# AN ANALYSIS OF CASES OF DEATHS DUE TO DROWNING BASED ON THE AUTOPSY EXAMINATIONS CONDUCTED IN GANDHI HOSPITAL MORTUARY, SECUNDERABAD

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**Abstract**

Drowning is a multispectral issue and is an important public health issue with major impacts on children and youth. Drowning is the second leading cause of unintentional injury death for children aged 1-14years and the fifth leading cause for people of all ages. The major tragedies of drowning occurs due to Natural disasters like cyclones and floods, the Hindus religious events like holy dips in pushkharalu, in canals of punyakshetralu, during religious ritual celebrating the birth of the elephant headed Hindu deity Ganesha and Economic events like tourism, transport. Beside all these, some persons committed suicide by drowning, as it is one of the painless and easy way of death, some murderers dispose off the dead bodies of their victims in the rivers, seas and well to simulate death due to drowning and sometimes unwanted bodies are thrown into water. In our Indian set up the time required to complete the inquest formalities and transport of the body to the mortuary is enough to cause the decomposition advanced and mask most of the post mortem evidence of cause of death. In advanced decomposed and skeletonized bodies, the only method of identifying a classical antemortem drowning is estimation of diatoms from the bone marrow and comparing them with the diatoms available in water and identification of dead body by DNA analysis.

Drowning is preventable. Proven strategies implemented at household, community and national level range from teaching basic swim skills and installing barriers that control exposure to water hazards, to providing safe spaces for children such as crèches and learning about safe rescue, tailored to individual settings and risk groups.

**Keywords:** Multispectral issue, major tragedies, ante mortem drowning, diatoms, preventable, proven strategies.

**Introduction**

India is a vast country, having plenty of water supply from rivers, ponds, wells and an extensive seacoast. Under such conducive circumstances, it is a matter of small wonder that cases of death due to drowning is frequent event. Every hour, every day more than 40 people lose their lives due to Drowning. Drowning is the second leading cause of unintentional injury death for children aged 1-14 years and the fifth leading cause for people of all ages.

Of the multitude of ways that people die in India, one of the most heart breaking and tragic is by drowning. Indians perish by drowning in lakes, rivers, ponds, in the ocean and when overcrowded ferries capsize.

The Risk factors for drowning are Increased access to water; Unprotected watery bodies; Individuals with occupations such as fishing or transport; Children living near open water sources like ditches, ponds, irrigation channels or pools; Economic factors like tourism, transport; Natural disasters like cyclones and floods; Unsupervised children; Recreational activities; Medical co morbid conditions (epilepsy); Consumption of alcohol and drugs; Absence of safety skills, Customs and religious events like holy dips in pushkharalu, in canals of punyakshetralu, during religious rituals celebrating the birth of the elephant headed Hindu deity Ganesha.

**Impacts of Drowning are**

- ✓ Health impacts
- ✓ Social impacts
- ✓ Psychological
- ✓ Economical- direct and indirect
- ✓ Legal (Health sector bears the brunt of drowning to the maximum)

**Bodies taken from the water may have:**

- ✓ Died of natural causes before falling in (Heart attacks on the edge of the well, River banks, epilepsy, etc.)
- ✓ Died of injuries before falling or being thrown in to the water (Head injuries etc.,)
- ✓ Died of natural causes in the water (cardiac deaths while swimming).
- ✓ Suffered injuries while falling in to water (e.g., against Bridge piers, wharves, etc.)
- ✓ Suffered injuries while in the water (boats, propellers, bridges, rocks, etc.,)
- ✓ Suffered death from immersion.

**Objectives**

1) Present trends in drowning by statistical analysis from the Department of Forensic Medicine, Gandhi Medical College, secunderabad.
2) To know the latest advances in the study of Immersion deaths.
3) Study the water diatoms and tally them with sternal bone marrow diatoms.
4) To know the validity of Diatom test.

The present study is based on the autopsies conducted in the mortuary of Gandhi Hospital, Secunderabad. The total number of autopsies conducted during 2014 were 5576, out of which

161 cases were of submersion and total number of autopsies conducted during 2015 (up to September) were 4349, out of which 132 cases were of submersion. The statistical analysis of these cases of drowning with regard to general incidence, age, sex, marital and suicidal, accidental or homicidal and epidemiology etc., are worked out.

**Drowning and Types of Drowning**

The term "Drowning" should be used, to denote the process resulting from submersion in water, in which there is loss of consciousness and a threat to life. Complete submersion is not necessary, for submersion of the nose and mouth alone for a sufficient period can cause death from drowning.

**Drowning is of four types**

**Wet Drowning:** In this, water is inhaled into the lungs and the victims has severe central chest pain, if resuscitated, he has no pleasant recollections.

**Dry Drowning:** In this type of immersion, water does not enter the lungs but death results from immediate sustained laryngeal spasm, due to inrush of water into the nasopharynx or larynx.

**Secondary drowning:** (Post immersion syndrome or near drowning). In this type, death occurs from within ¼ hour to several days after resuscitation. Electrolyte disturbances and metabolic acidosis occur.

**Immersion syndrome:** (Hydrocution or submersion inhibition) Death results from cardiac arrest due to vagal inhibition

**Mechanism of Drowning**

Brouardel carried experiments with dogs. The process was divided into 5 stages.

1) Stage of surprise.
2) 1st stage of respiratory arrest.
3) Stage of deep respiration.
4) 2nd stage of respiratory arrest
5) Stage of terminal gasps.

1) **Stage of Surprise:** Lasting for 5-10 seconds, animal inspired once or twice but inactive.
2) **1st stage of respiratory arrest:** This stage lasts for about 1 minute, the dog violently agitated, fighting against its bonds and mouth was set with. Respiration arrested.
3) **Stage of Deep respiration:** Lasts for about 1 minute. Dog made some deep inspirations and expelled white foam to the surface. The agitation stopped. The eyes and mouth were open. A few swallowing movements were noted.
4) **2nd stage of Respiratory Arrest:** The stage lasting for about one-minute, thoracic movements were not observed, corneal reflex was lost and pupils were widely dilated.
5) **Stage of terminal gasps:** Lasting for 30 seconds. The dog made 3-4 respiratory movements. The lip and jaw muscles showed fibrillary contractions. The whole process of drowning of these dogs in fresh water took 3 to 4 minutes. Under identical conditions, sea water is approximately twice as lethal as fresh water. In man, probably the course is similar, except rising to the surface once or more. Hypoxic convulsions may occur in 4th stage.

**Pathophysiology of Drowning**

During the past 5 decades, views on the mechanism of drowning have undergone a radical change and perhaps the pendulum of opinion has swung a little too far.

**Pathophysiology of fresh water drowning:** (0.6% NACI) Submersion in fresh water is more dangerous than salt water. The old idea that drowning was merely a form of asphyxia, due to exclusion of air from the lungs, has been shown to be quite incorrect. The true mechanism is a combination of massive, absorption of water via the alveolar membranes (with a consequent acute increase in blood volume up to 2.5 to 3 liters or more of water be inhaled and absorbed in three minutes) Hypoxia and electrolyte and osmotic imbalance.

