Introduction

Hair is among most common types of evidence reported in criminal investigations. roughout the stages of usual hair-growth parameters, hairs goes through a continuous loss from every individual, and due to this loss these hairs may be transferred from one individual to another in any criminal commotion [1]. Hair have gained a wide interest in its examination for various elds counting taxonomy, zoology, wildlife, clinical biology, dermatology and forensic investigation [2] due to its non-invasive and quick analysis along with précised and accurate results. Hair examination was in routine practice since last decades for species identi cation and dermatological uses but from last decade hair examination for clinical detection of various diseases [3] and for race, sex, age, and occupational identi cation has gained center of interest for forensic scientists/examiners [4]. Hair can be used in identi cation of environment exposure, food habits, soil and geographical parameters, in detection of criminal o ences related to wildlife poaching of protected animals [5] and also in detection of metal poisoning [6]. In recent years mitochondrial and genomic DNA from hair has opened wide vistas for forensic investigations [7] which lead to the investigation of not only cases related to disputed paternity [8] and species identi cation but due to mt-DNAs hair examination has received interest of scientists in the eld of evolutionary studies due to its matrilineal nature [9]. Has provides very useful information in cases of rape, sexual assaults, murder, illegal wildlife trade and so on [10]. e forensic evaluation of hair can be very important in the physical evidence examination and assessment by representing the association between the suspect anked due to a crime scene or a victim and a suspect or representing that no evidence exists for an involvement connecting a criminal with a crime scene or a culprit with a victim [11]. Even though the science of microscopic hair investigation can never result in identi cation [12], the nal aim of any forensic examination is to give statements on the bases of examination and scienti c observations that will provide information about criminal and crime scene connection with crime in court of law or to any other agency incorporated in the investigation [13,14]. e motto of this document is to analyze the bases of microscopic hair analysis and comparison including the analysis and comparison of the morphological uniqueness present in hair. Based on this morphological uniqueness suspected hair is examined for its origin identi cation weather from human origin or belongs from any other species [15,16]. Within each of these two groups, further information

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acids are bound in amide formations and hair contains for about 19% if dicarboxylic amino glutamic and aspartic acids. Serine hydroxyl group and some nitrogen group's dipole bonding are also possible and some anionically charged non-metals were separated in hair to nd more metals at lower pH [54].

When mare carboxyl anions on hair would be neutralized by protonation. e incorporation of metals to hair occurs in hair bulb due to secretary mechanism inside skin or at surface of skin. e cuticle layer of hair contains sul ydral groups longer than inside cortex.

Metal incorporation may also occur directly at keratogenous zone above the hair bulb which results in the presence of cystine in sweat which includes the secretion of sweat and sebaceous glands. Sweat has noncrediated as a hair metal content factor where as a signi cant loss of some trace metals have been reported. Sebaceous glands are attached to hair canals just inside the skin layer where the sebum is secreted by gland which is incorporated by keratinized hair sha . Reports revealed more accumulation of elements in growing hair than in stagnant hair growths [55-57].

Uses of Hair Analysis

Hair of all the organisms varies in a numerous ways including morphological appearance, physiology, genetic makeup, elemental composition and trace elements. Animals from same family have similar characters then with others. Taxonomists and forensic examiners search for identi cation of these di erences for using the results in di erentiation and to classify the organisms for solving crime and taxonomic issues. Not only for forensic examiners hair have played a vital role for wildlife biologist, archaeologists, anthropologist and textile conservators. Many researchers have revealed the morphological hair characteristics using various microscopic techniques based on their medullary index and scale pattern using Scanning Electron Microscopy (SEM) as well as light microscopy. Scientists and forensic examiners have incorporated SEM and TEM studies in identi cation of hair samples from di erent species in cases related to wildlife crime, textile industry frauds, taxonomic classi cation and also in cases involving hair as a physical evidence either in identi cation of origin, or sex in rape assaults or in cases where domestic animals were involved. Hair can be used in identi cation of various crimes in ways to identify geographical location, elemental composition, species, sex, occupation, food habits and also the environmental conditions.

Microscopic examination

ere are di erent characteristics associated with hair identi cation using three di erent anatomical regions present in hair: inner Medulla, outer cuticle and intermediate cortex. Cuticle is di erentiated on the bases of scale pattern and also on the bases of scale layer di erence using SEM and other parameters like width of the cuticle, the changes in the thickness throughout the hair, presence of the pigments. Nature of the cuticle margin may vary from smooth, looped, ragged to damage. e cortex can provide information regarding the density, organization, size, and distribution of the pigments and it varies tremendously between racial groups. e medulla also provide information regarding its pattern varying from continuous, discontinuous, fragmented to absent in hair. e presence of root cells provides the information regarding the force used to pullout the hair and the root point of the hair also provides information regarding instrument/ weapon used to cut the hairs [58,59].

investigator in identi cation for the cases related to acute and chronic metal toxicity. It is worldwide recognized that hair tissue serves as an accumulator for trace elements analysis and also play a vital role in criminal investigation by both types as clinical evidence in metal poisoning cases as well as in cases of occupational exposures. NAA provides a wide range of elements and is among quickest methods for hair elemental pro ling [7,64,65].

Use of Hair in e Diagnosis of Heavy Metal Poisoning

Heavy metals are most frequently concerned in human poisoning includes lead mercury cadmium and arsenic and were in use since long time. Distant from their clinical symptoms, the e ect on tissue and cellular level due to heavy metal poisoning, for example proteinuria due to mercury and basophilic stippling of erythrocytes in lead are useful in providing information as adjunctive evidence but because of uneven circulation of metals inside the body, the levels of these will varies in the blood and urine that is not su cient to imitate the speci c levels within the organ system. Notwithstanding this restriction, hair analysis is invasive and provides a large freedom in both humans as well as in animals and makes it an attractive alternative to both humans and animals for analysis of toxic metals [62-64,66].

Use of Hair as Bio Indicator

Hair is useful bio-indicator to estimate exposure of the environmental trace elements because of its easy collection and trace element re ection from long exposure durations. Although trace elements are not only incorporated inside it due to endogenous uptake but also from exogenous materials such as soil, dust, water etc and can be used as a bio indicator to study the exposure of various trace as well as toxic elements. Hair is composed of keratin and main elemental component is sulfur which found to be uniformly distributed all over the hair but the metals present on the outer surface/ surface metals provide a signi cant demarcation regarding the environmental exposure of that element over hair and does not penetrate into the internal hair [13,27,67].

DNA Analysis of Hairs

e tools in molecular biology have enabled investigators to identify biological evidences at the DNA levels, both mitochondrial and

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