ISSN: 2096-3246
Volume 54, Issue 02, December, 2022
Special Issue

FORENSIC AND LEGAL ASPECTS OF ALCOHOL

Uttam Singh
Department of Forensic Science, MD University, Rohtak

Nidhi Hooda
nidhihooda_fosc@sgtuniversity.org
SGT University, Gurugram, Haryana, India

Priyanka Verma
SGT University, Gurugram, Haryana, India

Arunima Dutta
SGT University, Gurugram, Haryana, India

Harinath Dwivedi
Babu Banarasi Das University, Lucknow (U.P.), India

Abstract
Alcohol abuse in India has become a serious concern for the legal system. Given the fact that the production, sale, storage and consumption laws for alcohols are state dependent in India and alcoholic drinks being a major source of their revenue, the states seem to be least concerned about public health. Accurate and precise analytical methods are used for alcohol testing as high concentrations of alcohol in breath or blood (BrAC or BAC) may lead to serious legal consequences. Gas–liquid chromatography by so far is the gold standard for ethanol testing in biological specimens. Biological specimens which require qualitative and quantitative analysis of alcohols are sent to the forensic science laboratories in India. Breath-alcohol analyzers are used as roadside screening tests which act as evidence for prosecution of traffic offenders.
Keywords: Alcohol, Abuse, Health, Forensic, Blood

1. Introduction

Toxic homemade liquor kills scores in India, India bootleg alcohol death toll crosses 100, methyl alcohol poisoning leads to 111 deaths in Punjab, 168 deaths in Assam, 97 deaths in Uttar Pradesh, 30 deaths in Uttarakhand, 167 deaths in Mumbai and so on are just a few of the headlines that can be found on a regular basis on Indian and international news networks and newspapers [1,2,3]. Nearly 3 million people lose their lives and many more face severe impairments and degraded health as a result of alcohol consumption in India on yearly basis. Of the overall global disease burden, 5.1% can be attributed to alcohol abuse. Alcohol abuse also causes illness and to be precise, 2.2% of females and 7.1% of males around the world feature ill health due to misuse of alcohol. Nearly 10% of the deaths among the age group of 15 to 49 years occur due to alcohol abuse. According to the WHO worldwide status report on alcohol and health (2018), there were an estimated 2,64,468

alcohol-related deaths (AADs) in India in 2016 [4,5].

India holds ninth position among the largest alcohol consuming countries. In India, an estimated 160 million individuals (14.6 %) use alcohol, with 29 million (2.7 %) relying on it. Apart from this, nearly 29 million people (5%) are engaged in risky drinking. More than 60% of the alcohol drank was in the form of "spirits". These spirits are gin, whisky, rum, vodka, tequila as well as liqueurs. India has the greatest annual per capita alcohol consumption (5.7 litres) of the South-East Asia Region (SEAR) countries. India also ranks second among the spirit consuming countries with China being at the first place. The consumption of spirits has grown by 11% in India since 2017 with an annual consumption of almost 663 million liters. Whisky consumption in India is highest in the world. The whisky consumption in India is thrice the whisky consumption of the United States which finds itself at second place as far as whisky consumption is concerned. In India, nearly one out of every two bottles of whiskey imported is being sold [4,5,6]. Although the alcohol consumption noticed a downfall across the globe in 2018, India still managed a 7% surge in the whisky market. In the last two decades, the percentage of young drinkers has increased from 2% to 14%, with the average age of beginning dropping from 19 to 13 years [4,6,7,8].

By 2022, it is predicted that the Indian alcohol market will be of 16.8 billion litres, rising at an annual rate of 8.8%. Wine and vodka have a CAGR of 21.8% and 22.8%, respectively, in terms of popularity. The per capita alcohol consumption per week consumption is also predicted to increase from 147.3ml inn2017 to 227.1 ml in 2022 with a CAGR of 7.5% [4,5,6,10].

2.1 Some Notable Alcohols of Forensic Importance

Ethanol

Ethanol (Ethyl Alcohol), often known as Grain Alcohol, is a clear, colourless, volatile liquid with a characteristic spirituous odor and a burning taste. Methyl Carbinol, or Spirit of Wine, is another name for it. It's usually made from ethylene in a synthetic process. It is found in free form in a few fruit juices, and as a byproduct of starch, molasses, grapes, and other fermentations. Ethanol dissolves in both water and lipids. Both hydrophilic and lipophilic qualities are conferred by the hydroxyl and ethyl groups. As a result, ethanol is classified as a "amphophyle." It has a specific gravity of 0.79, which means that one millilitre of alcohol weighs 0.79 grams. It is hygroscopic and boils at a temperature of 78.40°C. The ethanol concentration of various alcoholic beverages is represented as a volume percentage or as proof, with the latter representing twice as much alcohol by volume. Ethanol is hazardous when taken orally or when inhaled, used subcutaneously, intravenously, intra-arterial, intraperitoneally and dermally. Inhalation of vaporized ethanol can result in drunkenness very quickly. Ethanol is a CNS depressant, however, due to the weakening of inhibitory control mechanisms in the brain, it has some initially stimulating effects. There are other drugs also which contain alcohol like decongestants, antihistaminics, multivitamins and cough syrups. The ABV in such medicines can range from 2 to 25%. Ethanol has been used as an antiseptic in the past as well as in the present. Ethanol with small amounts of methanol, methyl salicylate and castor oil is still the basic composition of surgical spirits used these days.[10,11]