The blood volume after a few moments of submersion in fresh water may rise by over 50% and the immediate cause of death may be cardiac failure from inadequacy of heart to deal with increased volume. Added to this is dilution of electrolytes in the plasma E.g.:-Calcium falls to 2 m Eq/L with the exception of potassium, which is released from lysed red cells due to sudden hypotonicity of the plasma. The combination of hydraemia (and to some extent, potassium increase) may cause rapid myocardial failure. These changes may occur before pure anoxia becomes a lethal factor, though more recent work on the electrolyte changes suggests that this factor is not so important, as was though, some decades ago, pointing to dangers of accepting. Animal experiments as necessarily being applicable to the human situation.

**Patho physiology of sea water drowning:**

(3% NaCl) Sea water is hypertonic compared with plasma. No massive absorption of water into the circulation occurs. Infact, there may be a reverse transfer of lesser volume, leading to pulmonary oedema and the greater probability of frothy fluid in the air passages.

No cardiac embarrassment from hypervolemia takes place and there is no potassium toxicity.

These theoretical differences are born out in practice, by a much lower recovery rate of bodies recovered from fresh water as opposed to sea water. Naturally if immersion is continued for prolonged, artificial respiration and cardiac massage may occasionally achieve recovery after strongly long periods probably the longest, definitely authenticated cases is one of 30 minutes, submersion with complete recovery is occurred in almost icy water, where the hypothermic effects undoubtedly added the successful resuscitation.

**The Autopsy Signs of Drowning**

**I. External signs of drowning:**

**Cooling of the body:** Cooling of the body in water ordinarily occurs at about twice the rate of cooling in air.

**Post-mortem Hypostasis:** The post-mortem lividity is light pink in colour, simulates the tint of co poisoning due to oxygenation, but in some cases, it is dusky cyanotic, or it may be mixture of the two post-mortem staining. Usually found on the face, the upper parts of the chest, hands, lower arms, feet and the calves, as the body usually floods face downwards, buttock up, with legs and arms hanging down Infront of the body. The face may or may not be cyanotic, conjunctiva

are sometimes congested and few petechial hemorrhages are seen beneath the conjunctiva, especially lower eyelids.

**Maceration of the skin**: Maceration of the skin begins due to Imbibition of water into its outer layers within minutes in warm water, such as death in a bath-tub. But in cold water, it is visible after a variable time, the minimum probably being four or five hours, depending upon temperature. Polson's experience suggests a much longer time, from 12-48 hours, but sodden skin on the hands can undoubtedly occur much earlier than this.

**Froth in the air passages:** One of the most characteristic external signs of drowning is presence of frothy fluid in the air passages, which in fresh body, often exudes through the mouth and nostrils, some times in the form of a plume. The froth is a oedema fluid from the lungs and consists of a proteinaceous exudates and surfactant, mixed with the water of drowning medium. Inhalation of water, irritates the mucous membrane of air passages and stimulates the secretion of mucous. Respiratory movement of the air in passages whips up this substance into a foam in 3$^{rd}$ stage of drowning. It is usually white, but may be pink or red tinged, because of slight admixture with blood from intra pulmonary bleeding. Froth consists of fine bubbles, do not readily collapse when touched with the point of a knife. Froth also seen in death due to strangulation, acute pulmonary oedema, electrical shock, during an epileptic fit, in opium poisoning, and putrefaction, but in all these cases, it is not of such lasting nature and of such a large quantity, as in drowning, and the bubbles are also much larger.

**Cutis anserina:** (Goose flesh) Is a common finding in immersed bodies, but is related to cold rather than warm water. The erector pilae muscles attached to each hair follicle can contract in any type of death and cause a generalized pimping of the skin.

**Cadaveric spasm**: Weeds, gravel, glass, sticks, twigs, leaves etc., may be firmly grasped in the hands by cadaveric spasm, indicates that the person was alive when drowned, because, it indicates the struggle of the person for his life.

**Injuries over the body:** External examination of the body will include, of course, a search for injuries sustained before entering the water, in the water. Trauma in water is common, both as an antemortem and post mortem phenomenon. Water complicates the problem by washing away surface bleeding from open injuries. Even histological examination is often unhelpful in this respect, though stains for hemoglobin such as benzidine peroxide may give supportive evidence.

**II. Internal Signs of Drowning**

In the absence of putrefactive changes, the internal signs of drowning are clearer. Attention is directed primarily to the respiratory system. The froth extends into the trachea, main bronchi, smaller air passages, the lungs themselves in such cases will inevitably be water logged, and frothy fluid will exude from the bronchi when the lung is squeezed, and from cut surfaces, when they are sectioned with knife. The absence of water logging by no means excludes true drowning. The so called, dry lung drowning is not uncommon, in which the lungs appear normal in all respects, presumably, because all the aspirated water has been absorbed through the alveolar walls in to the plasma.

**1) Over inflation of the lungs**: Apart from generalized, water logging the lungs may be markedly over inflated filling the thoracic cavity when the sternum is removed. The normally bare area over the heat may be covered and the lungs may bulge upwards, meeting in the midline to obliterate the anterior mediastinum. The texture is rather pale and crepitant, superficially resembling those of Asthma-for the same reasons. The other name for this condition is "EMPHYSEMA AQUOSUM". This may be one of the most valuable positive signs of drowning to be gained at autopsy.

**2) Other organs in drowning**: There are no other reliable autopsy changes in drowning. The heart and great veins have often been said to be "Dilated and engorged with fluid blood, especially the right side", but this is such a subjective and nonspecific finding. Even though hemodilution in fresh water drowning, as a gross sign at autopsy, however it is totally subjective and unreliable. The stomach may contain watery fluid or even foreign material from the water, but this cannot be accepted as a positive aid to the diagnosis. Many undoubted drownings show no water in the stomach, at yet, other cases in which a dead body was immersed reveal copious water in the stomach. The limiting factor is the tone of the oesophagus and cardiac sphincter, not the drowning process. Hemorrhage in to the middle ears has been postulated as a positive sign of drowning, but it can occur in any type of death, where drowning can be definitely excluded.

**Chemical Changes in the Blood in Drowning**

Because of the marked hemodilution that occurs in the fresh-water drowning and the electrolyte shifts in Salt-water drowning, it is the reason able to expect that the chemical analysis of the plasma should provide reliable evidence of drowning.

Unfortunately, this theoretical hope, have not been realized in practice, mainly because of the biochemical echoes, that occurs soon after death from any cause, in which, the ability of live cell membrane to partition fluid and electrolytes is rapidly lost.

**Histological Changes in Drowning**

Much has been written about, both light and electron microscopy of the lungs in immersion death, especially in continental Europe. The accounts are confusing, however, and sometimes contradictory the consensus of opinion being that such changes are inconstant and unreliable. The skin changes in maceration are also well-recorded and some have been claimed to have use in dating the period of immersion.

