REVIEW

KOHL (SURMA): RETROSPECT AND PROSPECT

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ABSTRACT

Kohl, since antiquity has always been given a prime importance in ophthalmology for the protection and treatment of various eye ailments. However, for decades various conflicting reports in the literature have been published relating to Kohl application to eyes being responsible for causing higher blood lead concentration, which may cause lead poisoning. While at the same time, a number of research studies and reports have also been published negating any such links with increased blood lead level upon Kohl (surma) application. In view of the above mentioned facts, this review article is written with the objective to highlight various data from past and present research studies and reports about Kohl, so as to provide valuable information to both the users and the research workers about it's scientific background and effects when applied into eyes. A large number of items and topics (such as Kohl, surma, eye cosmetic, traditional eye preparations, environmental lead pollution, galena, lead sulphide etc.) have been taken into consideration while compiling this review article. In conclusion, the authors of this review article feel that the relation between Kohl and toxicity or increased blood lead concentration upon it's application to eyes as reported elsewhere is likely to be more of theoretical nature rather than a practical health hazard.

Keywords: Kohl, surma, collyrium, galena, traditional eye preparation.

INTRODUCTION

The protection of eyes against diseases has been reported since antiquity. Ancient civilizations were using many types of eye preparations for the protection and cure of eye diseases and Kohl was one of these. Thus, Kohl can be regarded as closely associated with almost all human civilizations. Primarily, the word "Kohl" is Arabic in origin and in actual the Arabic oculist called it as "Kahal" (Sweha, 1982). Literature search revealed that it was accepted by people of many ancient civilizations, such as Egyptian, Greek, Roman, Chinese, Japanese, Phoenician, Indians and Muslims (Glanville, 1947; Engelbach, 1961; Richard and Clara., 1962; Harris, 1962; Levey and Al-Khaledy, 1967; Bosworth *et al*., 1986; Keville and Green, 1995; Cohen, 1999; Sykes *et al*., 2000; Kathy, 2001; Catherine, 2005; Devine, 2006; Baptiste, 2008). In the Eastern system of medicine (Unani/Ayurvedic) and Greko-Arabic system of medicine, Kohl has been defined as ultra fine powder containing one or more ingredients (such as galena, herbs, pearls, gemstones etc.) to be used in the eyes for prophylaxis and treatment of various eye disease (Nadkarni, 1954, Kaushal, 2008). It is usually black or grayish black in colour and with respect to temperament in "Unani System of Medicine", it is classified as cold in the second order and dry in the third (Monograph of Unani Medicine, 2003). However, Kohls without galena are white, to grayish white etc., in colour depending on it's formulation (Kaushal, 2008). Different names, such as collyrium, the name used by ancient Egyptians; kollurion by Romans and Greeks; Kohl or kuhl/kahal by Arabs and also by Egyptians; sagal surmah by Iranians and anjan, sauviranjan, shurma, surmi and surma in Indo-Pakistan subcontinent (Nadkarni, 1954; Zaheer *et al*., 1991). Kohl is also mentioned as cosmetic for the eyes in several texts of "Old Testament" (Kings II, 9:30; Jeremieh 4:30; Ezekiel 23:40) as well (Narada, 2000; David *et al*., 2000). Among Muslims, use of Kohl is described as "Sunnah" in Abu Dawud Tib, 14; and Tirmidhi, Tib, 9 (Yursil, 2007). These findings make it evident that literature, secular and religious, past and present, handles the topic of Kohl from different aspects, such as physical, chemical, archaeological, medical and cosmetic. In the present review, to make the subject (Kohl) more useful, the discussion has been divided into three different parts, historical background, therapeutic value and criticism.

Historical background

Kohl has been utilized traditionally as far back as the bronzeage: c.3500-1100 (Catherine, 2005). It was originally used as protection against eye ailments. Darkening around the eyelids also provided relief from

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the glare of the sun. The earliest historical record of eyeliner use appears in the ancient Near East and Egypt (Keville and Green, 1995; Cohen, 1999). Kohl occupied an important social role in the lives of the Egyptian royalty, serving as a health treatment and cosmetic enhancement with an indicator of social rank and achievement. Kohl was so essential to the Egyptians that it was applied before mummification and beautiful vials of it were included for the trip to afterlife, preserved eternally. The Egyptian hygiene was based on sound medicinal, therapeutic and spiritual reasons (Pauline, 2007). From the tomb paintings of the Old Kingdom (Height of Classical Egyptian Culture "The Age of Pyramids," 2900-2240 BC) to the encaustic portraits of the Roman Occupation, recipes for Kohl were passed from one generation to other down through centuries (Susan, 2003; Devine, 2006).

Eye paint has been reported to be the most characteristic of the Egyptian cosmetics. Two colours were popularly used: green and black. The green pigment was malachite, an oxide of copper. In the "Early Dynastic Period" (3150 BC) green pigment was the most popular colour, and especially in the "Old Kingdom" when it was applied liberally from the eyebrow to the base of the nose. In the Middle Kingdom (2040-1640 BC) green eye paint continued to be used for the brows and corners of the eyes, but by the New Kingdom (1550-1070 BC) it had been superseded almost entirely by black eye paint (Kohl), which was usually made of galena, a sulphide of lead, was used in the early period, but did not come into its own until the Middle and New Kingdoms (Miraim, 1986). During Egyptian rule, galena (lead sulphide) was familiar under the name of "Mestem" or "Stim", while this word was identical to Greek word, "Stimmi" or "Stibi" and to a Latin word "Stibium", meaning Antimony (Fischer, 1894). Therefore, some authors have misinterpreted or rather mixed these words and reported antimony in place of lead sulphide in various books and reports. The controversy regarding chemical composition of Kohl was finally resolved after the publication of the said article and it was concluded that galena was the chief constituent after analyzing 30 samples of ancient Egyptian eye preparations (Kohls) obtained from Fayum (Egypt). The idea that Kohl is predominately made of antimony is also reported as fallacious (Sweha, 1982), while researhers working to identify the procedures of eye makeup manufacturing in the Middle and New Kingdoms of Egypt some 2000 years before Christ, also reported galena (PbS) as a major ingredient of Egyptian eye make-up after matching the microstructure of PbS in Egyptian cosmetic powders with that of the microstructures produced artificially in geological galena minerals (Ungar *et al.*, 2002). It was also reported by analyzing various ancient Egyptian eye cosmetics that these in fact consisted of galena, pyrolusite, brown ochre or malachite, and only in one instance, antimony sulphide (Harris, 1962). The history then continued right through to the "Coptic Period" (phase of Egyptian culture) which lasted from the end of the "Roman Period" – end of the 3rd century AD until the coming of "Islam" AD 641. This period is also called the "Christian Period". By this time, however, soot (carbon black) was also used as a black pigment. Both the malachite and galena were grounded on a palette and then mixed with either water or gum and water (Miriam, 1986). Galena is reported to be found near the "Red Sea", "Aswan", and in "Eastern Desert" at Gebel-el-Zeit, while malachite is found in "Sinai" and the "Eastern Desert" (Pauline, 2007). These were carried across the trade routes into Egypt (North Africa) and Middle East (Catherine, 2005). Results of the studies on the medicinal uses of natural substances in "Medieval" and "Ottoman Al-Sham" also indicate that galena (lead sulphide) was used to cure eye diseases (Lev, 2002). More evidences relating to composition of Kohl have cited in "The Encyclopedia of Islam (Bosworth *et al.,* 1986) and in "Medieval Islamic Civilization – An Encyclopedia (Meri, 2006). Based on the various studies, reports and observations (as cited in The Encyclopedia of Islam), the authors also concluded that the words, "Al-Kuhl" (Kohl), "Surma" and "Ithmid" (Ismad), indicate that the substance was in fact only galena, and rarely antimony sulphide. It therefore seems reasonable to assert that the Kohl mined at Isfahan (Iran) was a lead mineral.

Few researchers also investigated cosmetic powders that were preserved in original alabaster and reed containers (Tsoucaris *et al.,* 2001). The quantitative crystallographic and chemical analysis of the mineral and organic components revealed surprising facts. In addition to the well known galena PbS and cerussite $PbCO_3$, two unexpected constituents have been identified: laurionite PbOHCl and phosgenite $Pb_2Cl_2CO_3$, which are rare halide minerals found in lead slag only in certain places where the sea water has weathered lead debris, left over from silver mining operations in antiquity (Tsoucaris *et al*., 2001). Together with galena and cerussite, these two (laurionite and phosgenite) have been used as cosmetics in Egyptian times (Martinetto *et al.,* 1999; Walter 1999; Martinetto *et al*., 2001; Tsoucaris *et al*., 2001; Frost *et al.*, 2003). Laurionite and phosgenite are rare in nature and it is inferred that such minerals were synthesized. Ancient literature has provided information on the pharmaceutical preparations of these minerals (Walter 1999; Walter *et al.*, 1999). Support for this statement comes from recipe of medicinal products to be used in "Ophthalmology", reported by Greco-Roman authors such as Dioscorides and Pliny (1st Century BC). It follows that Egyptians very early mastered this kind of chemical synthesis and technology, a fact of great importance in the history of science. Fire-based technology had been mastered to manufacture Egyptian blue pigments during the 3rd millennium B.C. It is now suggested that wet chemistry was already in existence some 4000 years ago (Frost *et al*., 2003). Ancient Egyptians had a pharmacopoeia that was discovered by early travelers like Herodotus, who visited Egypt in 440 BC and wrote about his findings. These writings eventually spread to Greece and Rome where the use of cosmetics continued to flourish. As Europe lapsed into the "Dark Ages", the birth and rapid growth of Islam in AD 622 nurtured the growth of beauty culture. The writings of Galen, Dioscorides, and others were preserved and translated into Arabic. Thus, the Islamic culture contributed great advances in mathematics, weights, measures, chemistry, and use of botanical treatment for cosmetology (Epstein, 2004).

Recently, a very interesting research work relating lead-based chemistry was published (Walter *et al.*, 2006). The authors studied and reported a hair-dyeing recipe using lead salts described in text since Greco-Roman times. They reported direct evidence about the shape and distribution of PbS nanocrystals that form within the hair during blackening. It is remarkable that the composition and supramolecular organization of keratins can control PbS nanocrystal growth inside a hair. It is known that the blackening of hair is due to the precipitation of galena (PbS) crystals during the chemical treatment: the lead is provided from the paste deposited externally on the hair shafts, and the sulfur involved in the reaction comes from the amino acids of hair keratins (Raber, 2002). One more interesting finding relating to black writing ink during Egyptian time was also been reported (Barbara *et al*., 2007). According to authors, Galena was also used in writing ink during Eyptian time. These articles certainly indicate the importance of galena a part from it's use in eye preparations.