Methanol

Methanol (CH3OH) is a light, volatile, colourless, flammable, toxic liquid having a faint odour. It is

also known as Methyl alcohol, Carbinol, or wood spirit. It is the most basic alcohol, and it is made by distilling wood or molasses in a damaging manner. It has a smoky flavour. It has a boiling point of 64.7°C, combines well with water and organic solvents, and has a strange odour and burning flavour. It creates an explosive combination when exposed to oxygen or air and burns with a pale blue non-luminous flame. It's utilised as an antifreeze, a solvent, a fuel, and an ethyl alcohol denaturant. Methanol is absorbed quickly from the gastrointestinal tract, lungs, and skin. Methanol is not poisonous in and of itself, but two of its metabolites, formaldehyde and formic acid, are. These chemicals cause severe metabolic acidosis, as well as vision impairment and blindness.[10,12]

Isopropanol

Isopropanol, also known as isopropyl alcohol or 2-propanol, is often known as "Blue Heaven" because it is frequently highlighted blue to discern it from the other liquids which are colourless, leading users to call it "blue heaven." Dimethylcarbinol, 2-Propanol, Alcojel, and Avantine Sterets are some of its other names. It's clear as well as colourless, flammable, volatile liquid which smells like acetone and has a harsh taste. Its boiling point is 82.5°C. Water, ethanol, chloroform, and ether are all miscible with it. Rubbing Alcohol (70%) is commonly used in massage, as a disinfectant, as an antifreeze, as a paint remover, as a cleaning solution, and in cosmetics such as hair tonics. Isopropanol is also an CNS depressant being thrice as efficacious as ethanol, with a typical Fatal Dose of 250 to 300 ml. Isopropanol can be absorbed in a variety of ways. Alcohol dehydrogenase breaks it down quickly in the body. It takes longer for it to break down in the human body than ethanol. It is majorly (80%) converted into acetone, with the left eliminated unaltered in urine whereas, acetone is eliminated in the urine by being metabolized into formate, acetate, and CO_2. Isopropanol may be produced spontaneously in the body of a deceased person, owing to bacterial or other putrefaction processes.[11,12]

Ethylene Glycol

Also known as 1, 2-Ethanediol or Glycol alcohol, ethylene glycol is a non-volatile, colourless, thick, odourless liquid with a bittersweet flavour. It cannot be absorbed dermally and does not cause toxicity when inhaled due to its low vapour pressure. The GI tract readily absorbs it. It’s main metabolites include Glycolic Acid, Glycoaldehyde and Oxalic Acid. These metabolites alter a number of metabolic processes within the body. Some other metabolites of ethylene glycol are malate, glycine, glyoxylic Acid, formic acid, benzoic acid, etc. Ethylene Glycol has a lethal dose of 70 to 100 ml.[10,11,12]

What is a "Standard Drink"?

The concentration of alcohol in a drink varies from beverage to beverage. 10ml of absolute alcohol in a drink constitutes the standard drink in India. The standard drinks can be understood in terms of ABV% also. A regular beer generally contains 4.9% ABV, so the standard amount for beer becomes 285ml of the drink. Similarily, the ABV% in a wine is usually 13%, so the standard drink of a wine is 100ml of the beverage. The ABV% in liquor is around 40%, so the standard drink of a liquor is usually 30ml. A unit of alcohol in India is defined as 10ml of absolute alcohol [14].

2.2 Legal drinking age in India

As the laws relating to liquors are a state subject in India, the regulations relating to drinking age, sale, consumption and possession of liquors also vary from one state to other. In general, the legal drinking age in India ranges from 18 to 25 years old. Also, there are states like Gujrat, Bihar, Mizoram, Nagaland, the UT of Lakshadweep as well as in some Manipur districts where alcohol is banned. In several states, the legal drinking age varies depending on the type of alcoholic beverage [15-21].

Dry days

A Dry day is a day on which alcohol sale and consumption is forbidden in India. Republic Day, Independence Day along with Gandhi Jayanti are observed as dry days in India [15].

2.3 Laws for driving under influence (DUI) in India

Driving under the influence or drunk driving occurs when a person's blood-alcohol level exceeds 30 milligrams per 100 ml of blood, as determined by a breath analyzer test. The same is applicable for anyone who is under the influence of a substance to the point that they are unable to maintain adequate control of the vehicle. In India, Section 185 of the Motor Vehicles Act, 1988 covers the laws concerned with driving under the influence of any substance. For the first such offence, the offender can be imprisoned up to six months and/or a fine extending up to 2000 rupees. The imprisonment can extend up to two years for the second/subsequent offence or/along with a fine extending up to 3000 rupees given that the offence is committed within three years of the first offence. The latest amendment relating to motor vehicle laws is the Motor Vehicle Bill of 2016. Improved road safety along with higher fines/penalties (up to Rs.10,000) for mixing drinking with driving are the main agendas of this bill [15-19,22].