**Atypical Drowning Deaths from Immersion Other Than Drowning**

Irrespective of natural disease or injury, some persons who die after falling into water do not drown in the accepted physiological sense. The great problem for the pathologist is that even in true drowning, there may be no autopsy signs, especially any appreciable delay has occurred before recovery or autopsy or both. Therefore, it may be difficult or impossible for him, to say, whether a death is a true drowning or one from the non-drowning mechanisms.

All that can then be offered is that death was due to ÏMMERSION" and even such a diagnosis is usually one reached by exclusion of natural disease, trauma, or toxic condition, using here say circumstantial evidence to arrive at a pathological diagnosis. This is why drowning and

immersion deaths present one of the most difficult problems for the Forensic Practitioner. In certain circumstances, death may be extremely rapid after falling into water, there being insufficient time for drowning to occur, the typical occasions familiar to any Forensic pathologist. Other witnesses' accidents of a similar nature are relatively common, in which rapid, almost instantaneous death must be presumed in circumstances where true drowning can be excluded by history and lack of autopsy findings.

**Estimation of Duration of Immersion**

This is another difficult problem, one that is too dogmatically answered by doctors with insufficient experience. To appreciate the potential errors, the overriding variable factor is water temperature, which has the most effect upon decomposition. Water pollution has little to do with the spread of putrefaction, as most of the decomposing organisms come from the gut of the body itself. When a body falls into the water in average temperate climate the following is an appropriate guide to timing in conjunction with the other usual signs such as rigor.

- ✓ If no wrinkling of the finger pads is present-less than few hours.
- ✓ Wrinkled fingers, palms and feet progressively-from ½ a day to 3 days.
- ✓ Early decomposition often first in the dependent head and neck, abdomen and thighs-4 to 10 days.
- ✓ Bloating of face and abdomen with marbling of the veins and peeling of the epidermis on hands and feet and slippage of the scalp-2 to 4 weeks.
- ✓ Gross skin shedding, muscle loss, the skeletal exposure, partial liquefaction-1 to 2 months.

**Treatment of Near Drowning**

Probably the most effective method is "Mouth to mouth" respiration commenced as soon as possible and when practicable before the victim is recovered from the water, postural drainage and any other appropriate treatment takes second place to efficient artificial respiration. Examination of the patient can also await his recovery from submersion. Since a doctor rarely reaches the scene, members of the public should be instructed in the application of safe and simple method of artificial respirations, obviously the best treatment is prevention i.e., by taking precautions to avoid accidents in Hospital sectors, external defibrillation, adjustment of electrolyte balance, acidosis and hemoconcentration. Tracheal intubation, mechanical ventilation, administration of "Broad Spectrum" antibiotics and exchange blood transfusion are advised in appropriate circumstances.

**Prognosis of Drowning**

Although the biochemical changes differ according to the nature of the medium, the practical consideration is that, whether it be fresh or salt water, the duration of submersion or more exactly, the volume of fluid inhaled determines the prognosis. In any event the period is only a matter of few minutes. The prospect of successful resuscitation is slight, when complete submersion has lasted for 6 minutes and death is almost invariable when the period exceeds 10 minutes. When, as is then likely large amount of water have been inhaled, the continued feeble beating of the heart for several minutes after rescue does not alter the gravity of the prognosis. When resuscitation has been successful, the outlook is good, although a guarded prognosis is necessary for a few days, since there are certain possible complications. Some may develop

pneumonia especially after submersion in infected water. A temporary renal failure caused by excessive red cells destruction, may be indicated by hematuria. Myocardial anoxia may cause delayed heart failure, which may not occur until a few hours after rescue.

**Mechanism of Entry of Diatoms into the Bone-Marrow**

When a person falls into the water, he goes down immediately under water-surface, provided there is sufficient water available. The depth to which the person descends, depends upon the momentum of the body before striking the water. This person goes on descending until the gravitational force is neutralized by the upward checking force of water mass, the buoyancy and the struggling movement of the person.

Then the involuntary movements of the person and the force of buoyancy, brings the person to the surface only up to the nostrils, because the specific gravity of human body as a whole is greater than that of water. When the head comes up, an automatic violent effort for inspiration takes place. A large quantity of water enters into the lungs with the air as the mouth and nostrils are not clear of water surface. Next, because of water entering into the larynx a violent expiratory effort takes place with choking to throughout the water with coughing. This leads to rupture of alveoli because of increased intra pulmonary pressure, resulting in disturbances in filtering mechanism of lungs. So, the water along with diatoms and its particulate suspension mixes up with pulmonary circulation from where they are carried over through, systemic circulation to the bone marrow, thus the diatoms enter into the bone marrow, during the process of drowning. The violent expiratory phase is followed by an automatic inspiration.

During the phase of inspiration, the mouth and nostrils are almost under the water surface and thus, more water enters into the lungs. This leads to further displacement of air in lungs. The quantity of water in lungs increases so that the weight of the lungs also increases. The vicious cycle of water entering into the lungs during inspiration and expulsion of air from lungs during inspiration and expulsion of air from lungs due to choking continues until the person sinks. Death results due to Hypoxia.

**Limits of Diatom Test**

1) Water frequently contains no diatoms. In others diatoms may be both very scanty (especially in quickly running streams) and they are seasonal abundance, being very sparse or absent in cold water and they may be seasonally abundant. Sea water is more constant, in its diatom content and even their numbers may be very small.
2) Diatoms less than 30 microns in diameter can only enter into circulation. That is why, smaller diatoms are found in distant viscera and larger diatoms in lungs.
3) There is a small but appreciable diatom contamination of the atmosphere and everything in contact with it. Diatoms have been obtained from many sources around a dry body, though admittedly in small numbers. Tap water frequently contain diatoms.
4) Contamination at autopsy is extremely difficult to avoid.
5) Though entry in to the body is thought to be mainly through the lungs, there seems no reason why they cannot penetrate the intestinal lining and again asses to the blood stream and hence any body tissue.

6) Certain foods, notably shell fish, contain vast quantities of diatoms that may enter the circulation and reach the tissue.

**Methodology of Study**

For the present study the material was collected from the post-mortem examination during the calendar year 2014-15 conducted in the mortuary of Gandhi Hospital, Secunderabad by the Department of Forensic Medicine, Gandhi Medical college, from the inquest reports and from the FSL reports. First, we made charts for collecting all the information regarding the drowned body, entering the details regarding age, sex marital status, religion, medium of immersion, history from inquest etc., Then we have prepared individual informative charts such as, age, sex, marital status, religion, known-unknown, suicide, accident and month wise distribution etc. We have analyzed the frequency distribution of each feature. Out of them we prepared the possible number of bar graphs and % percentage distribution circles and frequency polygons, to show the statistical trends in drowning. We also presented some a typical case of drowning for which most of the histories were collected by visiting the scene of crime and photographs taken at scene of crime and few photographs taken at autopsy are presented in this work.