Kohl, under chemical/common name of "Collyrium" (Surma/Ismad) in which galena is mentioned as major constitute has also been reported (Khan *et al*., 1997). The authors, further reported galena as an inorganic lead compound found in mineralized fissure veins and replacement bodies. Some other metals (such as silver, copper, zinc etc.) may be found combined with this ore in trace amount. Galena occurs as grayish black cubic crystals and is practically insoluble in water or aqueous medium. Based on all these information and research articles published elsewhere, it is reasonable to conclude that the major constituent of Kohl was and is always been galena (lead sulphide).

After extensive search of literatures, the authors of this review have come to a conclusion to define Kohl (surma) as under:

"Kohl (surma) may be defined as an eye preparation in ultra fine form of specially processed "Kohl Stone" (galena) incorporated with some other therapeutically active ingredients from marine, mineral and herbal origin for the protection and treatment of various eye ailments. The other ingredients blended to develop special Kohl formulation may include Kohl adjuvant, (e.g., zinc oxide, silver leaves, gold leaves), gemstone (e.g., ruby and emerald etc.), marine coelenterates (e.g., coral, coral reef and pearls etc.) and herbs (e.g., neem, saffron, mumeera and fennel extract etc.).

Therapeutic value

Perhaps, Kohl is the most popular eye product reported in almost every human civilizations used to keep the eyes cool and clean and for the prevention and treatment of eye diseases such as, blepharitis, trachoma, chalazion, pterygium, cataract, conjunctivitis, ectropion, as well as for the prevention of recurrence of trichiasis (Sweha, 1982). Further, Kohl is also reported for improvement of vision, strengthening and keeping the eyes healthier (Awan, 1956; Levey and Al-Khaledy, 1967; Zaheer *et al.,* 1991; Khan *et al.,* 1997; Monographs of Unani Medicine, 2003). Toxicology of the eye (Textbook – 4th ed), reports some minute conjunctival abrasion when lead sulphide is applied in the form of eye cosmetic (surma) but no toxic injury (Grant and Schuman, 1993). One of the most striking property of Kohl has been observed in Arabian Peninsula. It was reported that the black and shiny particles of galena or lead sulphide (a major constituent of Kohl) shield the eyes from the glare and reflection of sun and thus protects the eyes from the harmful effect of UV rays emerging from the sun and dust of the desert (Heather, 1981; Cohen, 1999, Kathy, 2001). Some more references relating to solar absorption, photo resistant, humidity and temperature sensor and solar properties of galena (lead sulphide) have also been reported by various authors (Nair *et al.,* 1991and1992; Pop *et al.,* 1997).

The authors of present review did try to find some scientific basis of this claimed property of lead sulphide (Galena) relating to absorption of sun rays when applied into the eyes in the form of Kohl. Some references do correlate this specific property of galena (Nair *et al.,* 1992; Pop *et al.,* 1997). A comprehensive study in this connection was conducted and reported by a group of researchers in China (Li-Yun *et al.,* 2008). The authors reported the ultraviolet (UV) absorption spectra of a thin film of lead sulphide prepared on "Indium Tin Oxide" (ITO) substrate. The spectra showed that lead sulphide thin films had higher absorption and lower transmittance in UV light band which further increases with the increased deposition voltage. Lead sulphide is an important direct narrow-gap semiconductor material with an energy bandgap of -0.4 eV at 300K and a relatively large excitation Bohr radius of 18nm. These properties also make lead sulphide suitable for infrared (IR) detection applications as well (Gadenne *et al.,* 1989). These findings and references give some good scientific basis and reasonable justification to conclude that Kohl containing lead sulphide (galena) as a major ingredient

does have a natural protective effect against glare of the sun when applied in the eyes in the form of Kohl and thus support the earlier claims and uses as reported elsewhere.
The role of other ingredients of Kohl was also investigated through literatures for some scientific correlation and the possible reasons of incorporation of these into various Kohl formulations. We did find some interesting formulations, reflecting some benefits of these ingredients for the eyes reported elsewhere in the literature. Such as, zinc oxide, probably used in Kohl because of its powerful natural sun block property (Mitchnick *et al.*, 1999) which may possibly enhance the protective capacity of galena against the glare of the sun. Neem (*Azadirachta indica*) is very well known world wide for its astringent and antibacterial properties (Almas, 1999; Linda, 2001). Like silver leaf, neem also possesses anti-viral activity as well (Badam *et al.,* 1999).

Chaksu (*Cassia absus*) is usually used to strengthen the eye sight. It is also useful in purlent opthalmia and conjunctivitis. While, fennel (*Foeniculum vulgare*) plant extract actually used for processing Kohl stone (Galena). Mamiran (*Coptistis teeta*) is highly beneficial in catarrhal and rheumatic conjunctivitis and also used as eye salve or as a paste on sores (Dastur, 1952; Chopra *et al.*, 1956; Kirtikar and Basu, 1984; Khan *et al.,* 1997; Linda, 2001; Monographs of Unani Medicine, 2003).

The ancient history indicates considerable information regarding uses and application of saffron (*Crocus sativus*) in various eye diseases. In the Hippocratic Corpus, saffron is mentioned several times in connection with ailments of the eyes. It is recommended as a treatment for watery eyes (fluxes), inflammation and pain in the eyes. Dioscorides, prescribed saffron against fluxes of the eyes. He claimed that saffron ointment is effective against glaucoma. Dioscorides further described saffron as an excellent medication used to anoint the eyes. In addition he referred to cataracts (dullness of the sight) and recommended a mixture that includes saffron. Finally, Dioscorides advocated saffron for inflammation of the eyes as well (Forsyth., 2000). It is attributed with extraordinary properties for improving weak eyesight and highly valued as a complexion builder (Chopra *et al.*, 1958: Kirtikar & Basu, 1984, Forsyth, 2000).

The materia medica of “Eastern System of Medicine” showed considerable description on the role of various gemstones on eyes. However scientific studies or research articles are lacking to correlate the beneficial effects of gemstones on eyes. Some descriptions are available showing a possible relationship between gemstones and eye ailments. The use of green stones (emerald) to relieve diseases of the eye was evidently suggested by the beneficial influence exerted by this colour upon the sight. The verdant emerald represented the beautiful green fields, upon which the tired eye rests so willingly, and which exert such a soothing influence upon the sight when it has been unduly strained or fatigued. One of the earliest Greek writings to the therapeutic value of gems, appears in the works of Theophrastus, who wrote in the third century before Christ where in the beneficial effect exercised by the emerald upon the eyes (Kent, 2004)

Criticism

Lead intoxication after application of Kohl (Surma) into eyes:

The lead poisoning came into picture after the publication of an article in which the author proposed a theory that “Fall of Rome” is a result of lead poisoning (Gilfillan, 1965). It is worth reviewing and discussing while discussing Kohl (surma) in the context of afore mentioned situation as well. The major focus of author (Gilfillan, 1965) in this article was citation on the declining birth rate amongst the “Aristocratic Romans”, which was brought about by the sub-fertility of this class leading to diminution of life span. There was hardly any definite reason or evidence submitted by the author in support of the hypotheses. In fact, less attempt was made by the author to assess scientifically to what extent the people of antiquity absorbed lead to which they were exposed. Report shows that out of twenty two bone samples collected from various archaeological sites, only four indicated presence of lead, two from “before and two from “after” the Roman conquest of the city (Rosenblatt., 1906). Based on this, it was stated (Gilfillan, 1965) that the results of lead estimations of forty bones were consistent with the theory, but no details were presented in this regard to elaborate the statement. The author reported that the amount of lead found in a rib from the skeleton of “Pope Clement II” who died in 1047 and documented this as the only evidence in the whole study and thus the amount of lead found was sufficient to propose that the “Pope Clement II” had died of lead poisoning (Specht and Fisher, 1959).

Analyzing all these statements, it was reported (Waldron, 1973) that these data are insufficient in determining the extent of lead poisoning in Rome and thus demands more in depth study before reaching to a conclusion. The author further reported that it is indisputable that the Greeks and Romans knew lead to be poisonous and that they were familiar with the symptoms of plumbism. Clearly then they dissociated this hazard from the use of the metal in their cooking vessels, and it is beyond doubt that this resulted in lead becoming incorporated into their food and drink. However, we also need to find out the reasons as to why Greeks and Romans used such kind of utensils for cooking, eating and drinking purpose. How far beyond these bare statements it is safe to venture is difficult to say, but to suggest lead poisoning as the cause of the decay of Roman civilization may be exceeding the bounds. The civilization did decay, but all empires have a

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finite life. The decay of Rome is not unique and it is perhaps too facile to suppose it to have a unique cause. Indeed, the earlier worker not unwittingly mislead generations of readers to believe that this was a sudden event through the use of the phrase, the "Fall of Rome", all-embracing theories might not be so much in vogue (Rostovtzeff, 1957).

Based on current literature search, perhaps the first proper report about lead poisoning was reported in Japan (Snyder, 1947), followed by France, United States, Great Britain, and Australia. In 1967 for the first time lead poisoning in Childhood was reported in Ceylon (Mirando and Gomez, 1967). The authors discussed nine different cases of lead poisoning in children. The suspected source of lead in six, were identified as "refining jeweler's waste", reconditioning of batteries – recovery of scrap lead in two, lead type foundry in one, while the source in three cases remained untraced. No indication of lead poisoning due to Kohl or due to any eye cosmetics reported by these authors. Soon after this, a report relating to lead poisoning from eye cosmetic (surma) was published (Warley *et al.,* 1968). At the same time, another report supporting the earlier one was published (Srivastava and Varadi., 1968). However, in this case the product was colourful lipstick made up of lead carbonate and not the lead sulphide (Kohl) as mentioned in the first case (Warley *et al.,* 1968).