2.4 Fate of ethanol inside the human body

Alcohol is a one-of-a-kind substance. It's a simple, tiny molecule (CH3CH2OH) that is water-soluble and volatile. Its pharmacokinetics is also straightforward. In comparison to other drugs, alcohol is comparatively non-toxic and can present in large concentrations in the blood. The concentration of alcohol in the blood is measured in mg, whereas the concentration of THC in the blood is measured in nanograms which shows that alcohol detection is much easier.[22]

Absorption

Alcohol is highly water-soluble and is consumed orally. As it can readily pass through the stomach and intestinal walls, it takes little time to emerge in the bloodstream. Alcohol does not need to be digested and just diffuses through the body's different membranes.[19,22]

Distribution

After entering in the bloodstream, alcohol is quickly distributed in all of the body by the blood. Alcohol is transported into various tissues based on the amount of water present. The tissues which contain higher amounts of water like the brain, liver, kidneys absorb larger amounts of alcohol than tissues with low water content (such as bone or fat). The basic pathway of alcohol distribution in the body is:

Mouth →Stomach and Small Intestines → Liver → Heart (right) → Lungs → Heart (left)→ All tissues of the body → Heart (right)

Thus, the blood supply distributes alcohol into the total body water (TBW). Generally, the body water distribution is 70% in men and 60% in women. Higher TBW results in dilution of larger amount of alcohol that has been consumed.[13,14]

Elimination

The liver removes alcohol at a consistent rate once it has been taken into the bloodstream. Various metabolic pathways are utilized to remove alcohol from the body. Aldehyde dehydrogenase (ALDH), alcohol dehydrogenase (ADH), cytochrome P450 (CYP2E1), and catalase are the main enzymes involved. Majority of alcohol (95%) is eliminated by the liver by the following mechanism:

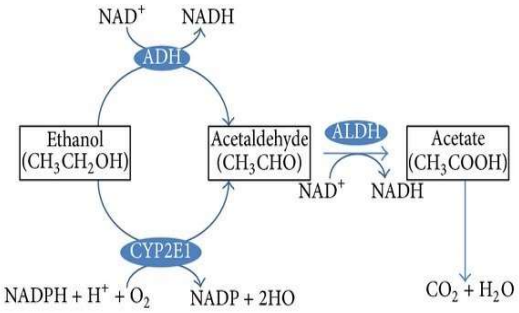

Fig 1: The pathway of ethanol metabolism [11]

Only around 5% of the alcohol is excreted in its pure form in the breath, perspiration, and urine. The balance of elimination and absorption determines the BAC attained and whether it is increasing or decreasing. This process is described below.

Absorption > Elimination results in increase in BAC

Absorption = Elimination results in constant BAC

Absorption < Elimination results in decrease in BAC

The alcohol elimination rate can range from 10 to 20 mg/100ml/h depending upon the person consuming it. The elimination rate is generally low for light drinkers and high for heavy drinkers.[22,23]

2.5 Alcohol abuse, Alcoholism, Alcohol Intoxication and Dependence

Alcohol abuse refers to a drinking pattern that alters the day to day lifestyle of an individual. Such a person drinks alcohol regularly which is a serious problem although there is no physical dependency on alcohol in such cases. Alcohol abuse is rather a mild type of Alcohol Use Disorder (AUD). Alcoholism, on the other hand, relates to dependence on alcohol. It can be used synonymously with AUD. Such individuals have physical reliance on alcohol and are subject to withdrawal symptoms like nausea, sweating, insomnia and also crave for a drink.[6]

Alcohol intoxication is a result of heavy alcohol consumption at a given time. It can be used synonymously with alcohol poisoning or drunkenness. The toxic nature of alcohol is basically due to its conversion into acetaldehyde upon metabolism. Also, the effects of alcohol on a person vary with the amount consumed as well as the individual's tolerance. Moderate to less consumption may show signs like flushed skin, euphoria as well as decreased social diffidence while a high dose may

result in slurred speech, vomiting, poor balance, nausea, lack of coordination of muscles, decreased capacity to take any decision, coma and death. [6,8]

2.5.1 Symptoms of alcohol abuse

Several symptoms develop in individuals who had been consuming alcohol for more than a year. Some are discussed below:

- Such a person craves for alcohol and can't resist himself/herself from consuming it.
- Most of the time of such a person is spent in buying alcohol, drinking it, remaining drunk/intoxicated and then overcoming the effects of alcohol consumption.
- Such a person tries to decrease his/her alcohol consumption but fails to do so.
- The limits that were once set by such individuals are ultimately broken and the consumption dose keeps on increasing with time because he/she develops tolerance for the drink and thus to get the desired effect, he/she has to consume more alcohol than he previously used to consume.
- As such a person remains intoxicated for most of the time, he/she is unable to fulfil his/her duties related to work, family and society which ultimately results in social, personal and financial problems. Although he/she may know the damage that alcohol is causing to his/her health, personal life and social life, he cannot resist the craving for alcohol and continues the consumption.
- Such a person mixes alcohol consumption with situations like driving which often results in serious accidents.
- If anyhow, such persons stop consuming alcohol, he/she may face withdrawal symptoms. He/she fails to sleep properly, may have tremors, altered moods, excessive sweat, seizures, lack of orientation, hallucinations etc. [7,8,9]

2.6 General effects of alcohols on human body

A person who is not dependent on alcohol and started consuming it recently may show short term effects like:

- The vision is usually blurred.
- Such a person is often confused, not in a clear state of mind.
- Dizziness and Impaired judgment
- Lack of awareness
- Uncoordinated
- Memory loss
- Nausea

- Vomiting
- Usually dehydrated
- Inability to speak properly, mumbling, slurred speech
- Inclined towards sexual crimes