**1) For Diatoms of Water**: Not less than 3 liters of water, is collected from the site of drowning, with the lid of the container inverted and immersed underneath the surface of the water where in, the surface water is avoided (for dust and other artefacts) and middle layer water is collected into the container. This water container is put un-disturbed by adding potassium iodide over a platform for as long as possible, then the supernatural water is decanted without disturbing the bottom. About 40 ml of bottom layers are retained for centrifuge in 4 test tubes. This material on centrifugation forms a button like sediment at the bottom of the centrifuge tube. If there is large quantity of organic matter this material again may be treated with Nitric acid as treated as for the bone marrow. If the sediment is clear of vegetable artefacts, this can be examined directly under the microscope by putting on a slide or after mounting.

Few of the water samples surrounding twin cities were collected personally and from distant places were collected by Police. The diatoms of water are compared with that of the tissue diatoms when present. For the whole procedure contamination is a major problem. For that every equipment before using was thoroughly washed with double distilled water and samples were never left open in air, because silica particles of the dust and diatoms of atmosphere may fall into the containers and liable to interfere with the results.

**2) For Diatoms of Bone Marrow**: If the water is negative for diatom test, it is needless to conduct the test in bone marrow. For diatom test, sternum of doubtful cases is collected from the mortuary attaching a P.M.E.No. & P.S., labelled and brought to the department. Where sternum is washed in the double distilled water and fixed in a bowl with its posterior view facing the operation. The posterior ligament over the body of the sternum and periosteum is chiseled out and the maximum quantity of cancellous bone marrow underneath it, is scooped by means of a curette and chisel and put into a kjeldahl flask. In some cases, especially female bodies, the sternum is small. In such cases the manubrium is also chiseled out in the same way to collect some more quantity of the marrow. Concentrated fumic nitric acid is poured over the bone marrow to cover the tissue sufficiently i.e., not less than five times the quantity of the marrow

and kept overnight. Or if the case is urgent, this flask is heated in water bath, till the tissue is converted into a transparent straw-colored liquid. This liquid is subjected to centrifugation with 5000 revolutions per minute for a period of 15 minutes or 3000 revolution per minute for a period of ½ hour. The sediment is washed with distilled water and again centrifuged, the present sediment is put on the slide and examined directly for diatoms or the slide is mounted & then examined for diatoms & compared with that of water diatoms.

The total number of autopsies conducted during 2014 were 5576, out of which 161 cases were of submersion. Total number of autopsies conducted in 2015 (up to September) were 4349, out of which 132 cases were of submersion. Taken all 161 cases of submersion during the year 2014 for month wise distribution.

**Table 1: Distribution of victim based on month and sex. (2014)**

| Month | Male | Female | Total |
|---|---|---|---|
| January | 6 | 5 | 11 |
| February | 9 | 1 | 10 |
| March | 10 | 3 | 13 |
| April | 4 | 4 | 8 |
| May | 15 | 4 | 19 |
| June | 15 | 2 | 17 |
| July | 12 | 3 | 15 |
| August | 8 | 3 | 11 |
| September | 15 | 6 | 21 |
| October | 10 | 4 | 14 |
| November | 11 | 3 | 14 |
| December | 7 | 2 | 9 |
| Total | 121 | 40 | 161 |

**Figure 1: Distribution of victim based on month and sex.**

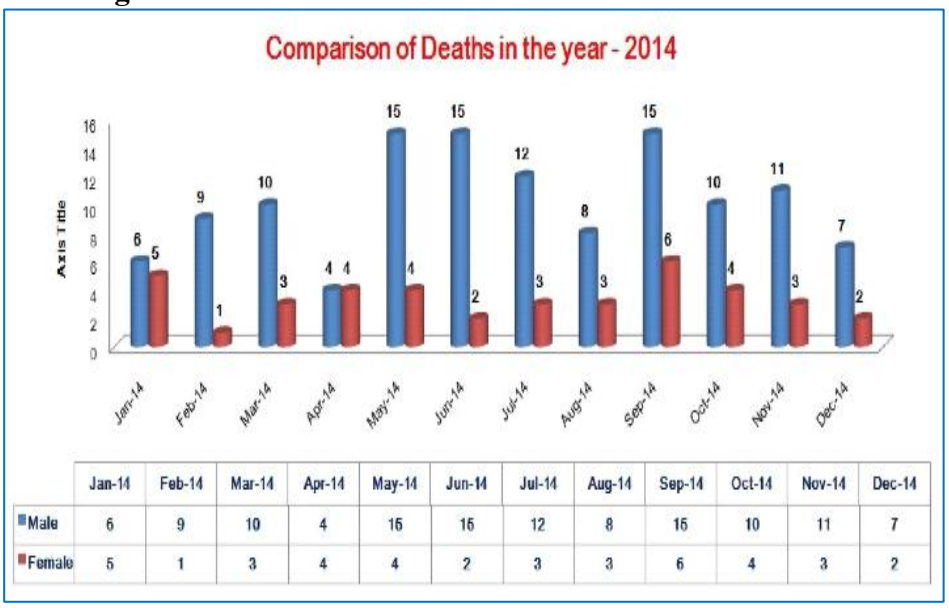


**Table 2: Distribution of victim based on sex, age and marital status.**

| Years | Age | Male | | | Female | | |
|---|---|---|---|---|---|---|---|
| | | Married | Un-Married | Un-Known | Married | Un-Married | Un-Known |
| 0-10 | 12 | | 7 | | | 5 | |
| 11-20 | 12 | | 10 | | | 2 | |
| 21-30 | 25 | 6 | 10 | 2 | 5 | | 2 |
| 31-40 | 32 | 5 | 3 | 25 | 5 | | 2 |
| 41-50 | 8 | 5 | | 6 | 2 | | |
| 51-60 | 8 | 2 | | 3 | 4 | | 1 |
| >60 | 3 | 2 | | | | | 1 |

| **MALES** | | **FEMALES** | |
|---|---|---|---|
| Married | -20 | Married | -16 |
| Un-Married | -13 | Un-Married | -7 (Girls) |
| Un-Known | -21 | Un-Known | -6 |
| Boys | -17 | | |
| TOTAL | -71 | Total | -29 |