Two simultaneous reports were published in British Medical Journal in 1973. The first (Betts *et al.,* 1973) identified blood lead concentration greater than 37 µg/100 ml in thirty eight children. Eight, diagnosed had encephalopathy with blood concentration of 99µg/ml and one died. The major source of lead intoxication was reported to be due to environmental pollution and paint (containing lead chloride), however, the authors showed their concerned over black eye liner (surma), which is widely used by Asian community living in UK. The authors reported that out of thirty eight children, fifteen were Asian but unfortunately did not mention how many children out of fifteen were applying surma. Further, surprisingly the blood lead concentration of fifteen Asian children were also not reported separately to reach to a certain conclusion to correlate the lead intoxication due to surma application in at least fifteen Asian children as discussed in the study. The second report (Snodgrass *et al.,* 1973) published under the heading of "Cosmetic Plumbism". The authors reported lead concentration of 36 µg/100 ml in ten out of twelve children from five families and considered the value as upper limit of normal for pediatrics. However, the authors further reported blood lead level between 61 to 69 µg/100 ml in three children of aged 2 to 3 years. No definite reasons were cited, however on the basis of the eye cosmetic, surma obtained from homes in three instances, it was considered as source of lead poisoning. Surprisingly, no clue was given in the rest of seven cases. In both reports (Betts *et al.,* 1973; Snodgrass *et al.,* 1973) the authors seem to be very hurry in predicting surma as the potential source of lead poisoning in their study and left some temptation for the readers and researchers.

While these reports and studies were published, another very interesting study report came into view in the "British Medical Journal" describing effect of lead absorption on mental health (Gordon *et al.*, 1967). Originally, the possibility of a causal relationship between lead absorption and mental retardation was also suggested (Moncrieff *et al.,* 1964). According to these authors blood lead level of over 36 µg/100 ml should be treated as an indication of lead intoxication. However, other group of researchers (Gordon *et al.,* 1967) obtained different results in their study. They summarized the study by analyzing data of one hundred and twenty three children of uncertain etiology (mean BLL 31.6 µg/dL), 24 Mongols (mean BLL 35.1 µg/dL), and 73 controls (mean BLL 30.9 µg/dL) for lead intoxication. These results indicate that the three groups do not differ significantly as regards to blood lead levels (BLL) and no definite evidence of either acute or chronic lead poisoning has been obtained.

Under the heading of surma and lead poisoning, the blood lead concentration of sixty two Asian children of whom thirty seven had applied surma to their eyes, while twenty five were supposed not to have applied surma was reported (Ali *et al.,* 1978). On the basis of blood lead concentration of 20.3 ± 8.7 µg/100 ml in those who had not use surma with that of 34.2 ± 14.1 µg/100 ml in those who had, the authors concluded that the use of surma is associated with high blood lead concentration. However, soon after publication of this research article, it was categorically rejected by another investigator (Bakhshi, 1978) on three very basic grounds which were not discussed and justified by author (Ali *et al.,* 1978). The investigator (Bakhshi, 1978), questioned about the socioeconomic status of the test and control group, the amount of blood lead in control group which was not insubstantial, and finally as to why the number of children in the test group were more than twice that in the control group. He further quoted "Birmingham Lead Studies" (HMSO, 1978), which have shown that boys have a higher blood lead level than girls. He further stated that the authors (Ali *et al.,* 1978) were wrong to assume that surma was solely responsible for lead poisoning in their study. There may be many complex causal factors – albeit uniquely important in this study – in the etiological chain giving rise to excess body lead levels which find their ultimate expression in clinical lead poisoning. The authors of this review had also extensively studied this proposed concept and will focus more in this regard when we will discuss the role and importance of "Nutritional

Factors" in lead toxicity and will try to correlate the concept in the development of high blood lead level.

Another very interesting report published in "Lancet" (Attenburrow *et al.,* 1980), also rejecting the study results (Ali *et al.,* 1978). In their study (Attenburrow *et al.,* 1980) conducted in Glasgow, reported mean blood lead concentration in the group using surma as 0.799±0.285 mmol/L and in the group not using surma the mean concentration was 0.760±0.302 mmol/L and concluded that surma remains a theoretical rather than a practical health hazard. However, soon after the publication of this report, a reply was published, recommending that the use of surma should be discouraged based on it's possible health hazards (Aslam *et al.,* 1980).

In a study in California carried out from 1991 to 1994 (Sprinkle, 1995), average lead level of 4.3 µg/dL for Pakistani/Indian children not using eye cosmetics and 12.9 µg/dL for those using the product was reported. During same period, two very interesting studies have also been reported (Khalid *et al.,* 1992 and 1995). Both studies were carried out in the Pakistan Council for Scientific and Industrial Research Laboratories Complex, Government of Pakistan – Karachi. In the first report (Khalid *et al.,* 1992) based on animal studies (rabbits) indicated no increase in blood lead levels after application of surma in rabbits even after continuous application (once, twice, and thrice a day) for sixty days (24.7 ± 3.1 µg/100 ml for control; 26.5±2.9 µg/100 ml for test group with one application per day; 26.4 ± 1.3 µg/100 ml for test group with two application per day; 28.5±2.4µg/100 ml for test group with three application per day). The surma used in this study contained 69% lead as PbS. Thus, negating the earlier study carried out in Birmingham (Aslam *et al.,* 1980) and reported their results in accordance with the study carried out in Glasgow (Attenburrow *et al.,* 1980). The authors (Khalid *et al.,* 1992) further reported the intraperitoneal toxicity test results in rats after administration of 2.6 mg/kg body weight. All animals appeared to be normal and showed no gross change in the liver and kidney on autopsy performed after fifteen days.

In the second study (Khalid *et al.,* 1995) reported results on human volunteers comprising of sixty two (23 children and 39 adults) in number. Their ages ranged between 12 to 55 years in case of adults (mean 35 years) and between 2 to 11 years (mean 6.5 years) in case of children. The blood lead level determined at day zero was treated as control figure and then after application of surma once a day (0.5 to 1.0 mg each time with an applicator) the blood lead levels were measured at day 30, 60 and at day 90. The results reported by the authors (Khalid *et al.,* 1995), showed no significant difference between the control and test. (BLL in children: control 0.88±0.038 µmol/L, test 0.91±0.042 µmol/L after 90 days; BLL in adults: control 0.78±0.024 µmol/L, test 0.77±0.027 µmol/L after 90 days). However, unfortunately, we have not seen these references in any of the studies or reports published by various authors. While studying various factors responsible for increased blood lead concentration, the blood lead concentrations of children who were exposed to surma at least twice a week had median concentrations of lead about 3 µg/dL higher than those in other children was also reported (Rahbar *et al.,* 2002). However, interestingly when the authors adjusted the values for other variables in the multivariate model, the effect of surma was not found statistically significant. The results of this study has also been reproduced by another author with their comments under the heading of "Lead intoxication in children: A global concern" (Ray and Laskar, 2004).

The presence of heavy metals in some Asian medicine and cosmetics, including surma has also been reported (Aslam *et al.,* 1979). Interestingly, four very similar reports have been published (Hardy *et al.,* 1998, 2002, 2004 and 2006). In all the four reports, the subject (composition of eye cosmetics – Kohls) was same and various Kohl samples collected from Oman, Abu Dhabi, Dubai, Sharjah, Ajman, Fujairah and Cairo etc., were analyzed for the presence lead sulphide and any other constituents if present. Analytical report showing presence of Galena in Kohl samples collected from different stores of Oman was also reported by another investigator (Vaishnav, 2001). In a similar study (Nnorom *et al.,* 2005) presence of heavy metals in eye cosmetics available in Nigeria was also reported. Few more researchers (Haq and Khan, 1982; Ali *et al.,* 1988) analyzed various Kohl samples collected from different cities of Pakistan and reported lead sulphide as major ingredient. Through interviews, the status of Kohl and it's users in Alexandria (Cairo) has also been reported (Mojdehi and Gurtner, 1996). Two different cases of lead poisoning, first relating to a necklace which when tested was found to have high lead content and second due to use of surma have also been reported (Jones *et al.,* 1999). The major constituent of Kohl is now well documented and established, however, the thing which is more important is to find out, how Kohl is responsible for an increased blood lead level upon application into the eyes. There is tremendous demand to authenticate the concept of increased blood lead level, if any, upon application of Kohl and not to observe and report the chemical constituents.

A similar type of study based on the analysis of Kohl samples collected from different cities, London, Rabat (Morocco), Nouakchott (Mouritania), Detroit, Pittsburg, and New York city have been reported (Parry and Eaton, 1991). The authors regarded Kohl as a lead hazardous eye makeup brought from the third world to the first world. The authors further reported that the physicians and health care workers in the third world are usually unaware of the possible lead uptake from unsuspected traditionally used items. It was further reported by these authors that both antimony and galena were used during Pharonic Egyptians to prepare Kohls, however as antimony is scarce and expensive, it has been gradually replaced by cheap and readily available material – galena. Similarly, use of Kohl, containing galena or lead sulphide has also been reported in Morocco (Lekouch *et al.*, 2001), Saudi Arabia and Middle East countries (Alkhawajah, 1992; Kaff, 1993; Al-Hazzaa, 1995; Al-Awamy, 2001; Al-Ashban *et al.,* 2004; Jallad and Hedderich, 2005), Jordan (Abdelaziz and Al-Kofahi, 1989; Al-Kofahi *et al.*, 1989), Israel (Nir *et al.,* 1992) and in Brussels (Bruyneel *et al.*, 2002).

Apart from Kohl, other factors have also been identified by various workers and reported as significant association with respect to increase blood lead concentration. These include exposure to paint, remodeling, and renovation; use of lead utensils and pica (Khan *et al.,* 2001), battery recycling and battery repair, corridors along heavy trafficked roads (Falk, 2003; Safi *et al.,* 2006) and effect of environmental pollution (Falk, 2003; Farida *et al.,* 2005). The severe problem of lead poisoning in Hangzhou city (China) due to gasoline was also reported (Chaochun and Zhengyan, 2004). The geometric mean of blood lead levels was 75.94 µg/dL (ranged from 11 µg/dL to 380.0 µg/dL) with a positive skewness distribution. Certainly, these factors are equally important in increasing blood lead concentration and thus demand from the intellectuals and scientists to pay more and more focus in minimizing the risk of increased blood lead concentration through these factors. In a study in Albania, the mean blood lead concentrations in 145 school children living in Berat, close to a battery plant were reported as 26.6 µg/dL, compared to 16.0 µg/dL in 228 school children living at a greater distance (Tabaku *et al.,* 1998). In another study to establish a correlation between low level lead exposure and intellectual impairment in children, the authors reported a number of factors, such as diet, lead-based paint, lead in soil and dust, gasoline as main source of lead affecting children health (Koller *et al.,* 2004). According to these authors, current lead exposure accounts for a very small amount of variance in cognitive ability (1 to 4%), where as social and parenting factors account for 40% or more. Blood lead levels of construction workers was also reported (Reynolds *et al.,* 1999). It ranges from 0.1 to 50 µg/dL. Similarly, high blood lead level (130 µg/dL) in a persons working in a smelting company was also reported (Santiago and Alex, 2006). Similarly, mean blood lead level among traffic constables in Islamabad (Pakistan) was reported as 27.27 µg/dL compared to 3.22 ug/dL in controls (Farida *et al.,* 2005). While at the same time in a similar study conducted in Karachi (Pakistan) which has greater concentration of public and private transport vehicles, the mean blood lead levels were higher than the study conducted in Islamabad (Sadruddin and Manser, 1992; Tahseen and Amir, 2005). Results of all these studies reinforce the need to focus efforts on controlling and preventing exposure to lead during high-risk activities.