A person who is dependent on alcohol will show long term effects like:

- Damage to brain and liver
- Blood pressure usually remains high
- Diseases related to heart and pancreas
- Prone to cancers
- The immune system becomes weak
- Problems related to family, society and work issues as well
- Intense hankering for alcohol.[19-23]

2.6.1 Effect of Alcohol on Brain

The physiological and behavioural changes of alcoholic intoxication on various parts of the brain are as follows:

Cerebral cortex: It processes information from multiple senses, processes thoughts and consciousness, and triggers voluntary muscle activity. Alcohol has the following effects on the cortex:

- It inhibits the proper thought process, affecting a person's judgement and thinking abilities;
- It depresses the behavioural inhibitory regions, causing the person to become more talkative and overconfident.
- It slows the processing of data gathered through the senses. The person experiences a hazy vision, as well as trouble hearing, smelling, chewing, and tasting. The pain threshold rises as well.[6,23]

Hippocampus: This part of the brain controls a person's emotions and memory. The emotions of a person intoxicated with alcohol are usually exaggerated along with loss of memory.[6]

Cerebellum: It is responsible for coordinating the body's muscular actions. As the cerebellum is affected by alcohol, muscular actions become uncoordinated. Aside from that, the cerebellum controls fine muscle movements, which is important for body balance. As a result, impairment of this region leads to a stage known as "falling down drunk."[13]

Hypothalamus and Pituitary Gland: These glands coordinate hormones. Alcohol affects these glands in the following way:

- Uncontrolled sexual behaviour: The nerve centres controlling the sexual instincts of a person are suppressed by alcohol. As a result, the individual becomes sexually aggressive, and in the case of extreme intoxication, the person may even commit a crime.
- Urine Excretion: Alcohol impairs pituitary function and so lowers anti-diuretic hormone synthesis (ADH). When ADH levels fall, the kidneys are unable to absorb as much water, and the rate of micturition rises.[5,6,7]

Medulla: It regulates vital bodily activities such as heart rate, body temperature, respiration, and awareness. As alcohol affects the upper centres of the medulla, the person begins to feel tired and may finally pass out. If the BAC is high enough to affect other centres such as respiration, heart rate, and temperature, the person begins to breathe slowly and their body temperature and blood pressure begin to plummet. This could possibly result in death.[6,8]

2.6.2 Effect of Alcohol on Other Body Parts

Apart from the brain, alcohol affects other parts and organs of the body as well in the following ways:
Liver: Alcohol causes alcoholic cirrhosis i.e. damage to the linings of the liver. The cirrhosis symptoms may vary with the stage of the illness and there may not be any symptoms in the initial stages. The chief symptoms are:

- Less desire to eat food
- Low in energy
- Urine is brownish to orange in colour
- Such a person is usually confused and disorientated
- Stools may have traces of blood
- Oedema[6,7]

Stomach and Intestine: The stomach produces more acid than usual as a result of alcohol consumption, which results in inflamed inner linings of the stomach (gastritis). This may further cause vomiting, pain, diarrhoea and even bleeding.

- Alcohol causes damage to the muscle layers of the stomach and intestinal wall.
- Alcohol consumption can result in lack of GI smooth muscle contraction.
- The propulsive contractions are increased in chronic alcohol users, which results in diarrhoea.[8,9]

Muscles: Muscle development requires protein synthesis. Alcohol suppresses protein synthesis, which means it halts muscular growth. Alcoholic cardiomyopathy is a condition in which drinking too much alcohol over time damages the heart muscle, preventing it from pumping blood properly.[9,10]
Skin: Much of the focus of alcohol is centred on the liver, but the skin is left out. The chief effects of alcohol on skin are:

- Alcohol depletes the body's nutrition, including vitamins and antioxidants. Vitamin A especially aids in the production of collagen and the regeneration of new skin cells in the body.

- Excessive alcohol consumption causes the blood vessels in the face to dilate, resulting in red and spider-like veins.
- Alcohol dehydrates or depletes the body's water and highly oxygenated blood, both of which are required to keep skin hydrated and moisturised, resulting in dry skin.
- Alcohol can exacerbate rosacea flare-ups, a common skin condition that causes redness in the nose, chin, and cheeks.
- The face of the intoxicated person looks flushed as a result of the increased blood flow in the skin and such person starts sweating profusely.[2,3]

2.7 Social and Economic issues related to Alcoholism

- ***Road Traffic accidents:*** Alcohol intoxication is the cause of almost 40% of road accidents in India. Majority of such people age between 20-50 years. These are young and working individuals which usually mix drinking with driving and thus face serious consequences.
- ***Poverty:*** Alcoholism certainly leads one to poverty. Apart from the money spent on drinks, heavy drinkers may suffer other economic problems such as lower wages, lost employment opportunities, increased medical and legal expenses, and decreased eligibility for loans.
- ***Suicides:*** Alcohol dependent people are much prone to suicides as they regularly face financial, family and social problems. A roughly 10-15% of such people commit suicide.
- ***Crime:*** Crime and alcohol abuse has a strong association. Activities like indulgence in high-risk behaviour, domestic violence, high-risk sexual behaviour, violent acts, robbery, sexual assault, homicides, aggravated assaults, intimate partner violence, child abuse etc. are some common crimes related to alcoholism.
- ***Coexisting issues & mental health disorders:*** AUD is frequently associated with other substance use disorders, antisocial personality disorder, anxiety disorders, mood disorders like depression and bipolar disorder and usually the combination becomes complex and difficult to manage. Apart from it, alcohol use can lead to alcohol-induced psychotic disorder, alcohol-induced mood disorder, alcohol-induced anxiety disorder and alcohol-induced sexual dysfunction.
- ***Decreased productivity:*** Heavy drinking results in lack of interest in work. This reduces productivity. The professional relations of such persons are also affected due to this.
- ***Foetal Alcohol syndrome****:* drinking during pregnancy results in increased chances (35-40%) of being born with birth defects. Foetal alcohol syndrome results in babies born with a small head, deformities in face and limbs, defects of heart and deficient intellectual skills.[5,6,7]