**Figure 2: Distribution of victim based on age**

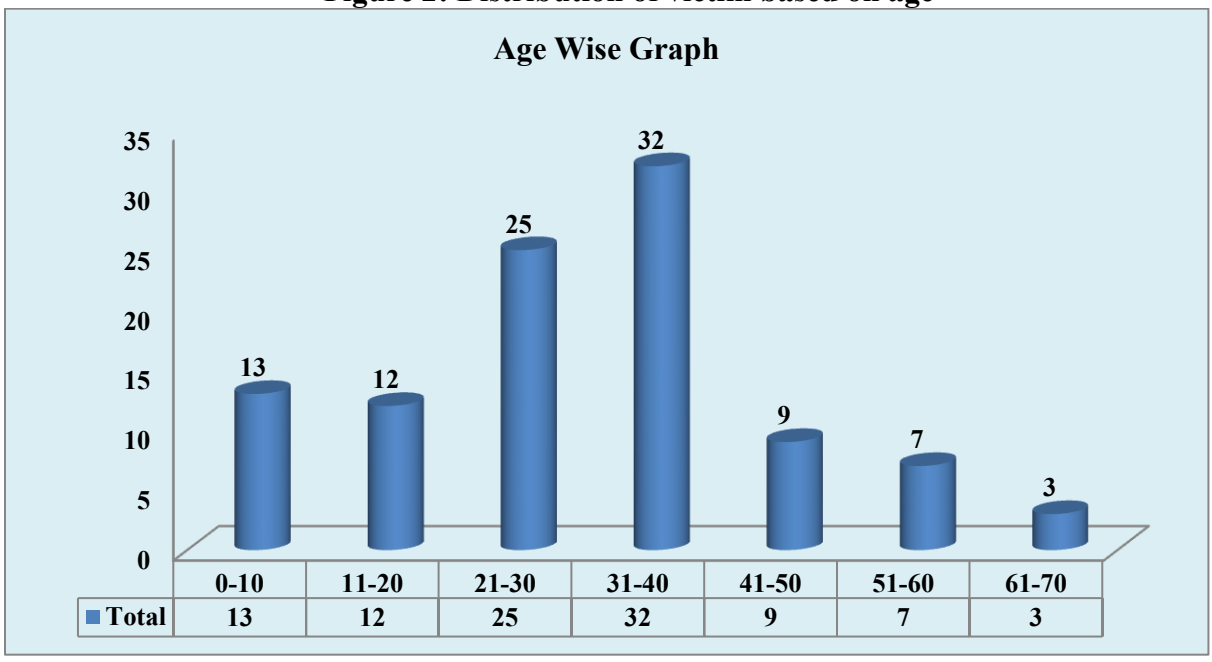


**Figure 3: Distribution of victim based on age, sex.**

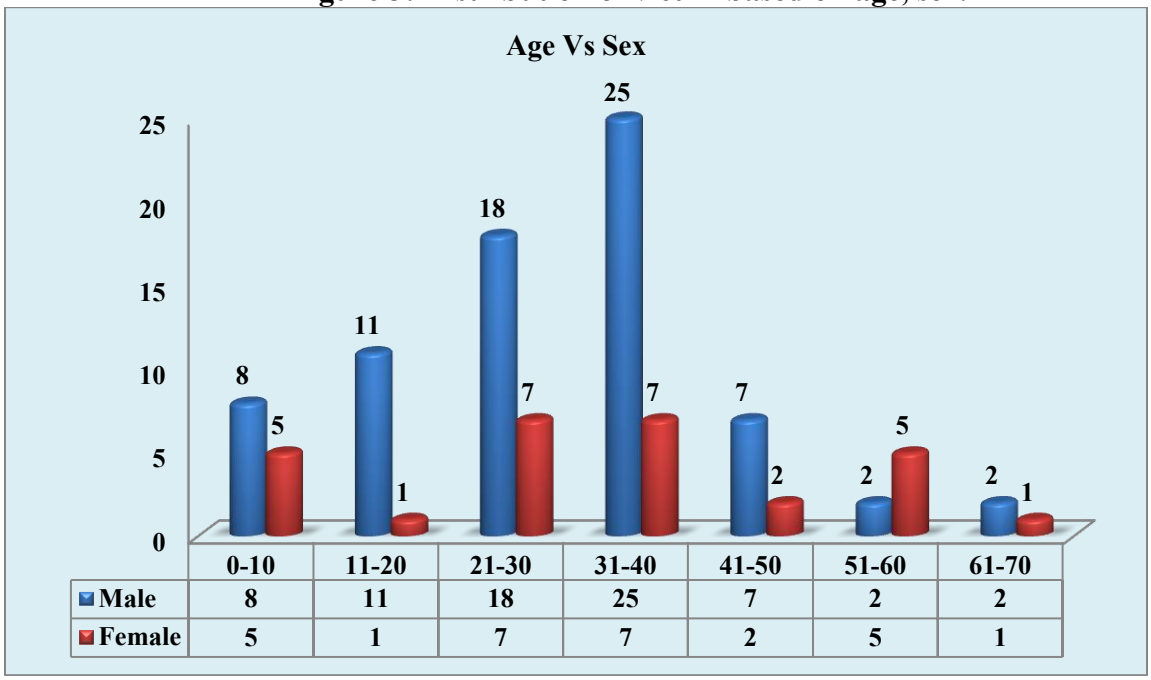



**Table 3: Distribution of victim based on age and manner of death.**

| Years | Age | Suicide | Homicide | Accidental | Un-Known |
|---|---|---|---|---|---|
| 0-10 | 12 | 1 | 1 | 10 | |
| 11-20 | 12 | | | 12 | |
| 21-30 | 25 | 10 | | 13 | 2 |
| 31-40 | 32 | 13 | | 10 | 9 |
| 41-50 | 8 | 3 | | 5 | |
| 51-60 | 8 | 5 | | 2 | 1 |
| >60 | 3 | 2 | | 1 | |
| Total | | 34 | 1 | 53 | 12 |

**Table 4: Distribution of victim based on sex and manner of death.**

| Manner | Male | | Female | | Total |
|---|---|---|---|---|---|
| | **0-21yrs** | **>21yrs** | **0-20yrs** | **>21yrs** | |
| Suicide | 1 | 20 | | 4 | 35 |
| Accidental | 17 | 25 | 5 | 5 | 52 |
| Homicidal | | | 1 | | 1 |
| Un-Detected | | 8 | | 4 | 12 |
| Total | 71 | | 29 | | 100 |

