drugs with less efficacy or altered action;
V. Sec. 276 I.P.C.- Punishment for selling a drug as a different drug or Preparation;
VI. Sec. 277 I.P.C.- Punishment for fouling water of public spring or reservoir;
VII. Sec. 278 I.P.C.- Punishment for voluntarily making atmosphere noxious to health;
VIII. Sec. 284 I.P.C- Punishment for negligent conduct with respect to poisonous substance;
IX. Sec. 328 I.P.C.- Punishment' for causing hurt by means of poison or any stupefying, intoxicating or unwholesome drug.

Law governing expert witness

In so far as the Indian legal system and its position is concerned, when Indian Evidence Act 1872 or the Code of Criminal Procedure, 1973 were enacted, legislature could not anticipate the tremendous development of modern science and technology and its deep impact on the forensic science as well as well as administration of justice. However, it was later on that the reports of the expert in relation to the results of forensic toxicology, became admissible as the Indian Evidence Act permits evidence of the opinion of persons (called 'experts' under the Act itself) specially skilled upon a point of foreign law, science, art, or as to identity of handwriting or finger impressions, the opinions upon that point.[27] Expert evidence is appreciated based on several factors such as the skill of the expert[28] and the exactness of the science.[29] Since Expert witnesses may deliver expert evidence about facts from the domain of their expertise therefore, they are usually instructed to produce a joint statement detailing points of agreement and disagreement to assist the court or tribunal.

[26]Murari A, Sharma GK, A comparative study of poisoning cases autopsied in LHMC New Delhi and JIP-MER Pondicherry. J Forensic Med. Toxicol. 19-21, (2002).
[27]Section 45, Indian Evidence Act, 1872.
[28]State v. S.J. Choudhary, AIR 1990 SC 1050 9, quoting the 69th Report of the Law Commission, 17.31.
[29]Pratap Misra v. State of Orissa, AIR 1977 SC 1307, 5.

However, the Supreme Court has opined, in a case concerning specifically with the medical examination of a victim of rape, that edical jurisprudence is not an exact science.[30] If the science itself is imprecise, expert opinion is only of corroborative value and insufficient to secure a conviction by itself. Therefore such evidences have to be seen along with the physical and circumstantial evidence in every case.

The main legal provisions, which govern the expert evidences, are in:

a) Indian Constitution. (Article 20 (3)),

b) Indian Evidence Act, 1872. (Sections 45 & 112),

c) Code of Criminal Procedure, 1972. (Sections 53, 194 & 293).

Several other provisions

For collection of blood samples, S. 53 of the CrPC is required which goes with the marginal heading "Examination of the accused by Medical Practitioner at the request of the Police." This section deals with examination of the accused by a medical practitioner at the request of the police officer, if there are reasonable grounds for believing that an examination of a person will afford evidence as to the commission of offence. So it shall be lawful for a registered medical practitioner at the request of the police officer not below the rank of sub-inspector and for any person acting in good faith in his aid and under his direction, to make such an examination of the person arrested as is reasonably necessary in order to ascertain the facts which may afford such evidence and to use such force as is reasonably necessary. This section does not specifically say whether it would be applicable for DNA tests also. This section does not state that the police officer shall be entitled to personally collect semen, blood, hair root, urine, vaginal swab, etc for the purpose of investigation himself. By the amendment Act of 2005 the CrPC has been amended and added S. 53A which states that examination of a person accused of rape by medical practitioner. The new Explanation now stands which include within its ambit examination of blood, blood stains, semen, sputum, swabs, sweat, hair samples and finger nails by the use of modern techniques in the case of sexual offences including DNA profiling and such other tests which is necessary in a particular case. Though, S. 53 of CrPC refers only to examination of the accused by medical practitioner at the request of the public officer but the Court has wider power for the purpose of doing justice in criminal cases. By issuing direction to the police officer to collect blood samples from the accused and conduct DNA test for the purpose of further investigation under S. 173(8) of CrPC.

a. S. 293 (4) (e) of the CrPC provides for report of certain Government scientific experts. This section is only an ancillary provision which provides for giving of report by scientific experts.

b. S. 112 of the Evidence Act raises a conclusive presumption about the paternity of a child born during the subsistence of a valid marriage. The said conclusiveness can be rebutted and it can be shown that the parties had no access to each other at the time when the child could have been begotten. The result of genuine DNA test is said to be scientifically accurate. If a husband and wife were living together during the time of conception, and the DNA test revealed that the child was not born to the husband, the conclusiveness in law would remain unrebuttable. There was an admitted access between husband and wife during which she could have conceived and delivered normal child. The presumption under s. 112 was not rebutted. No adverse inference can be drawn against refusing to submit himself to blood test. Section 112 requires the party disputing the paternity to prove non-access in order to dispel the presumption. "Access" and "non-access" mean the existence or non-existence of opportunities for the sexual intercourse. It does not mean actual co-habitation. It is a rebuttable presumption of law under s. 112 that a child born during the lawful wedlock is legitimate, and that access occurred between the parents. This presumption can only be displaced by a strong preponderance of evidence and not by a mere balance of probabilities.