2.8 Alcohol testing

2.8.1 Roadside Sobriety Tests – A number of tests have been designed by scientists and government officials to access whether any person is under the influence of any drug or alcohol. Such tests include: [22]

HGN Testing: Horizontal Gaze Nystagmus is an involuntary shaking of the eyeball that happens

when you look towards any side of the eye. Rotation of eyes at high peripheral degrees can cause nystagmus in normal persons while the same occurs at relatively low angles in persons who have consumed alcohol recently. Also, due to the compromised ability of an alcoholic to monitor an object which is moving, an official can easily conclude that a person is drunk or not. In the HGN test, an officer watches a suspect's eyes as he follows a slowly moving object horizontally with his eyes, like a flashlight or a pen. An alcoholic's eye will not be able to monitor the object smoothly and at maximum deviation of the eye, there will be noticeable jerking initiated at angles within 45 degree of the centre. Such individual may have BAC ≥ 0.10.

Divided Attention Test: The person is asked to perform physical movements and listen to the officer at the same time in such tests. Impaired persons find it difficult to perform such tasks that divide their attention both mentally and physically.

Walk-And-Turn Test: In this test, the person is instructed to walk nine steps in a straight line, heel to toe. After walking the steps, the suspect is asked to turn on any single foot and walk back to the starting point. There are seven important signs that are tracked by the examiner; the balance of the person, while the examiner is giving instructions if the person starts to walk before the instructions, are finished, if to regain balance he stops walking, if he is unable to touch the heel with the toe, if he uses his/her arms to balance himself/herself, if the balance is lost while turning, if the number of steps taken are wrong.

One-Leg Stand Test: In this test, the person is asked to stand on one foot with the other hanging 6" off the ground and loudly count by thousands till he or she is directed to put the foot down. The officer keeps a 30-second timer on the individual. Swaying when balancing, use of arms to balance, maintaining balance by hopping and placing down the foot are the four impairment signs that the officer looks for.[22,23]

2.8.2 Breath alcohol testing

What is a Breath Test?

To get an estimate of a person's BAC, a 'breath test' is carried out by a government-approved device. Such test can estimate the amount of alcohol in the human breath which can then be related to BAC. Such tests are accurate as well as non-invasive.

Who can take a Breath Test

A breath test can be conducted by a uniformed police officer or a Motor Vehicles Department officer who has been authorised to do so by that department. If a breath test shows that a person has BAC beyond legal limit, the officer in uniform can arrest that person and there is no need of any warrant in such cases, unless that person is hospitalised. If the subject refuses or fails to take the breath test, the police officer might arrest him. heavily drunk persons usually fail to produce a test because they are unable to continuously blow air into the instrument. Any person detained in this manner must have a medical examination by a registered medical practitioner within two hours of his arrest, failing which he must be released from detention.

When does one take a Laboratory Test The breath test can be used only for screening individuals and there is always a need of a confirmatory test which is performed in laboratories. Screening tests are important because all laboratory instruments can't be carried to the field. Moreover, such tests

give objective, scientific and trustworthy reasons to the examiner to detain the suspect and exonerate the innocents. The detained person can be asked to provide a sample of his blood at the police station itself so that it can be tested at the laboratory.[22]

Presumption of unfitness to drive

Any person can be judged as alcohol intoxicated and unfit to drive if he/she does not co-operate with the officer or fails to provide a breath sample at the time of testing.[22]

Principle of Breath Testing

Alcohol readily enters the bloodstream after being absorbed by various organs of the body. The intensity of alcohol in blood increases with its intake. Metabolism of alcohol does not take place in the blood stream so it is not altered chemically. Being volatile in nature, some of it flows past the alveoli and enter the air as the blood passes through the lungs. The breath alcohol-testing gadget capture this air and detect any alcohol present in it. There exists a relation between the BAC and BArC. The alcohol in breath to alcohol in blood ratio is 2100:1. Thus, 2100ml of air from the alveoli contains the same amount of alcohol present in 1ml of blood. [16,17]

Types of Breath Alcohol Testing Devices: There are three major types of breath testing devices distinguished from each other on the basis of their working principles. The common parts of all devices include a mouthpiece connected to a tube through which air is blown and a chamber where the air sample goes. Following are some important breath testing devices: [12]

Breathalyzer: Invented by Dr. Robert Borkenstein in 1954, this device utilizes an alcohol-based chemical reaction to achieve a colour shift. A suspect breaths into the gadget and the exhaled air is bubbled via a chemical combination. Any change in colour is detected and the degree to which the colour changes determines the concentration of alcohol in exhaled air. A secondary vial containing an unreacted mixture in the photocell system is used for comparison with the reacted mixture. The production of electric current initiates a movement of the needle sitting in the metre attached to the photocells. Thus the amount of alcohol in that air is determined. The needle has to be brought back to the resting position by turning a knob. Higher alcohol levels require more turning of the knob to bring back the needle to rest.