**Figure 3: Distribution of victim based on manner of death.**

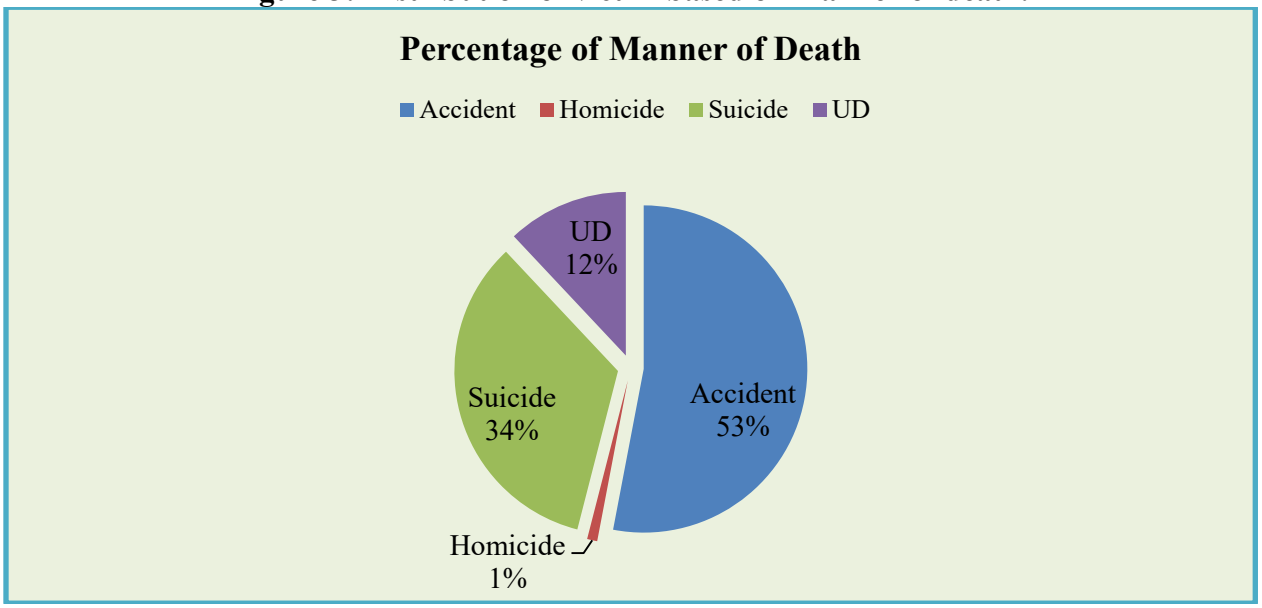



**Figure 4: Distribution of victim based on different immersion mediums.**

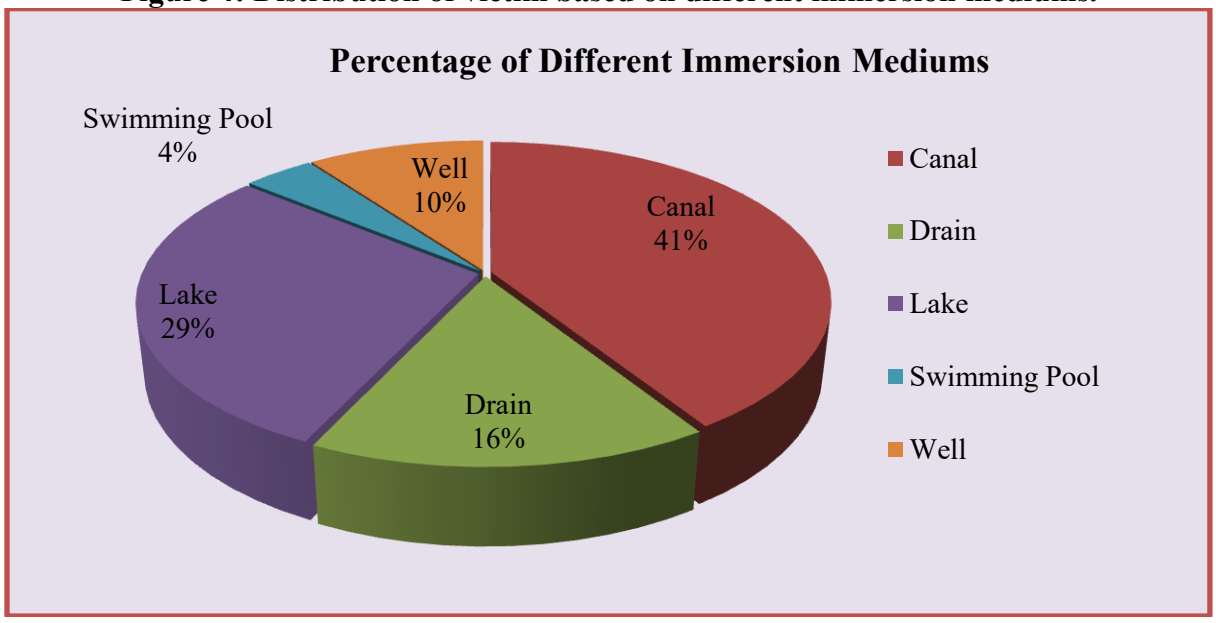


**Figure 5: Distribution of known and un-known victims.**

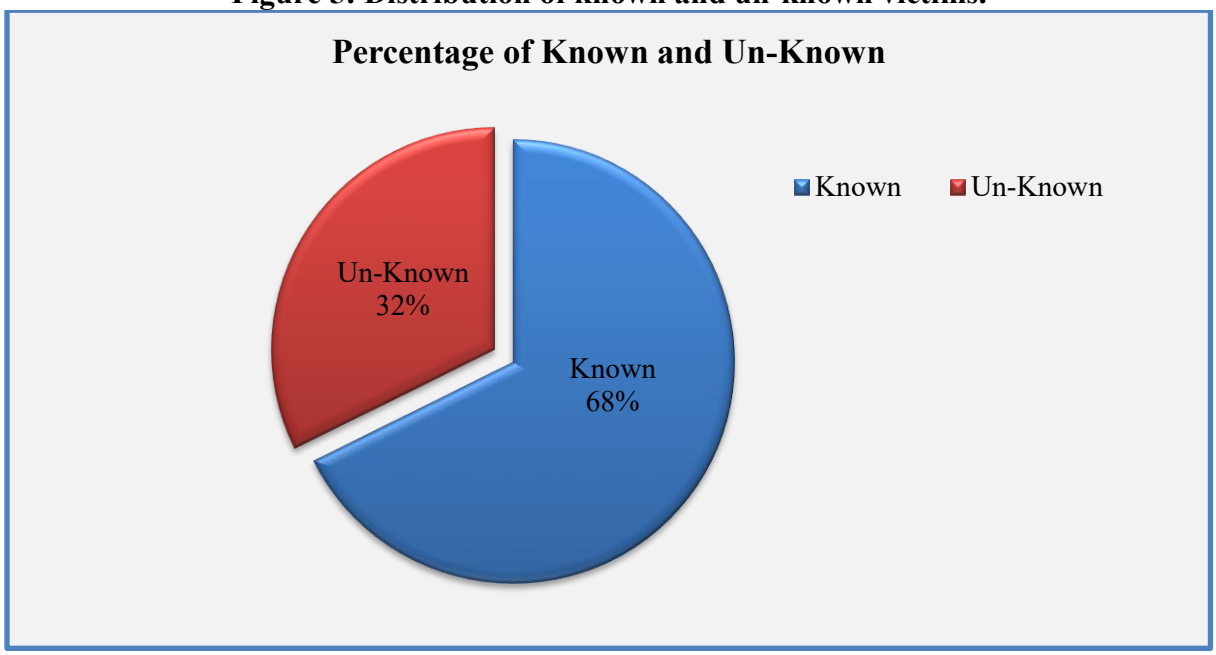