[30]Ibid.

Cases solved with the help of forensics (In India)

The incidence of poisoning in India is among the highest in the world, and it is estimated that more than 50,000 people die every year from toxic exposure.[31] The causes of poisoning are many - civilian and industrial, accidental and deliberate. The commonest agents in India appear to be pesticides (organophosphates, carbamates, chlorinated hydrocarbons, and pyrethroids), sedative drugs, chemicals (corrosive acids and copper sulfate), alcohols, plant toxins (datura, oleander, strychnos, and gastro-intestinal irritants such as castor, croton, calotropis, etc.), and household poisons (mostly cleaning agents).[32] Therefore, with the ever increasing cases of poison in India, the role of forensic toxicology has been greatly appreciated in various cases.

Tandoor murder case (1995) Delhi

This was the first criminal case in India solved by the help of forensics and an attempt was made by the criminals to conceal a homicide by firearm by putting the dead body on fire. However a clever and systematic forensic investigation revealed the true cause of death. The case involved an incident in which the victim was shot by Shusil Sharma (husband of the victim) and then put in tandoor. After murdering his wife Sharma took her body in his car to the Bagiya restaurant, where he and restaurant manager Keshav Kumar attempted to burn her in a tandoor. Police recovered Sharma's revolver and blood-stained clothes and sent them to Lodhi Road forensic laboratory. They also took blood sample of Sahni's parents, Harbhajan Singh and Jaswant Kaur and sent them for a DNA test. According to the lab report, "Blood sample preserved by the doctor while conducting the post mortem and the blood stains on two leads recovered from the skull and the neck of the body of deceased Naina are of 'B' blood group." Confirming that the body was that of Sahni, the DNA report said, "The tests prove beyond any reasonable doubt that the charred body is that of Naina Sahni who is the biological offspring of Mr. Harbhajan Singh and Jaswant Kaur." And finally Mr. Shusil Sharma was found guilty with the help of forensic evidences.

Sister Abhaya murder case (1995) Kerala

The Sister Abhaya Case is a case regarding the death of a Knanaya Roman Catholic nun, who was found dead in a water well in Kottayam, India, on 27 March 1992. She was 19 years old at the time of her death and was a member of St. Joseph's Congregation for women under the Knanaya Catholic diocese of Kottayam, Kerala in India.

[31]Aggarwal P, Handa R, Wali JP, Common Poisonings in India, J. Forensic Med. Toxicol. 15: 73-79 (1998); Boesche Roger, "Kautilya's Arthasastra on War and Diplomacy in Ancient India," The Journal of Military History, 67: 9-37 (2003).

[32]Qureshi JM, Bano S, Mohammad T, Khan MA, Medicinal potential of poisonous plants of Tehsil Kahuta from district Rawalpindi, Pakistan, Pakistan Journal of Biological Sciences, 4:331-332 (2001).

On the day of her death she got up from sleep early at around 4 am to study for her exam, had gone down to the kitchen of the hostel to get water from the refrigerator. Later her body was found in the well outside the kitchen in the convent/hostel compound. Scientific investigation methods such as polygraph tests, brain mapping/brain fingerprinting and narco-analysis were used to solve the case. As part of its investigation in August 2007, the CBI conducted Narco-analysis tests. Subsequently with the help of these, two fathers of the church were arrested.

Aarushi talwar murder case (2007) Noida

In year 2008, Aarushi Talwar, the 14-year-old daughter of a successful dentist couple, was found dead with her throat slit in her parents' home in Noida, Delhi. Along with the girl, the servant of the house Hemraj was found dead. In this case fingerprinting was applied and DNA was extracted from the clothes containing blood stains. Also several fingerprints were found on the glasses of the house at the time of murder. Several narcoanalysis tests were applies on Aarushi's father on CBI's suspicion, but after no evidence Aarushi's father was acquitted. The final verdict of the Court on this case is still pending. The case also discussed about the admissibility of the narco tests as legal evidence.

Anant Chintaman Lagu v. state of Bombay33

The court stated in a case of poisoning, the prosecution must establish:

a) That the death was caused due to poison;

b) That the accused possessed the poison;

c) That the accused had an opportunity to administer the poison to the deceased.

If these facts are proved and there is motive, the court may be able to draw the inference, that the poison was administered by the accused to the deceased resulting in his death.