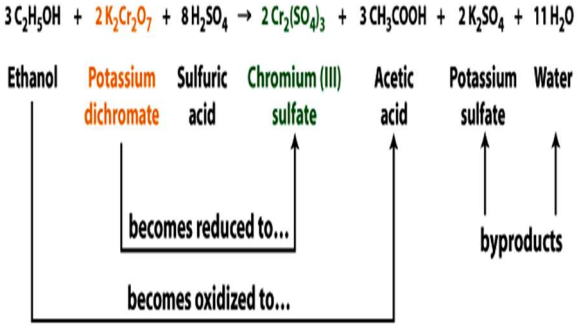

Fig 2: Working principle of a breathalyzer [13]

Intoxilyzer: It uses infrared (IR) spectroscopy for alcohol detection, which is based on the phenomenon of change in vibrations of molecules upon absorption of IR light. The molecules of any substance are always in vibrational state and when they interact with IR light, the intensity of such vibrations change as the bonds bend and stretch upon interaction with IR light. The wavelength at

which IR is absorbed is different for every bond in a molecule. In cases related to ethanol, the wavelengths of its bonds are studied and the IR absorption is measured. The wavelength at which IR is absorbed determines the presence of ethanol and the amount of absorption determines the quantity of ethanol present.[13,14]

Alcosensor III or IV: It is also based on a chemical reaction that takes place in a fuel cell. A porous acid-electrolyte substance is placed between two platinum electrodes in the fuel cell. Exhaled air from the suspect's lungs is oxidized by platinum to give products like electrons, protons and acetic acid as the air passes through one side of the fuel cell. From the platinum electrode, electrons pass through a wire. On one side, the wire is attached to an electrical current metre, while on the other, it is connected to the other platinum electrode. The protons proceed through the fuel cell's lower section, where they react with oxygen and electrons on the other side to form water. The amount of electric current produced is directly proportional to the amount of alcohol oxidized. The current produced is measured by a microprocessor and thus the BAC is calculated.[10,11]

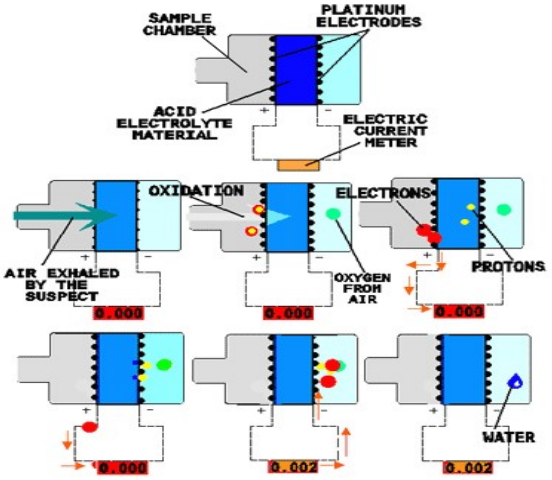

Fig 3: Principle of Alcosensor [10]

2.8.3 Laboratory analysis for determination for Ethyl Alcohol and other volatiles in Blood/Urine/Visceral distillate:

In India, there is an excise act in place for all the types of liquors available in the market. This act determines the rules for the possession, sale as well as the transit of liquor from one place to another. Smuggling of such drinks from one state to the another is a common practice in India. The Police seize these samples and they are sent to FSL's for examination purposes. Such samples are tested for two important reasons: first, due to excise related issues, where the major concern is whether alcohol is present or not, and thus the qualitative and quantitative inspection of liquor samples is the investigations primary goal. The second aim is to analyse the liquor for its quality or duplicacy. Such investigation is carried out by considering all the possible aspects which may lead to adulteration in liquor samples. The strength of such samples is reported in degree proof, weight by volume % of alcohol and volume by volume % of alcohol after examination. [11,12]

2.8.3.1 Qualitative Analysis

***Tests for Ethanol*:** Following are some important colour tests for ethanol:
***Iodoform Test*:** To 1 ml of sample, 1 ml of NaOH solution (5%) is added. This is followed by drop by drop addition of iodine solution which is prepared by mixing 20 gms of KI and 10 gms of iodine in 100 ml of water. The solution is shaken continuously until the solution attains a dark brownish colour. It is then kept still for two to three minutes. If the brownish colour fades, a little more iodine solution is added until the brownish colour becomes persistent. Extra iodine can be removed by addition of dilute NaOH solution. Following this, equal amounts of water is added to the solution and kept for 10 minutes. The presence of ethanol is suggested by formation of crystalline yellow precipitates.[14]
***Dichromate Test*:** To 1 ml of sample, approx. 0.2 ml solution of potassium dichromate (2%) is added followed by addition of 1 ml of conc. sulphuric acid. The change in dichromate's yellow colour to green of blue suggests the presence of ethanol. [15]
Test for Methanol:
Chromotropic Acid Test: Approx. 1 ml of sample is taken in a test tube and add approx. 2 ml solution of potassium permanganate which is prepared by dissolving 3 gms of potassium permanganate and approx.15 ml of phosphoric acid or orthophosphoric acid in 100 ml distilled water followed by shaking. This is followed by addition of few sodium bisulphite crystals with continuous until the colour of potassium permanganate disappears. Now 1ml of an 5% aqueous solution made from a sodium salt of chromotropic acid is added followed by drop by drop addition of about 15ml conc. Sulphuric acid along the inner wall of the test tube. Emergence of violet colour suggests the presence of methyl alcohol.[16]
Schiff's Reagent Test: Approx. 4.5 ml of sample is taken in a test tube and add approx. 0.5 ml ethanol to it. This is followed by addition of 2 ml solution of Potassium Permanganate (3%) along with .2ml phosphoric acid. The solution is left still for 10 minutes. Now, 1 ml of oxalic acid (10%) and 1ml of conc. sulphuric acid is added and the solution is allowed to cool at room temperature. 5 ml of schiff's reagent is now added and the solution is now kept still for half hour and its colour is observed. Emergence of purple colour suggests the presence of methyl alcohol.[17]