**Figure 6: Distribution of fresh and decomposed victim bodies**

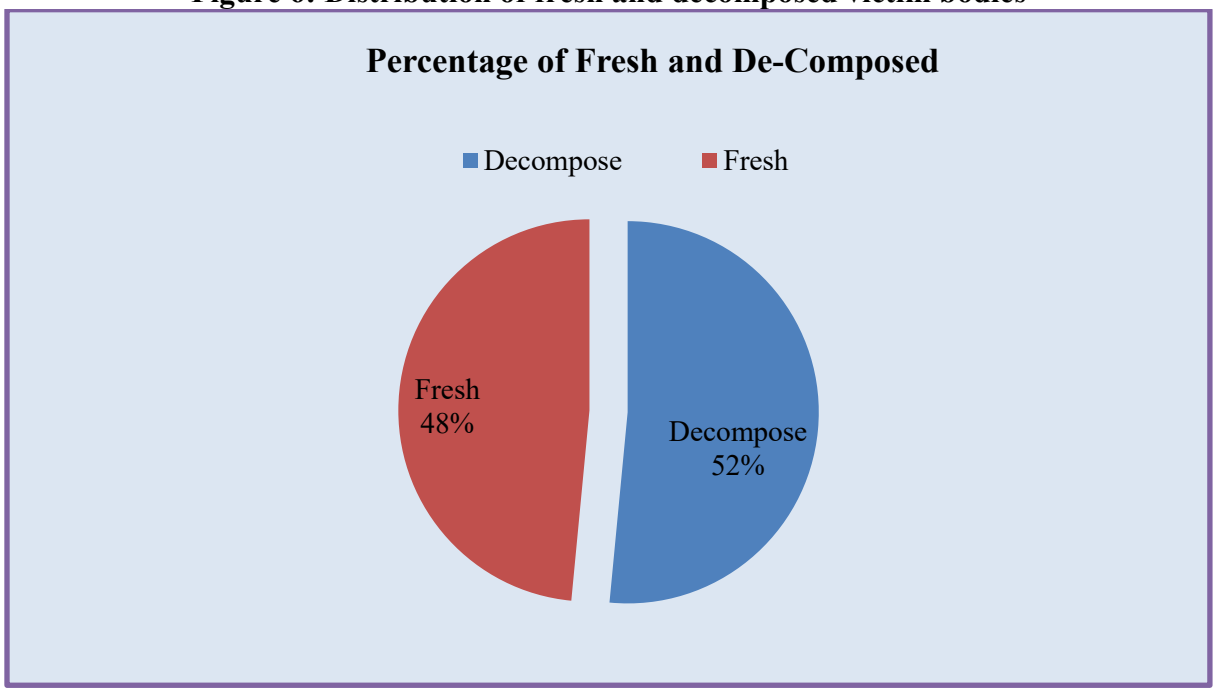


**Figure 7: Distribution of victims based on religion.**

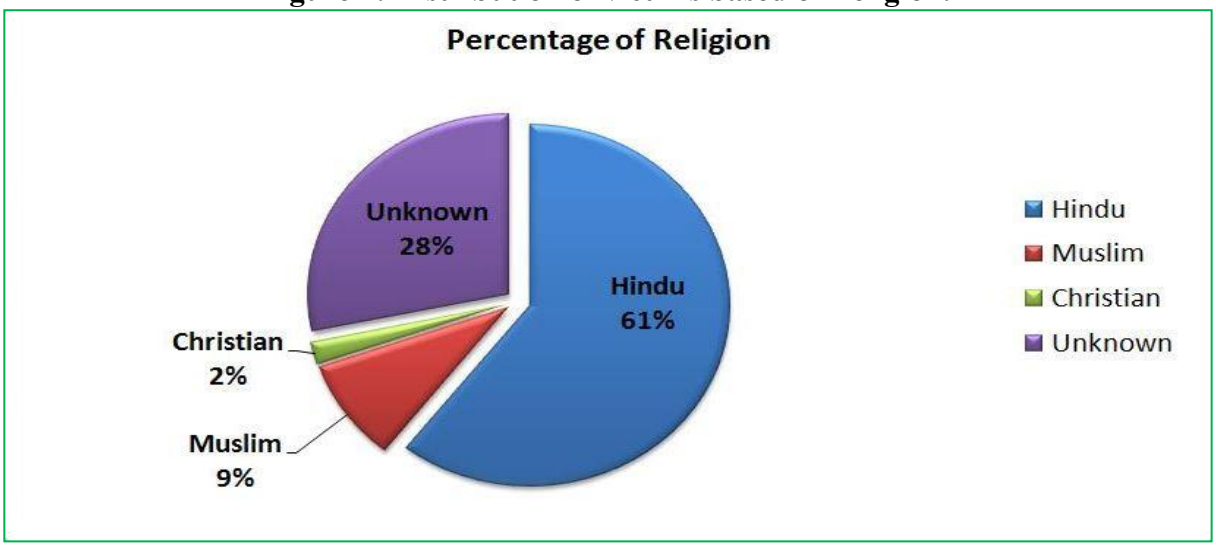



**Figure 8: Distribution of victims based on marital status**

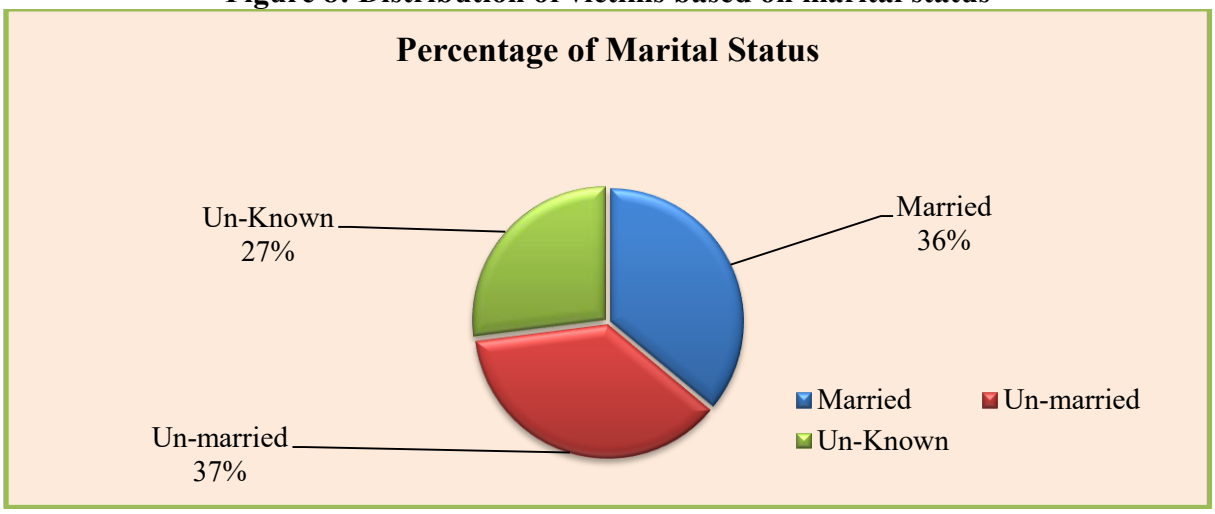
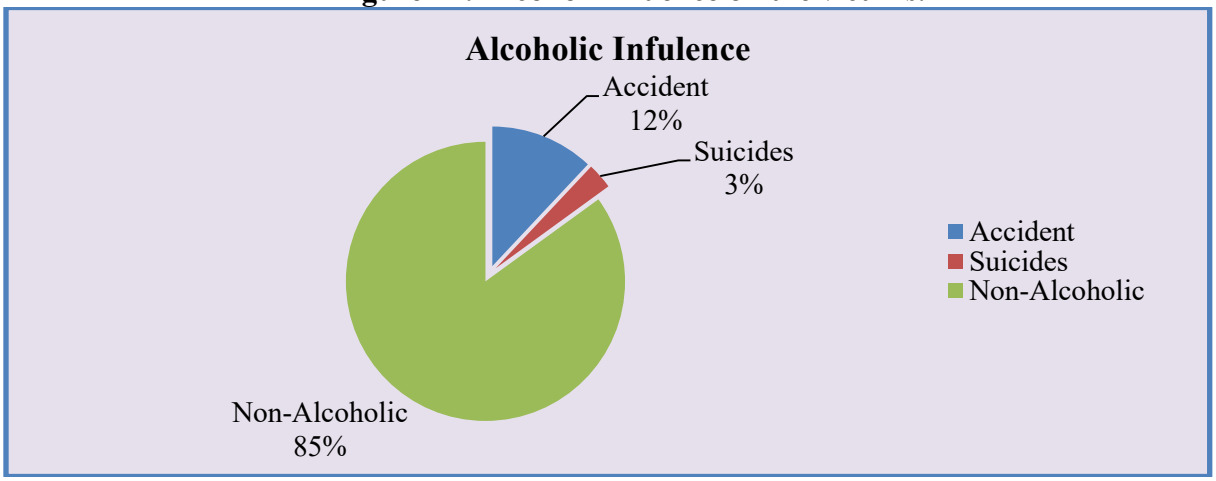