In a separate study (Al-Naemi *et al.,* 2007), authors reported lead exposure as still an important public health problem in Mosul City (Iraq) and the major predictors for high blood lead levels include the location of the household in relation to traffic density and home characteristics namely age of home and/or presence of chipping paint. Though the authors did mention high blood lead levels among surma users, but at the same time the stepwise logistic regression model used in this study did not reinforce the risk association for high blood lead levels significantly. Further, no criteria were established by the authors to differentiate the influence of environmental and other factors on the high blood levels observed in surma users. The reliability of this study become further doubtful when the authors themselves were not sure about the accuracy and sensitivity of the method & instrument (Lead Care Testing System and Lead Care Blood Lead Test kits) used in their study against atomic absorption spectrophotometry. The lead in gasoline, paint, socioeconomic status and other factors have also been reported as contributing factors for elevated blood lead levels in children (Gulson *et al.,* 1994). The authors further reported low solubility, thus low bioavailability of galena and sphalerite. A number of reports have also been published by some investigators on the bioavailability of lead. Many such investigations and evaluations as reported (Gulson *et al.,* 1994) in relation to soil/dust lead in mining communities have found lower blood lead levels (generally <10 µg/dL) than the in urban and smelter communities, and this has been attributed to the low "bioavailability' of the lead species. The bioavailability is the proportion of lead considered to be extracted in the gastrointestinal tract, compared with the total available lead (Gulson *et al.,* 1994). The absorption (uptake) of lead into the circulation is the critical kinetic component of the bioavailability. Not only the amount, but also the rate of uptake of that given amount is important, particularly under acute or sub-acute exposure conditions, and when dealing with lead-containing media in the gastrointestinal tract (EPA – US, 1994). The low blood lead levels found in these communities lead other investigators (Steele *et al.,* 1990) to state that lead in soil (or dust) from mine waste has a low impact on blood lead level. The possible reasons for a reduced impact of lead sulphide on blood lead in children is due to low solubility of lead sulphide in gastrointestinal tract compared to other species was also reported (Steele *et al.,* 1990) . It has also been reported (Grigg, 2004) that in Europe, children are at risk of exposure to more than 15,000 synthetic chemicals, nearly all developed over the past 50 years, and worldwide between 50,000 to 100,000 chemicals are being produced commercially, the most toxic of which are used in less developed countries. Certainly these chemicals are also highly toxic and can develop physical, mental and intellectual abnormalities and thus need a positive control and consideration on this sector as well.

Neurotoxicity at low levels of lead exposure was not clearly demonstrated until the last 30 years. The blood lead levels earlier mentioned as safe by various investigators, are now reported to cause toxicity. For example, the blood lead level threshold for adverse effect has been progressively lowered from about 150 µg/dL in 1930s to 80 µg/dL in the 1970s (Sprinkle, 1995). It was further lowered to 40 µg/dL in early 1980s and then to 20 µg/dL as a mean acceptable value with 25 µg/dL being regarded as elevated (Tietz, 1983; Manser, 1989). However, finally further lowered to 10 µg/dL in 1991 and regarded as a safe limit (Goyer, 1990a; Paloucek, 1993). The WHO also stands at 10 µg/dL (Koller *et al.,* 2004). Due to extensive use of the two units in the scientific literature, lead concentration is measured using the metric system (µmol/L) with conversion to µg/dL. It should be noted that 0.48 µmol/L equals 10.0 µg/dL, and that for an approximate conversion from µmol/L to µg/dL, simply multiply by 20 (Levesque *et al.,* 1999).

It has been reported (Aslam *et al.,* 1980, Healy *et al.,* 1982) that the primary route for lead absorption from Kohl (surma) is not transcorneal transport. However, the possibility of some of the material being washed into the naso-lachrymal duct on tear formation after application of Kohl should not be excluded in children. The principal route for ingestion in man appears to be orally, via the fingers. When applied to children, it may finally been absorbed through ingestion as children usually rub or wipe their eyes with their fingers which provides a way for the lead present in the product to ultimately reach to stomach where absorption takes place, but this is very unlikely among adults. However, according to others (Khalid *et al.,* 1995) such a possibility has been suggested but has not been conclusively established. It is generally assumed that in most cases oral consumption of lead migrated through dust and dirt originating from contaminated soil encountered in the environment should be regarded as the major source of lead exposure, especially in children. However, it appears that not all exposures to lead pose the same risk. That is, lead bioavailability can vary greatly with the form and matrix in which lead is received. This fact in the human population exhibited that lead levels detected in the blood of exposed children are frequently not proportional to the total lead in their environment or their estimated level of ingestion. Given this fact, it is unlikely that a single default assumption of lead bioavailability would be appropriate to assess risk associated with all environmental source of lead exposure (Freeman *et al.,* 1996).

Few investigators (Aslam *et al.,* 1980 and Healy *et al.,* 1982) reported that if the eye cosmetic (Kohl) is assumed to have a lead content of 50%, then the possible weakly absorption of lead from this single source is in the range of 35 to 70 µg. This was on the basis that during each application 20 mg Kohl (apparently very high in view of the authors of this review) is transferred onto the conjunctival margins from the applicator road and by analysis of swab samples taken from the fingers of children who just have Kohl applied, it can be estimated that of the order of 0.2% of this applied lead is transferred to the mouth via fingures. This theoretical mechanism of lead absorption and over all calculation as proposed by the authors, looks highly contraversial in the development of high blood lead level upon Kohl application when the authors themselves adimitted that the proposed calculations are necessarily dependent on a variety of factors including diet, state of health and, principally, solubility of ingested lead compound.

The content, sources and reasons of using surma have been reported by various workers (Healy and Aslam, 1986a and 1986b; Green *et al.,* 1979). The survey of these authors is primarily based on communication with the people living in Nottingham and Bradford. With regard to reason for using surma, include: 40% (medical), 35% (Beauty), 20% (Traditional), and 15% (habit). The use of Kohl in the umbilical cord of children and identifying it as a risk factor for the increase blood lead level was also reported by some workers (Iman *et al.,* 2003). In a similar study, (Fernando *et al.,* 1981) reported an exceptional use of Kohl as bakhoor in Kuwait. The authors of present review did try to find any such reported application or use of Kohl (surma) in “Unani” or “Traditional” or “Ayurvedic” system of medicine, but fail to find presence of such application or uses in the compendias of these systems of medicine. Apparently it looks a misuse of the product, Kohl as reported by various authors.

The authors of this communication would like to quote here the results of a study carried out on an animal model to investigate the bioavailability of different sources of environmental lead, including lead sulphide, the major component of Kohl (Dieter *et al.,* 1993). The experiment was carried out on male F344 rats feed with lead sulphide, lead oxide, lead acetate and lead ore concentrate along with diet at a dose of 0, 10, 30, and 100 ppm as lead for 30 days. The authors (Dieter *et al.,* 1993) reported maximum blood lead concentrations attained in the 100 ppm groups (very high dose of lead) were approximately 80 µg/dL in rats fed with lead acetate and lead oxide, and were approximately 10 µg/dL in those fed with lead sulphide and lead ore concentrate (galena). There was no mortality or clinical signs of lead toxicity in the treated or control groups of rats. Further, the food consumption increased from an average of 7 g/rat/day to 11 g/rat/day over the 4 weeks measured. Body weights were also not affected by lead consumption, except in animals receiving very high dose, 100 ppm of lead acetate and lead oxide, where a 14-20% reduction in body weight was observed. The bone lead concentration indicated maximum value (200 µg/g) in rats fed with lead oxide and lead acetate, while approximately 10 µg/g was recorded in rats fed with lead sulphide and lead ore. Kidney lead concentration were also about 10 fold greater in rats fed with lead acetate and lead oxide compared to those fed with lead sulphide and lead ore. This report is in consistence with the earlier studies (Khalid *et al.,* 1992, and 1995, Attenburrow *et al.,* 1980). In another study (Healy *et al.,* 1982), the authors tested different Kohl samples (keeping lead sulphide as control) in order to establish the solubility of ingested lead sulphide. The experiment was carried out using the staurated solution of eye cosmetics (Kohl) in real gastric fluid *in vitro*. The authors reported formation of a few white, microscopic, needle-shaped crystals. Upon analysis through X-ray diffraction methods, the crystals were identified as lead chloride. While, clearly, no suggestion is made that the same crystallization could occur in vivo as well depending upon the known chemistry of the metal in solution. However, the authors (Healy *et al.,* 1982) still believe it will not be unreasonable to suggest that within the gastrointestinal system lead chloride may readily be generated from lead sulphide suitable for absorption. The authors of this review article could not find any other reference in support of such proposed or hypothetical mechanism of solubility. The authors (Healy *et al.,* 1982) did not elaborate much about their "suggested model" of solubilization and degree of crystaliztion between the Kohl samples and lead sulphide used as control, though they reported formation of "few" microscopic crystals (no quantification given, i.e., how much quantity of crystals were formed from a given quantity of surma) produced but it is not clear whether the crystalliztion has occurred only in Kohl samples or in the control (lead sulphide) as well. Under such case the possiblity of the presence of lead chloride as a contaminant or adultrant in the Kohl samples can not be ignored which may had crystallize out because of the saturated solution. Above all, the quantity of "white crystals" formed were so small that the authors remained unable to quantify and to check it's solubility in ammonium chloride or ammonium nitrate or in alkali hydroxide as a primary test to ascertain formation of lead chloride. The solubility of lead sulphide in HCl is linked with temperature of the medium and it is reported to be soluble in "hot" dilute HCl (Cullen *et al.,* 1996). The degree of reliability of this proposed mechanism futher became uncertain and doubious when the authors extended the formation of one more product, lead sulphochloride and suggested a complex chloroaquolead specie with the possible formation of lead hydroxide and proposed the release of lead ions into the solution for absorption. However, at the same time conflicting reports have also appeared in the literature as to what extent, lead sulfide can be absorbed from the gastrointestinal tract (Wetherill *et al.,* 1975; Chamberlain *et al.,* 1978). It is evident from the earlier study (Dieter *et al.,* 1993) that the blood and tissue concentrations in rats fed with lead sulphide and lead ore, the bioavailability of lead was much lower than that from lead acetate and lead oxide. It is, therefore, reasonable to conclude that if lead sulphide and lead ore (galena) would have been converted into lead chloride (more soluble form of lead) in the stomach, as suggested in an earlier study (Healy *et al.,* 1982), the blood and tissue lead concentrations in the test group of rats should have increased but evidence did not match to see any cosiderable increase in this study (Dieter *et al.,* 1993). In an experiment using rats blood, kidney and femur (Barltrop and Meek, 1975), the authors reported significant difference in the lead absorbed from different lead compounds. The blood, kidney and femur lead contents were all found to be well correlated. As much as a twelve-fold difference being seen between metallic lead (Pb) and lead carbonate. Lead carbonate gave a mean kidney lead content of 18 µg, followed by lead acetate 11.4 µg., lead sulphide 8 µg, lead chromate 5 µg and metalic lead 3 µg. The high absorption from lead carbonate may reflect the greater solubility of this compound in gastric juice but it is not possible to relate the observed differences in the other compounds to their solubility in biological fluids. An important finding, substantiating other research work was that an increase in dietary fat increased the lead absorbed from a given lead compound (Barltrop and Khoo, 1975). With lead acetate, the mean kidney lead content was raised from 11.4 ug to 20 µg with the addition of 7.5% corn oil to that diet (Barltrop and Meek, 1975). These data suggest that it is not possible to device a single relevant standard for the lead content of surface-coating material and the various environmental situations in which lead contamination occurs. Reference should be correlated to the chemical form of the lead involved in relation to dietary factors in each situation as well. In two separate studies (Barltrop *et al.,* 1974 and 1975), the authors observed no consistent relationship between blood lead values and pica for soil. In this situation, lead in soil provided a small additional burden for children but in itself was insufficient to constitute a hazard.