Poloniswamy v. state[34]

When the murder is alleged to have been caused by poison and the medical evidence is unable to determine poison, even then conviction can be recorded if the other evidence, oral or circumstances on the record establishes the guilt of the accused.

Mahabir v. state of Bihar[35]

The court upheld that the fact that the heart of the deceased at the time of post-mortem examination was found to be empty would not rule out asphyxia death as a result of poisoning. It is difficult to isolate and recognize the poison in a number of cases where the deceased dies due to poisoning. The doctor's part in the diagnosis of poisoning is secondary. Several poisons particularly of the synthetic hypnotics and vegetable alkaloidal group do not leave any characteristic signs which can be noticed on postmortem examination.

Significance of forensic toxicology

Forensic science is the application of a broad spectrum of sciences to answer questions of interest to a legal system. This may be in relation to a crime or a civil action. Besides its relevance to a legal system, more generally forensics encompasses the accepted scholarly or scientific methodology and norms under which the facts regarding an event, or an artifact, or some other physical item are ascertained as being the case. In that regard, the concept is related to the notion of authentication, where by an interest outside of a legal form exists in determining whether an object is what it purports to be, or is alleged as being. As it has been noted above that the use of drug has become a significant and social problem in the society therefore the chemical testing of biological specimens from individuals is generally accepted to be the most objective method for determining the drug use.[36] Drug testing with the help of forensic is increasingly used within the criminal justice system to monitor drug use. As such, toxicological analysis represents a tool for assessing the degree of impairment exerted by a drug or combination of drugs. With the ultimate degree of impairment being death, toxicological findings are also used to determine cause and manner of death. Every year many people are found dead in unexplained circumstances: they may be found in bed at home or in hotels, or in squats or on open ground. Evidence found at the scene, such as empty tablet bottles, bottles of alcohol or drug-taking paraphernalia can help to indicate a drug or alcohol-related death. Toxicological analysis can be crucial in determining the cause of death and many such cases are submitted to LGC Forensics from coroners and the police. Suspicious deaths in nursing homes and hospitals are particularly challenging, as the interpretation of high levels of a prescribed drug in an individual with some tolerance to its effects can be complex.

The most common application of toxicological findings to assess or explain performance impairment is to determine whether an individual has been driving under-the-influence (DUI) of ethanol (alcohol) and/or drugs (DUID). Another application is to determine whether the actions, behavior or demeanor of a homicide subject or suspect were affected by drugs or alcohol at the time of the incident and, thereby, offer potentially mitigating circumstances when the case is brought before a jury.[37] The study of toxicology serves society in many ways, not only to protect humans and the environment from the deleterious effects of toxicants but also to facilitate the development of more selective toxicants such as anticancer and other clinical drugs and pesticides.[38] Clearly, toxicology is preeminently an applied science, dedicated to the enhancement of the quality of life and the protection of the environment. Data on forensic evidence collected at crime scenes included DNA material, weapons evidence, latent prints, ballistics, trace evidence, and other types of forensic evidence. Through crime lab reports, it was possible to determine the number of cases with requests for analysis by investigators and the results of the analysis by forensic scientists. Comparisons were then made between open and closed cases from the two participating sites.[39]

Conclusion

As a matter of fact we know that with the advent of 21st century, the scope of a forensic toxicology service has technically and intellectually become very demanding. Even though the short-comings of forensic toxicology persists in some spheres, still its role in delivering the

[33]Anant Chintaman Lagu v. State of Bombay, AIR 1960 SC 500.
[34]Poloniswamy v. State, AIR 1968 Bom. 127.
[35]Mahabir v. State of Bihar, 1972 SC 1331.
[36]Barry Levine, Ch-3 *Forensic Drug Testing,* in Principles of Forensic Toxicology, Pg 31 (2006).
[37]Available at http://www.adfs.alabama.gov/Toxicology/ToxicologyMain.aspx
[38]Ernest Hodgson, *Introduction to Toxicology*, A Textbook of Modern Toxicology, p. 3 (Third Edition). [hereinafter Ernest]
[39]Tom McEwen, The Role and Impact of Forensic Evidence in the Criminal Justice System, p. 1, (2010), available at https://www.ncjrs.gov/pdffiles1/nij/grants/236475.pdf

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justice and solving criminal cases has been highly appreciated and relied upon. Yet after the limitations, the court and society at large depends on the findings of the forensic examination and reports. The growth of forensic studies in field of toxicology is witnessed because as the society advances and becomes more complex, the crime presents itself in different forms. This correspondingly necessitates the employment of modern scientific techniques in investigation. This need of the society is taken care by the field of forensic toxicology.

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Conflicts of imterest

None.

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