2.8.3.2 Quantitative Analysis:

Modified Kozelka – Hine Method:
Kozelka – Hine Method is a highly appreciated method worldwide for blood/urine alcohol testing purposes. The basic assembly consists of four tubes made of good quality glass each having a length of 20 cm and a diameter of 2.5 cm. Approx. 5 ml solution of potassium dichromate in concentrated Sulphuric acid (2%) is added to the first tube. Moisture along with organic volatiles are removed from the air by bubbling it through this tube. The second tube contains either blood sample (2 ml) or urine sample (10ml). Addition of 2 ml solution of sodium tungstate (10%) followed by 0.5 ml of sulphuric acid (2N) is now done for deproteinizing the blood. Urine sample doesn't require deproteinization. The third tube contains 5 ml mercuric chloride (saturated) along with 5 ml solution of NaOH (saturated). These two solutions upon mixing form a yellow ppt. of hydrated mercuric

oxide which is used for trapping acetaldehyde, acetone etc. The fourth and final tube contains 10 ml solution of potassium dichromate (0.1N) along with 10 ml conc. sulphuric acid. The arrangement of the tubes is such that excluding the first tube, the rest are submerged in hot water. An aspirator is used to suck air through these tubes (25ml/minute). The air is first sucked through the first tube followed by the second tube, the third tube and finally the fourth tube. The dichromate solution is taken out after an hour and made 100 ml using distilled water. The resulting solution is now iodometrically titrated with 0.1N solution of sodium thiosulphate. It is also necessary to perform a blank experiment side by side which features all reagents but not the sample of blood.[20,21]

The basic calculations are as follows:

For a given redox reaction,

1ml of $K_2Cr_2O_7$ solution (0.1N) = 1.15 mg of ethyl alcohol

Therefore,

$$BAC\% = \frac{1.15(X-Y)100}{V}$$

miligrams per 100ml of blood

Where;

V = Volume of blood in milliliters taken for performing the experiment.

X = Volume of sodium thiosulphate (0.1N) in milliliters required in the blank experiment.

Y = Volume of sodium thiosulphate (0.1N) in milliliters required for the experimentation with the sample of blood.

Gas Chromatographic analyses of Ethyl alcohol and other volatiles in Urine/Blood/Visceral distillates:

Isolation of volatile substances from blood*:* Approx. 1 ml sample of blood taken and diluted with about 4 ml distilled water. This solution is now acidified using few drops of tartaric acid (5%). Now the solution is subjected to distillation. The distillate (5ml) is collected in icy conditions. An aliquot (10 µl) of the distillate is injected into the gas chromatograph.[48]

Isolation of volatiles in Urine: In a microcentrifuge, 1ml sample of urine is centrifuged for 15 minutes. The supernatant is collected and about 5 µl ot it is injected into the gas chromatograph.

Necessary requirements:

Type of column: A Porapack polymer bead 80-100 mesh column is required as it can easily separate ethyl alcohol.

Temperature of the column : 160^0C

Carrier Gas: Nitrogen

Gas flow rate: 50 ml/min

Detector required: Flame Ionization Detector (FID)

Quantitation: Quantification is done by measuring the corresponding peak's area. Following equation is used for quantification:

Ca/Aa = Cb/Ab

Where,

Ca = Conc. of volatile substance in the given sample

Aa = Area of the peak of volatile substance detected in the sample
Cb = Conc. of the standard taken for blank experiment
Ab = Peak area of the standard of a volatile substance per 100 ml. of blood.[22,23]

Discussion

In India, alcohol drinking is becoming a big public health issue. To further comprehend the situation, multi-centric scientific community-based research investigations must be done in diverse particular states. Sensitization initiatives and health education campaigns must be used to educate legislators, the media, experts, and the general public on the dangers of chronic alcohol consumption. A reasonable alcohol control policy with specified objectives such as alcohol taxation, production, and promotion policy is urgently needed. India continues to strive for social and economic growth as a developing country. Alcohol may likely be a big roadblock for objectives. India today progresses on the path of providing all its people with their basic needs like good education, better nutrition and a secure environment in the society. Such goals can only be achieved by controlling and limiting the use of alcohol in the country. India must avoid efforts related to the expansion of its alcohol market as it will result in increased consumption and negative consequences for the country's population. Alcohol, rather than just being another commodity to be liberalised, should be recognised as an addictive and hazardous substance. The country today needs to develop long term policy regarding alcohol that considers its negative effects on the people of India. One must also remember that alcohol use is a psychosocial as well as an issue related to behaviour. Legislative solutions like a complete ban might not be as effective as it seems. India should take note of other developed and emerging countries' experiences and take steps to curb its rising alcohol use before it is too late.