It is proposed by the "Environment Protection Agency – US" (EPA, 1994) that if a blood lead study is to be evaluated in the risk assessment, it is important that all of the sources of lead exposure at the site be characterized and quantified. Accordingly, the most useful data base contain "paired" data sets. The biggest advantage of this parining of environmental data with blood lead data allows the risk assessor to examine the relationship between a child's blood lead and his or her sources of exposure. Therefore, at the time of evaluation, the environmental data would include the lead concentration in soil, water, and in house dust at the child's residence. A part from this particular measure to authenticate the blood lead concentration, the publication (EPA, 1994) also suggests to consider various other seasonal and physiological factors while examining or studying blood lead concentration for possible lead toxicity. Susceptibility to lead toxicity is known to be influenced by a number of physiological and environmental factors, such as, age, season of the year (including body temperature, dehydration, ultraviolet light), nutritional factors (including calcium, phosphorous, iron, vitamin D, protein, ascorbic acid, nicotinic acid intake), alcohol as well as some other heavy metals (Mahaffey, 1974). The seasonal fluctuations in blood lead concentrations have been reported as great as 4 to 6 µg/dL in some studies (EPA, 1994). The literature search during present study has also indicated that in a large number of studies performed to ascertain lead toxicity upon application of Kohl, the results have been published without considering these important factors and guidelines. For example, few few reserachers (Ali *et al.,* 1988) reported blood lead concentration as 0.4 ppm in none users, while 1.2 ppm in the casual and frequent users of surma, without using any standard protocol for their study. Also the environmental lead level and nutritional factors were not taken into consideration. However, interestingly, the authors further reported that 15% from the casual users and 85% from the frequent users had blood lead concentrations between 0.6 to 0.8 ppm, which we believe is insignificant statistically, but still they (Ali *et al.,* 1988) had the opinion that it may cause mild toxicity. In a review article (Kapoor, 2007), the author reported "Sindoor", a part from Kohl as a possible source of lead poisoning on the basis of various contraversial articles.

Surprisingly, the nutritional factors, as mentioned earlier, which are very important and play a significant role in the interpretation of blood lead concentration had not been taken into consideration while analyzing blood lead levels of Kohl users or non-users. Recently, it has been reported (Ahamed and Siddiqui, 2007) that nutritional factors (some elements and vitamins) are important modifier for the metabolism and toxicity of lead. Animal experiments have demonstrated that essential elements, such as calcium, zinc, iron, selenium, phosphorus and various vitamins can counteract the toxic effects of lead (Mahaffey, 1990; Miller *et al.,* 1990; Patra *et al.,* 2001; Pande and Flora, 2002). Major risk factors for lead toxicity in children in the United States include nutrition, particularly deficiencies of essential metals, calcium, iron, and zinc, and housing and socioeconomic status (Goyer, 1993). In humans, particularly children low dietary intake of iron, zinc, and calcium have been associated with increased blood lead levels (Osman *et al.,* 1998; Ahamed *et al.,* 2007). The extents of understanding how nutritional factors affect susceptibility to lead vary from nutrient to nutrient. The experimental literature on this topic is extensive and rather consistently supports the observations that ingestion of diets low in calcium increases lead absorption and toxicity. It has been reported (Mahaffey-Six and Goyer, 1970) that lowering dietary calcium from 0.7% to 0.1% significantly enhanced the body lead burden of rats exposed for 10 weeks to 200 ppm laed. Under these conditions, blood kidney, and femur level of lead increased significantly as did urinary excretion of delta aminolevulinic acid (δ - ALA). Based on this, nutritional factors have cited as a marked effect on the absorption of lead from the gastrointestinal tract (Barltrop and Khoo, 1975). Lead absorption was increased by high fat, low mineral, low protein and high protein diets but decreased by high mineral diet. Decreased lead absorption with increasing dietary intake of calcium also has been observed in humans (Heard, 1982). Iron deficiency is also recognized worldwide as one of the most prevalent nutritional problem (Grigg, 2004). An increase in blood lead with decreasing dietary iron intake has also been reported (Hammad *et al.,* 1996; Osman *et al.,* 1998). Thus, marked effects of the different nutritional factors as given in this review could in part explain the wide range of blood lead concentrations found in community studies done by various workers to establish the increased blood lead concentration with use of Kohl.

Lead concentration in maternal and cord blood in women after application of Kohl (Surma) into eyes:

In 2001, during world environment day, it has been reported (Jaffery, 2001) that exposure to lead is of special concern among women particularly during pregnancy. There is no apparent maternal – fetal barrier to lead (Goyer, 1990b). Thus, lead absorbed by the pregnant mother is readily transferred to the developing fetus (Buchet *et al.,* 1978; Ong *et al.,* 1985). A number of conflicting reports have been published on this topic, thus making once again difficult to understand and analyze the situation.

In a study conducted in "King Abdul Aziz University Hospital – Riyadh" (Moghraby *et al.,* 1989) blood lead concentration of 64 mothers, out which 90% used eye cosmetic and 45% of these used Kohl throughout the pregnancy was reported. The mean lead concentration in all blood samples were higher than the accepted natural levels of 0.001 µmol/L, but lower than the sub-toxic level of 1.9 µmol/L. It was concluded that other lead pollutants may also be involved as lead concentrations in the maternal and cord blood correlated well and did not show any significant difference between surma and non-surma users. Also none of the newborns showed any apparent congenital anomalies and their birth weights were comparable to average Saudi birth weights. No basophilic stippling was noted in any blood sample, while cell morphology showed normochromic, normocytic in appearance with mean haemoglobin level of 12 g/dL confirming no lead intoxication. Though the surma samples were not analyzed by the authors, but it is reported that the surma available in the market, reported to contain maximum 88% lead. In a similar type of study (Awasthi *et al.,* 1996), the authors reported increased concentrations of blood lead levels among pregnant women in the slums of Lucknow (India). In a sample of 500 women, the mean blood lead level was 14.3 µg/dL. Ninety six women (19.2%) has mean blood lead level >20 µg/dL, of whom 25 had ≥30 µg/dL. The blood lead levels were not found associated with the reported use of surma, or piped water or the presence of paint in homes. Other investigators (Saxena *et al.,* 1994), also reported a very high maternal blood lead level (>25 µg/dL) and cord blood lead level as >10 µg/dL. These results indicate that maternal blood levels were higher in those who experienced abnormal deliveries and in those who ate non-vegetarian diets or drank ground water compared with the respective control groups. The placenta, cord blood, and fetal membranes from both normal and abnormal delivery cases showed no significant differences in their lead content.

In a study to develop a relationship between blood lead level in children and fetal umbilical cord in China (Zhang, 2001), the author reported higher blood level (0.42 ± 0.15 µmol/L) in children was mainly caused by environmental pollution and unhealthy life behaviors. The average umbilical blood lead level was 0.16 ±0.12 µmol/L in neonates.

Summarizing all these data and reports, it can be suggested that in absence of the possibility of transcorneal absorption of lead from Kohl as well as by oral ingestion which is certainly not possible in adults (women and men), a higher blood lead level in pregnant women as reported by various authors after the application of Kohl, may be linked with the socio economic factors and deficiency of calcium, iron or zinc which facilitate the mobilization of lead from bone during pregnancy and lactation and not possibly from the use of Kohl (surma). Although bone has predominantly been considered a storage site for sequestering absorbed lead, bone is not simply an inert storage site. Once deposited in bone, lead can remobilize from bone in response to both physiological (e.g., pregnancy and lactation) and pathological (e.g., osteoporosis) conditions (Ahamed and Siddiqui, 2007; Jaffery, 2001; Han, *et al.,* 2000; Bruening, *et al.,* 1999; Silbergeld, 1991). These nutritional and concomitant exposures play an amplification factor in lead toxicity (West *et al.,* 1994; Bogden *et al.,* 1995; Kristensen *et al.,* 1995). Therefore, in state of calcium deficiency during pregnancy, calcium is mobilized from the bone and there is concomitant mobilization of lead and thus elevation of blood lead in women who have high bone lead stores (Hu, 1998; Awasthi *et al.,* 2002). Consequently, when the body of pregnant women demands more calcium for developing fetus, it mobilizes calcium out of the bone, carrying lead with it and thus indicate a high blood lead level as well (Jaffery, 2001). A similar process occurs when the body demands more calcium during lactation (Mahaffey, 1991). In an other study (Awasthi *et al*., 2002), the authors while working on maternal blood lead level reported results of 500 women, out of which 40 (8%) were in the first, 305 (61%) in the second and 155 (31%) in the third trimester. 34.6% of the subjects reported the use of surma (Kohl). The maternal, blood lead level was similar across in the first, second and third trimester of pregnancy being 14.6 7.9 µg/dL, 14.5 8.0 µg/dL and 14.1 7.6 µg/dl, respectively. No association was found between the reported use of surma and maternal blood lead levels. The various data and findings cited here provide comprehensive support to conclude that Kohl (surma) is primarily not associated with the high blood lead levels in pregnant and lactating mothers if used during pregnancy and demands to investigate in a more organized way, the other factors (occupational or environmental) which may have contributed in the results of the various investigators who reported a high blood lead levels in pregnant women and probably linked the same with the use of Kohl..