**Figure 11: Alcohol influence on the victims.**



**Conclusion**

Drowning is one of the commonest modes of death. About 9925 autopsies conducted in the mortuary of Gandhi Hospital 293 cases are due to drowning. (From January 2014 to September 2015). In deaths due to mechanical asphyxia drowning occupies the second place in completion with hanging. In our study, we observed that Males predominated the females in the ratio 3;1. The vulnerable age group is 31-40years among males, and 21-40years among females.

The causes for male predominance may be because of their number, un-employment, jealousy, revenge, lack of patience, intake of alcohol and bad accomplices, effect of vibrant attitude, non-obedience and the attitude of taking law in hands, etc. The lower incidence in females is mainly attributed to custom, social values and preference of females to stay indoors. Early marriage, dowry, arguments and revenge appear to be the common causes of deaths in females of this locality. Among the female victims the percentage of married are more. Marital status has no such influence among male victims.

Among males, most of the deaths were due to accidental while in females the cause was mostly suicide. It is observed that maximum number of victims (53 %) died by accidental immersion into the water, followed by suicidal drowning constituting 34 %, only one case is by homicidal drowning. 15 % of the victims was under the influence of alcohol and had consumed alcohol at the time of submersion. This observation was made based on the history, smell of alcohol at autopsy and FSL report. In cases where the victims were decomposed, the status of alcohol was recorded was not known. 10 % of cases are the cases were the presence of alcohol in the victim is documented by the FSL Report. In 5 % of the cases viscera was preserved, but no substance was found.

From the above it is observed that alcohol played a significant role in the drowning cases. The person is an inebriated state, loses control of one self and either accidentally fallen into the water or commits suicide by getting drowned into the water.

Almost all the cases were accidental in first decade, except one case of suicidal case noted, where the mother has thrown her 6 years boy before committing suicide by drowning and one unknown neonate thrown by unknown person.

As the age advances the number of suicide cases go up and suicides and accidents are almost equal in 3rd decade. This trend is because of increasing responsibilities and adjustment problems in society.

Among the total numbers of deaths due to drowning males are almost triple / double that of females, especially in $3^{rd}$, $4^{th}$ and $5^{th}$ decades. This may be because of extensive outdoor activity of men.

After $5^{th}$ decade, the difference between male and female in frequency occurrence is minimal and deaths in old age are mostly suicidal, may be because of their chronic ailments and financial difficulties, due to negligence of the society. The incidence of drowning was more in summer when compared to other seasons. When identity is taken into consideration, in the $1^{st}$ decade

nearly all the cases were of known type, even in 2nd decade also most of the drowning cases are of known type. But in the 3rd and 4th decade nearly half the cases were of unknown type because most of the deaths in this age group are due to suicide. The victims chose a distant place from their residence from where they are brought to the mortuary as unknown bodies.

**Actions that can help Prevent Drowning:**

High-income countries have reduced their drowning burden and some of the strategies, used have been successfully adapted in low- and middle-income settings.

**Community-Based Action**

1) Install barriers controlling access to water.
2) Provide safe places (for example, a crèche2) away from water for pre-school children, with capable child care.
3) Teach school-age children basic swimming, water safety and safe rescue skills.
4) Train bystanders in safe rescue and resuscitation.
5) Strengthen public awareness of drowning and highlight the vulnerability of children

**Effective Policies and Legislation**

6) Set and enforce safe boating, shipping and ferry regulations.
7) Build resilience and manage flood risks and other hazards locally and nationally.
8) Coordinate drowning prevention efforts with those of other sectors and agendas

**Develop a national water safety Plan**

In summary, donors and governments must prioritize drowning prevention, and its integration with other public health agendas.

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**References**

1. Bray–M. Chemical estimation of fresh water immersion. Intervals Am. J. Forensic Medical Pathol. 1985;61:133-9.
2. Bhaskar GR. Diatoms in cases of drowning. Journal of the Indian Academy of Forensic Science;1965;4:2-6.
3. Bernard knight Forensic Pathology;1991: 360-71 Immersion deaths-K.S. Narayan Reddy. The essentials of Forensic Medicine 1993-247-77 Mechanical Asphyxia.
4. Copeland A.R. An Assessment of lung weights in drowning Am. J. Forensic Med. Pathol 1985:6:301-4.
5. Copeland A.R. Homicidal Drowning. Forensic Sci. Int. 1986 13:247-52.
6. Cyril John Polson. The essentials of forensic medicine. 4th edition 1995. 421–448.
7. C.A.Franklen. Medical Jurispredence and Toxicology 1988 (Drowning Immersion) 209-220.

8. Davis J. Bodies found in the water; an investigative approach. Am J. Forensic Med. Pathol 1986. 7:291-7.
9. Ecology of algae J.No.6 Janardhan Rao O.U. Dissertation.
10. Ecology of algae in the rive manjara (A.P., Spl, reference to lithophytic flora J.No.41, O.U. Dissertation.
11. Ecological investigations of phytoplantation of two small lakes studies in Hyderabad Development area–Mary Esther Cynthia J.No. 91. O.U. Dissertaiton.
12. Ecological studies in plankton of certain fresh water ponds of Hyderabad G. Seenayya J.No. 137. O.U. Dissertation.
13. Ciliated protozoa and thanatology.Forensic Sci Int. June July 85, 28(2): 83-101.
14. Foged N. Diatoms and drowning–Once more forensic Science Int. 1980;16: 63-6.
15. Gordon I. The anatomical signs of drowning a critical review J Forensic Sci. 1972;1:389-95
16. I. Gordos & H.A. Shapiro, S.D. Berson. A guide to principles of Forensic Medicine. Third edition 1988 P.115-125.
17. Hendy NI. The diagnostic value of diatoms in drowning. Med. Science Law 1973;13: 23-34.