Conclusion

Alcohol is a part of life of many people and also source of livelihood in our country. Total boycott of alcohol would be an irrational step for any government or individual. There are regulations needed for preventing production, distribution and consumption of hazardous and even excess national wide alcohol policy like U.S. There should be proper implantation of enacted laws and certain prohibitions which are necessary for stability in the society. The laws made with motive to lower the rate of consumption of alcohol are violated rigorously. People who are habitual drinkers tend to avoid the state liquor laws to drink liquor. For example, in Delhi the government imposed fine on consuming liquor in public and people, who consume alcohol, do so breaking rules and pay fines. In spite of not consuming alcohol, they break laws to consume alcohol. It is very essential for the nation to ensure that legal drinking age should be strictly followed and there should be diligent participation of the law enforcement agencies towards this. There is a need of laws with strict punishments to make sure the implementation of those laws as well. When these steps are implemented, then there can be a stable legalization and which is also regulatory in nature. It will also decrease the alcohol related crimes in our country, if it is implemented in a subtle and rational manner.

Bibliography

1. World Health Organization. (2019). *Global status report on alcohol and health 2018*. World Health Organization.
2. Mohan, D., Chopra, A., Ray, R., & Sethi, H. (2001). Alcohol consumption in India: a cross sectional study. *Surveys of drinking patterns and problems in seven developing countries. Geneva: World Health Organization*, *59*, 103-114.
3. Prasad, R. (2009). Alcohol use on the rise in India. *The Lancet*, *373*(9657), 17-18.
4. Ghosh, A., Choudhury, S., Basu, A., Mahintamani, T., Sharma, K., Pillai, R. R., & Mattoo, S. K. (2020). Extended lockdown and India's alcohol policy: a qualitative analysis of newspaper articles. *International Journal of Drug Policy*, *85*, 102940.
5. Ambekar, A., Agrawal, A., Rao, R., Mishra, A. K., Khandelwal, S. K., & Chadda, R. K. (2019). on behalf of the group of investigators for the National Survey on Extent and Pattern of Substance Use in India (2019). *Magnitude of substance use in India*.
6. Reshi, Mohammad. (2020). ALCOHOL LEGALISATION IN INDIA: A CRITICAL ANALYSIS OF LAWS, REGULATIONS AND FUTURE PERSPECTIVES. 10.13140/RG.2.2.25124.91525.
7. *Drunk Driving Laws and Punishment in India*, https://www.indiafilings.com/learn/drunk-driving-laws-punishment-india/
8. The Motor Vehicles Act, 1988, No.59, Acts of Parliament(1988)
9. Liquor Laws. *Who gets to get drunk.* [Last accessed on 2018 Aug 22].
10. EATTREAT. *The Legal Drinking Age In Delhi Is The HIGHEST In The Country! But Where Is It the Lowest?* 2019.
11. Watson, P. E., Watson, I. D., & Batt, R. D. (1981). Prediction of blood alcohol concentrations in human subjects. Updating the Widmark Equation. *Journal of studies on alcohol*, *42*(7), 547-556.
12. Barnes, E. W., Cooke, N. J., King, A. J., & Passmore, R. (1965). Observations on the metabolism of alcohol in man. *British Journal of Nutrition*, *19*(1), 485-489.
13. Nyman, E., & Palmlöv, A. (1936). The Elimination of Ethyl Alcohol in Sweat 1. *Skandinavisches Archiv Für Physiologie*, *74*(2), 155-159.
14. Holzbecher, M.D., and Wells, A.E., "Elimination of Alcohol in Humans", Canadian Society of Forensic Science Journal, 17: 182-196, 1984
15. Olsen, H., Sakshaug, J., Duckert, F., & Strømmet, J. H. (1989). Ethanol elimination-rates determined by breath analysis as a marker of recent excessive ethanol consumption. *Scandinavian journal of clinical and laboratory investigation*, *49*(4), 359-365.
16. Benegal, V. (2005). India: alcohol and public health. *Addiction*, *100*(8), 1051-1056.
17. India. *Udta Bihar: Huge spike in substance abuse, alcohol bootlegging year after ban.*
18. Sharma, H. K., Tripathi, B. M., & Pelto, P. J. (2010). The evolution of alcohol use in India. *AIDS and Behavior*, *14*(1), 8-17.
19. Saxena, S. (2000). Alcohol problems and responses: challenges for India. *Journal of Substance Use*, *5*(1), 62-70.

20. Wigmore, J. G. (2014). The forensic toxicology of alcohol and best practices for alcohol testing in the workplace. *Ottawa, Canada: Canadian Nuclear Safety Commission*.
21. KRISHAN. VIJ. (2014). *Textbook of Forensic Medicine & Toxicology: Principles & Practice*. Elsevier India.
22. Reddy, K. S. (2005). The essentials of forensic medicine and toxicology. *Journal of Punjab Academy of Forensic Medicine & Toxicology*, *5*(5), 53-53.
23. Chemistry manual, Directorate of Forensic Science, MHA, Govt. of India.