CONCLUSION

In conclusion, it can be suggested that Kohl (surma) toxicity or increased blood lead concentration upon it's application to eyes as reported elsewhere are likely to be more theoretical rather than a practical health hazard. The detailed concluding remarks are as under which primarily reflects the conclusion of various authors mentioned in their studies.

1. Details published on chemistry of ancient eye make-up and results of the other studies on chemical composition of Kohls provided reasonable support to conclude that the major constituent of Kohl (surma) from very beginning was galena (lead sulphide) and that "Al-Kuhl" (Kohl), "Surma" and "Ithmid", all indicate only one substance, galena.
2. Lead sulphide from eye cosmetic Kohl has not been reported to cause toxic injury. Also there are no reports of chronic toxicity in the eye and systemic effects from ocular exposure would not be expected from lead.
3. Lead, after application of galena based Kohl is not absorbed through transcorneal route and that a number of studies, both in animals and in humans are available which indicate that Kohl is not responsible for increased blood lead concentration. Further, the high blood lead levels in pregnant and lactating mothers as reported by some authors after the application of Kohl, may be linked with the minerals, specially the calcium mobilization from bone when the body of pregnant women demands more calcium for developing fetus, which can also carry lead with it

and thus a high blood lead level is achieved which should not be linked with Kohl application.

4. The traditional system or Unani/Ayurvedic system of medicine recommends Kohl (surma) only for the prophylaxis and treatment of various eye diseases. Any such usage, like "bakhoor" and application of Kohl to umbilical stump be treated as misuse of the product and the adverse effects thus produced, if any, should not be linked with Kohl.

REFERENCES

Abdelaziz AA and Al-Kofahi A (1989). Microbiological profile of selected samples of A-Kohl eye cosmetics in northern Jordanian provinces before and after use. *Zentralbl. Bakteriol. Mikrobiol Hyg [B]*. **187**(3): 244-253.

Ahamed M and Siddiqui MKJ (2007). Environmental lead toxicity and nutritional factors. *Clinical Nutrition***, 26**: 400-408.

Ahamed M, Sing S, Behari JR, Kumar A and Siddiqui MKJ (2007). Interaction of lead with some essential trace metals in the blood of anemic children from Lucknow, India. *Clin. Chem. Acta.,* **377**: 92-97.

Ali AR, Smales ORC and Aslam M (1978). Surma and lead poisoning. *British Medical Journal*, **2**: 915-916.

Ali S, Iqbal M and Yaqub M (1988). Surma – A toxic cosmetic. *J. Pak. Med. Assoc.*, **38**(10): 281-282.

Al-Ashban RM, Aslam M and Shah AH (2004). Kohl (surma): A toxic traditional eye cosmetic study in Saudi Arabia. *Public Health,* **118**(4): 292-298.

Al-Awamy BH (2001). Evaluation of commonly used and traditional remedies in Saudi Arabia. *Saudi Med. J.*, **22**(12): 1065-1068.

Al-Hazzaa SA and Krahn PM (1995). Kohl: A hazardous eyeliner. *Int. Ophthalmol.,* **19**(2): 83-88.

Al-Kaff A, Al-Rajhi A, Tabbara K and El-Yazigi A (1993). Kohl – the traditional eyeliner; use and analysis. *Ann. Saudi Med.*, **13**(1): 26-30.

Al-Khawajah AM (1992). AlKohl use in Saudi Arabia. Extent of use and possible lead toxicity. *Trop. Geogr. Med.,* **44**(4): 373-377.

Al-Kofahi AS, Abdelaziz AA and Mahmoud II (1989). Cytotoxicity and mutagenicity of Al-Kohl, an eye cosmetic commonly used in Jordan. *J. Clin. Pharm. Ther.,* **14**(6): 443-450.

Almas K (1999). The antimicrobial effects of extract of *Azadirachta indica* (neem) and *Salvadora persica* (arak) chewing sticks. *Indian J. Dent. Res.,* **10**(1): 23-26.

Al-Naemi AH, Al-Khateeb AR, Fattohi BY, Ahmed MM and Al-Jawadi AA (2007). Environmental predictors for high blood lead levels among women of childbearing age in Mosul city. *Medicine and Society*, **5**(4/5): 46-51.

Aslam M, Davis SS and Healy MA (1979). Heavy metals in some Asian medicine and cosmetics. *Public Health London***, 93**: 274-284.

Aslam M, Healy MA, Davis SS and Ali AR (1980). Surma and blood lead in children. *The Lancet,* **22**; 1(8169): 658-659.

Attenburrow AA, Campbell S, Logan RW and Goel KM (1980). Surma and blood lead levels in Asian children in Glasgow. *The Lancet,* **9**; 1(8163): 323.

Awan MH (1956). Kitab al-Mufradat, 2nd edition, Sheikh Ghulam Ali & Sons, Lahore, pp.552.

Awasthi S, Awasthi R, Pande VM, Srivastav RC and Frumkin H (1996). Blood lead in pregnant women in the urban slums of Lucknow, India. *Occupational and Environmental Medicine,* **53**: 836-840.

Awasthi S, Awasthi R and Srivastav RC (2002). Maternal blood lead level and outcomes of pregnancy in Lucknow, North India. *Indian Pediatrics,* **39**: 855-860.

Badam L, Joshi SP and Bedekar SS (1999). *In vitro* antiviral activity of neem (Azadirachta indica A. Juss) leaf extract against group B coxsackieviruses. *J Commun Dis.,* **31**(2): 79-90.

Bakhshi SS (1978). Surma and lead poisoning. *British Medical Journal,* **21**; 2(6145): 1159.

Baptiste W (2008). Kohl – The precursor to modern mascara. *EzineArticle.com.,* pp.1-4.

Barbara W, Donten ML, Donten M, Bulska E, Jackowska A and Sobucki W (2007). *Microchimica Acta,* **159**(1-2): 101-108.

Barltrop D and Khoo HE (1975). The influence of nutritional factors on lead absorption. *Postgraduate Medical Journal,* **51**: 795-800.

Barltrop D and Meek F (1975). Absorption of different lead compounds, *Postgraduate Medical Journal,* **51**: 805-809.

Barltrop D, Strehlow CW, Thornton I and Webb JS (1975). Absorption of lead from dust and soil. *Postgraduate Medical Journal,* **51**: 801-804.

Barltrop D, Strehlow CW, Thornton I and Webb JS (1974). Significance of high soil lead concentration for childhood lead burdens. *Environ. Health Perspect,* **7**: 75-82.

Betts PR, Astley R and Raine DN (1973). Lead intoxication in children in Birmingham. *British Medical Journal,* **1**: 402-406.

Bogden JD, Kemp FW, Han S, Murphy M, Fraiman M and Czerniach D (1995). Dietary calcium and lead interact to modify maternal blood pressure, erythropoiesis, and fetal and neonatal growth in rats during pregnancy and lactation. *J. Nutr.*, **125**: 990-1002.

Bosworth CE, Donzel EV, Lewis B and Pellat C (1986). *The Encyclopedia of Islam.* Prepared under the patronage of the International Union of Academics, **5**: 356-357.

Bruening K, Kemp FW, Simone N, Holding Y, Louria, DB and Bogden JD (1999). Dietary calcium intakes of urban children at risk of lead poisoning. *Environ. Health Perspec.,* **107**(6): 431-435.

Bruyneel M, DeCaluwe JP, Des Grottes JM and Collart F (2002). Use of Kohl and severe lead poisoning in Brussels. *Rev. Med. Brux.,* **23**(6): 519-522.

Buchet JP, Roels H, Hubermont G and Lauerys R (1978). Placental transfer of lead, mercury, cadmium, and carbon monoxide in women. II. Influence of some epidemiology factors on the frequency distributions of the biological indices in maternal and umbilical cord blood. *Environ. Res.,* **15**: 494-503.

Catherine CJ (2005). Kohl as traditional women's adornment in North Africa and Middle East, *Introduction to Harquus: Part 2: Kohl,* pp.1-9.

Chamberlain AC, Heard MJ, Little P, Newton D, Wells AC and Wiffen RD (1978). Investigation into lead from motor vehicles. *AERE Report, HMSO,* London, R-9198.

Chaochum Z and Zhengyan Z (2004). Blood lead levels among children aged 0-15 years in Hangzhou, China, *Indian Pediatrics,* **41**: 404-406.

Chopra RN, Chopra IC, Handa KL and Kapur LD (1958). Chopra's Indigenous Drugs of India, U.N. Dhur & Sons, Calcutta, pp.323-325.

Cohen M (1999). Cosmetics and perfumes, Egypt, 10,000 BCE.

Cullen G, Dines A and Kolev S (1996). Monograph for UKPID (Lead), published by the National Poisons Information Service (London Centre), pp.1-46.

Dastur JF (1952). Medicinal Plants of India and Pakistan. Published by D.B. Taraporevala Sons & Co. Ltd., Bombay, pp.42-45.

David NF, Allen CM and Astrid BB (2000). *Eerdmans Dictionary of the Bible*, published by WMB Eerdmans Publishing, pp.287.

Devine D (2006). Kohl: Drawing the line. *Habbibi-Middleeastern Music & Dance Journal,* **21**(2): 1-6.

Dieter MP, Matthews HB, Jeffcoat RA and Moseman, RF (1993). Comparison of lead bioavailability in F344 rats fed lead acetate, lead oxide, lead Sulphide, or lead ore concentrate from Skagway, Alaska. *J. Toxicol. Environ. Health,* **39**(1): 79-93.

Engelbach R (1961). Introduction to Egyptian Archaeology with Special Reference to the Egyptian Museum, Cairo. Published by the Ministry of Culture and National Orientation Antiquities Department of Egypt, pp.343.

EPA–US (1994). More about the model. Chapter 4, Publication No.9285-7-15-1, pp.1-67 by Environmental Protection Agency – US.

Epstein HA (2004). Cosmetic Science Regulation, Skinmed: *Dermatology for the Clinician,* **3**(3): 160-162.

Falk H (2003). International environmental health for the pediatrician: case study of lead poisoning. *Pediatrics,* **112**(1): 259-264.

Farida A, Sadaruddin A and Naz K (2005). Effect of environmental lead pollution on blood lead levels in traffic police constables in Islamabad-Pakistan. *J. Pak. Med. Assoc.,* **55**(10): 410-413.

Fernando NP, Healy MA, Aslam M, Davis SS and Hussein A (1981). Lead poisoning and traditional practices: the consequences for World Health. A study in Kuwait. *Public Health London,* **95**: 250-260.

Fischer X (1892). The Ancient Egyptian Eye Preparation, *Arch Pham,* **230**: 9.

Forsyth PY (2000). The medicinal use of saffron in the Aegean Bronze Age. *Mouseion – J. Class. Asso. Canada, Classical Views,* **XLIV**, **19**(2): 1-18.

Freeman GB, Dill JA, Johnson JD, Kurtz PJ, Parham F and Matthews HB (1996). Comparative absorption of lead from contaminated soil and lead salts by weanling fischer 344 rats. *Fundamental and Applied Toxicology,* **33**: 109-119.

Frost RL, Martens W and Williams P (2003). Raman spectroscopy of some basic chloride containing minerals of lead and copper. *Mineralogical Magazine*, **61**(1): 103-111.

Gadenne P, Yagil Y and Deutscher G (1989). Transmittance and reflection in-situ measurements of semicontinuous gold film during deposition. *J. Appl. Phys.,* **66**: 3019.

Gilfillan SC (1965). Lead poisoning and the fall of Rome. *J. Occup. Med.,* **7**: 53-60.

Glanville SRK (1947). The Legacy of Egypt. Published by Oxford University Press, p.123.

Gogte ST, Basu N, Sinclair S, Ghai OP and Bhinde NK (1991). Blood lead levels of children with pica and surma use. *Ind. J. Pediatr,* **58**: 513-519.

Gordon N, King E and Mackay RI (1967). Lead absorption in children. *British Medical Journal,* **2**: 480-482.

Goyer RA (1990a). Lead toxicity: from overt to subclinical to subtle health effects. *Environmental. Health Perspectives,* **86**: 177-181.

Goyer RA (1990b). Transplacental Transport of lead. *Environmental. Health Perspectives,* **89**: 101-105.

Goyer RA (1993). Lead toxicity: current concerns. *Environmental Health Perspectives,* **100**: 177-187.

Grant WM and Schuman JS (1993). *Toxicology of the eye.* 4th ed., Charles C Thomas, Springfield, Illinois, pp.682-685.

Green SDR, Lealman GT, Aslam M and Davis SS (1979). Surma and blood lead concentrations. *Public Health, London,* **93**: 371-376.

Grigg J (2004). Environmental toxins; their impact on children's health. *Arch. Dis. Child.*, **89**: 244-250.

Gulson BL, Davis JJ, Mizon KJ, Korsch MJ and Law AJ (1994). Lead bioavailability in the environment of children: Blood lead levels in children can be elevated in a mining community. *Archives of Environmental Health,* **49**(5): 326-331.

Hammad TA, Sexton M and Langenberg P (1996). Relationship between blood lead and dietary iron intake in preschool children: a cross-sectional study. *Ann. Epidemiol.,* **6**: 30-33.

Han S, Pfizenmaier DH, Garcia E, Eguez ML, Ling M, Kemp FW and Bogden JD (2000). Effects of lead exposure before pregnancy and dietary calcium during pregnancy on fetal development and lead accumulation. *Environ. Health Perspec.,* **108**(6): 527-531.

Haq I and Khan C (1982). Hazards of a traditional eye cosmetic – Surma. *J. Pak. Med. Associ.*, **32**(1): 7-8.

Hardy AD, Vaishnav R, Al-Kharusi SSZ, Sutherland HH and Worthing MA (1998). Composition of eye cosmetics (Kohls) used in Oman. *J. Ethno Pharmacol*., **60**: 223-234.

Hardy AD, Sutherland HH and Vaishnav R (2002). A study of the composition of some eye cosmetics (Kohls) used in the United Arab Emirates. *J. Ethnol Pharmacol.,* **80**: 137-145.

Hardy AD, Walton RI and Vaishnav R (2004). Composition of eye cosmetics (Kohls) used in Cairo. *Int. J. Environ. Health Res.*, **14**(1): 83-91.

Hardy AD, Walton RI, Myers KA and Vaishnav R (2006). Availability and chemical composition of traditional eye cosmetics (Kohls) used in the United Arab Emirates of Dubai, Sharja, Ajman, Umm Al-Quwain, Ras Al-Khaimah, and Fujairah. *J. Cosmet. Sci.*, **57**(2): 107-125.

Harris JR (1962). Ancient Egyptian Materials and Industries (Revised), (through: Bosworth *et al*., 1986, p.356), pp.195-199.

Healy MA and Aslam M (1986a). Eastern eyes. *Nursing Times.* October, pp.36-37.

Healy MA and Aslam M (1986b). Lead containing preparations in the Asian community a retrospective survey. *Public Health***,** **100**: 149-151.

Healy MA, Harrison PG, Aslam M, Davis SS and Wilson CG (1982). Lead Sulphide and traditional preparation: Routes for ingestion, and solubility and reaction in gastric fluid. *J. Clin. Hosp. Pharm.,* **7**: 169-173.

Heard MJ and Chamberlain AC (1982). Effect of minerals and food on uptake of lead from gastrointestinal tract in human. *Hum. Toxicol.,* **1**: 411-415.

Heather CR (1981). *Art of Arabian Costume – A Saudi Arabian Profile.* Information on Kohl application. Arabesque Commercial, Saudi Arabia, pp.1-188.

HMSO (1978). Lead pollution in Birmingham. *HMSO Pollution Paper* No.14 (through: Bakshi, 1978, p.1159).

Hu H (1988). Heavy metal poisoning. *In:* Harrison's Principles of Internal Medicine (Eds: Fauci *et al*.), McGraw Hill, NY, pp.2564-2566.

Iman N, Nabulsi M, Muwakkit S, Kouzi S, Salem G, Mikati M and Ariss M (2003). Blood lead concentration in 1-3 year old Lebanese children: A cross-sectional study. Environmental Health: A global access science source. **2**: pp.5-13.

Jaffery FN (2001). Current status of lead in India. Report released on World Environment Day, UNEP, pp.1-42.

Jallad KN and Hedderich HG (2005). Characterization of a hazardous eyeliner (Kohl) by confocal Raman microscopy. *J. Hazard. Mater*., **30**: 124(1-3), 236-240.

Jones TF, Moore WL, Craig AS, Reasons RL and Schaffner W (1999). Hidden threats: Lead poisoning from unusual sources. *Pediatrics,* **104**(5): 1223-1225.

Kapoor VP (2007). Kohl and Sindoor: the potential source of lead poisoning. *EnviroNews,* **13**(3): 5-7.

Kathy C (2001). *An A to Z of places and things Saudi*. Published by Stacey International Stacey International, pp.139.

Kaushal D (2008). Fashion for your eyes only. *The Tribune India*, (Online edition) January **5**: 1-2.

Kent JJ (2004). Curative and medicinal uses of precious stones, Precious Stones Guide, **9**: 1-2.

Keville K and Green M (1995). *A History of fragrance*. The Crossing Press, pp.1-156.

Khalid Q, Maryam M, Qadeeruddin M, Rahman Z, Qureshi IH and Rizvi SSH (1992). Scientific investigation on surma. *Pak. J. Sci. Ind. Res.,* **35**(1-2): 30-31.

Khalid Q, Ismat M, Sultana L and Qadeeruddin M (1995). Studies on the blood lead levels after application of surma to eyes in children and adults. *Pak, J. Pharmacol.,* **12**(2): 37-41.

Khan AH, Khan A, Ghani F and Khurshid M (2001). Low-level lead exposure and blood lead levels in children: a cross-sectional survey. *Arch. Environ. Health,* **56**(6): 501-505.

Khan K, Saeed A and Alam MT (1997). Indusyunic Medicine, traditional Medicine of herbal, Animal and Mineral Origin in Pakistan, BCC&T Press, University of Karachi, pp.1-591.

Kirtikar KR and Basu BD (1984). Indian Medicinal Plants. Bishen Singh Mahendra Pal Sigh, **I**: 1920; **II**: 873-874; 1211-1212; **IV**: 2462-2463.

Koller K, Brown T, Spurgeon A and Levy L (2004). Recent development in low level lead exposure and intellectual impairment in children. *Environ. Health Perspect.,* **112** (9): 987-994.

Lekouch N, Sedki A, Nejmeddine A and Gamon S (2001). Lead and traditional Moroccan Pharmacopoeia. *Sci. Total Environ*, **3**: 280(1-3), 39-43.

Lev E (2002). Reconstructed material medica of the Medieval and Ottoman Al-sham. *J. Ethnopharma-cology,* **80**: 167-179.

Levesque B, Rhainds M and Prudhomme H (1999). Lead exposure investigation and follow-up protocol for nunavik. Manual of Public Health, Nunavik Public health Direction, pp.1-21.

Levey M and Al-Khaledy N (1967). The Medical Formulary of Al-Samarquandi. Published by University of Pennsylvania Press, Pennsylvania, pp.136.

Linda SR (2001). Mosby's Handbook of Herbs & Natural Supplements, Mosbey, pp.616-618.

Li-Yun C, Wen H, Jian-Feng H and Jian-Peng W (2008). Influence of deposition voltage on properties of lead sulfide thin film. *American Ceramic Society Bulletin,* **87**(6): 9101-9104.

Mahaffey KR (1974). Nutritional factors and susceptibility of lead toxicity. *Environmental Health Perspectives,* **7**: 107-112.

Mahaffey KR (1990). Environmental lead toxicity: Nutrition as a component of intervention. *Environmental Heath Perspectives,* **89**: 75-78.

Mahaffey KR (1991). Biokinetics of lead during pregnancy. *Fundam. Appl. Toxicol,* **16**: 15-16.

Mahaffey-Six MK and Goyer RR (1970). Experimental enhancement of lead toxicity by low dietary calcium. *J. Lab. Clin. Med.,* **76**: 933-942.

Manser WWT (1989). Surma – A toxic cosmetic. *J. Pak. Med. Asso.*, **39**(7): 196.

Martinetto P, Dooryhee E, Anne M, Talabot J, Tsoucaris G and Walter P (1999). Cosmetic recipes and make-up manufacturing in ancient Egypt. *Newsletter,* ESRF-April, pp.10-11.

Martinetto P, Anne M, Dooryhee E, Drakopoulos M, Dubus M, Saloman J, Simionovici A and Walter P (2001). Synchrotron X-ray micro-beam studies of ancient Egyptian make-up. Nuclear Instrument and Methods in Physics Research, Section B: *Beam Interaction with materials and Atoms,* **181**: 744-748.

Meri JW (2006). Cosmetic. *In:* Medieval Islamic Civilization – An Encyclopedia, **1**: 177.

Miller GD, Massaro TF and Massaro EJ (1990). Interaction between lead and essential elements: A review. *Neurotoxicology,* 11: 99-120.

Mirando EH and Gomez M (1967). Lead poisoning in Childhood in Ceylon. *Arch. Dis. Childh.,* **42**: 579-582.

Miriam S (1986). Egyptian Life, published by British Museum Publications, London, pp.1-72.

Mitchnick MA, Fairhurst D and Pinnell SR (1999). Microfine zinc oxide (Z-Cote) as a photostable UVA/UVB sunblock agent. *J. American Academy of dermatology,* **40**: 85-90.

Moghraby SA, Abdullah MA, Karrar O, Akiel AS, Shawaf TA and Majid YA (1989). Lead concentrations in maternal and cord blood in women users of surma eye cosmetics. A*nnals Trop. Paediat.,* **9**: 49-53.

Mojdehi GM and Gurtner J (1996). Childhood lead poisoning through Kohl. *American Journal of Public Health,* **86**(4): 587-588.

Moncrieff AA, Koumides OP, Barbara E, Clayton E, Patrick AD, Renwick AGC and Roberts GE (1964). Lead poisoning in children. *Arch. Dis. Childh.*, **39**: 1-13.

Monographs of Unani Medicine (2003). Surma. Hamdard Foundation Pakistan and DC & TMD, National Institute of Health, Islamabad, Pakistan, pp.1-664.

Nadkarni AK (1954). Phimbi Sulphuratum. *Indian Materia Medica,* **II**: 87-90.

Nair PK, Garcia VM, Hernandez AB and Nair MTS (1991). Photoaccelerated chemical deposition of PbS thin films: novel applications in decorative coatings and imaging. *J. Phys. D: Appl. Phys.,* **24**: 1466-1472.

Nair PK, Gomezdaza O and Nair MTS (1992). Metal sulphide thin film photography with lead sulphide thin film. *Adv. Mater. Opt. Electron.,* **1**: 139.

Narada T (2000). Ancient cosmetics and fragrance. Egypt, Greece and Rome. Cyonic Nemeton, pp.1-6.

Nir A, Tamir A, Zelnik N and Iancu TC (1992). Is eye cosmetic a source of lead poisoning? *Isr. J. Med. Sci.* **28**(7): 417-421.

Nnorom IC, Igwe JC and Oji-Nnorom CG (2005). Trace metal contents of facial (make up) cosmetics commonly used in Nigeria. *African Journal of Biotechnology***, 4** (10): 1133-1138.

Ong CN, Phoon WO, Law HY, Tye CY and Lim HH (1985). Concentrations of lead in maternal blood, cord blood, and breast milk. *Arch. Dis. Child.* **60**: 756-759.

Osman K, Schutz A, Akesson B, Maciag A and Vahter M (1998). Interaction between essential and toxic elements in lead exposed children in Katowice, Poland. *Clin. Biochem.,* **31**: 657-665.

Paloucek FP (1993). Lead poisoning. *Am. Pharm.,* NS **33**(11): 81-88.

Pande M and Flora SJS (2002). Lead-induced oxidative damage and its response to combined administration of lipoic acid and succimers in rat. *Toxocology,* **177**: 187-96.

Parry C and Eaton J (1991). Kohl: A lead hazardous eye makeup from the third world to the first world. *Environmental Health Perspectives,* 99: 121-123.

Patra RC, Swarup D Dwidedi SK (2001). Antioxidant effect of a – tocopherol, ascorbic acid and L-methionine on lead induced oxidative stress of the liver, kidney and brain in rats. *Toxicology,* **162**: 81-88.

Pauline WT (2007). Ancient Egyptian costume history, Part 6- Ancient Egyptian make up and cosmetics. www.fashion-era.com.

Pop I, Nascu C and Lonescu V (1997). Structural and optical properties of PbS thin films obtained by chemical deposition. *Thin Solid Films,* **307**: 240-244.

Raber L (2002). Hair color – Chemistry to dye for. *ChemMatters,* pp.10-11.

Rahbar MH, White F, Agboatwalla M, Hozhabri S and Luby S (2002). Factors associated with elevated blood lead concentration in children in Karachi, Pakistan. *Bulletin of the World Health Organization,* **80**(10): 769-775.

Ray T.K and Lasker AR (2004). Selected Summaries – Lead intoxication in children: A global concern. *The National Medical Journal of India,* **17**(6): 320-321.

Reynolds SJ, Seem R, Fourtes L, Sprince NL, Johnson J, Walkner L, Clarke W and Whitten P (1999). Prevalence of elevated blood leads and exposure to lead in construction trades in Lowa and Illinois. *Am. J. Indus. Med.,* **36**: 307-316.

Richard W and Clara W (1962). Science and secrets of early medicine. Published by Helen and Kurt Wolff Book Harcourt, Brace & World Inc., New York, pp 82-83.

Rosenblatt M (1906). Beitrage zur Kenntniss der chronischen Bleivergiftung, *Rostock,* pp.86-100.

Rostovtzeff M (1957). The social and economic history of the Roman Empire, Oxford, pp. 532-541.

Sadruddin A and Manser WWT (1992). Blood lead levels in traffic constables in Karachi, Pakistan. *J. Environ. Health,* **55**: 20-21.

Safi J, Fischbein A, El-Haj S, Sansour R, Jaghabir M *et al*. (2006). Childhood lead exposure in the Palestinian authority, Israel, and Jordan: Results from the Middle Eastern Regional Cooperation project, 1996-2000. *Environmental Health Perspective,* **114**(6): 917-922.

Santiago N and Alex C (2006). Burton's Line. *The New England Journal of Medicine,* **354**(20): e21.

Saxena DK, Singh C, Murthy RC, Mathur N and Chandra SV (1994). Blood and placental lead levels in an Indian city: A preliminary report. *Archives of Environmental Health,* **49**(2): 106-110.

Silbergeld EK (1991). Lead in bones: implications for toxicology during pregnancy and lactation. *Environ. Health Perspect.,* **91**: 63-70.

Snodgrass GJAI, Ziderman DA, Gulati V and Richards J (1973). Cosmetic plumbism. *British Medical Journal,* **27**: 230.

Snyder LJ (1947). Improved dithiazone method for determination of Lead. *Indust. & Engin. Chem.* (An Ed.), **19**: 684.

Specht W and Fischer K (1959). Vergiftungsnachweis an den Resten einer 900 Jahre alten Leiche. *Arch. Kriminol.,* **124**: 61-84.

Sprinkle RV (1995). Leaded eye cosmetics: A cultural cause of elevated lead levels in children. *J. Fam. Pract.,* **40**: 358-362.

Srivastava PC and Varadi S (1968). Lead poisoning from unusual source. *British Medical Journal,* **2**: 578.

Steele MJ, Beck BD, Murphy BL and Strauss HS (1990). Assessing the contribution from lead in mining wastes to blood lead. *Regul. Toxicol. Pharmacol.,* **11**(2): 158-190.

Susan JH (2003). Ancient African Civilizations To ca. 1500 – Text supplement and study guide for history/PAS 393, revised edition, pp.1-63.

Sweha F (1982). Kohl along history in medicine and cosmetics. *Hist. Sci. Med.,* **17**(2): 182-183.

Sykes CP, Claeys-Thoreau F and Petit D (2000). Blood lead levels and cosmetics. *International Journal of Cosmetic Science,* **22**: 395-396.

Tabaku A, Bizgha V and Rahlenbeck SI (1998). Biological monitoring of lead exposure in high risk groups in Berat, Albania. *J. Epidemiology and Community Health,* **52**: 234-236.

Tahseen K and Amir O (2005). Control of lead poisoning in Pakistan. *Journal of Pakistan Medical Association,* **55**(10), 409-410.

Tietz NW (1983). Chemical Guide to Laboratory Test. SW Saunders Co. pp.314.

Tsoucaris G, Martinetto P, Walter P and Leveque JL (2001). Chemistry of cosmetics in antiquity. *Ann. Pharm Fr.,* **59**(6): 415-422.

Unger T, Martinetto P and Ribarik G (2002). Revealing the powdering methods of black makeup in Ancient Egypt by fitting microstructure based Fourier coefficients to the whole x-ray diffraction profiles of galena. *J. Appl. Phys.,* **91**(4): 2455.

Vaishnav R (2001). An example of the toxic potential of traditional eye cosmetics. *Indian Journal of Pharmacology,* **33**: 46-48.

Waldron HA (1973). Lead poisoning in the ancient world, *Med. Hist,* **17**(4): 391-399.

Walter P (1999). Chemistry of ancient Egyptian cosmetics. *Actualite Chimique,* **11:** 134-136.

Walter P, Martinetto P, Tsoucaris G, Breniaux R, Lefebvre MA, Richard G, Talabot J and Dooryhee E (1999). Making make-up in Ancient Egypt. *Nature* (London), **397**: 483-484.

Walter P, Welcomme E, Hallegot P, Zaluzec NJ, Deeb C, Casting J, Veyssiere P, Breniaux R, and Leveque JL (2006). Early use of PbS nanotechnology for an ancient hair dying formula. *Nano Letters,* **6**(10): 2215-2219.

Warley MA, Blackledge P and Gorman PO (1968). Lead poisoning from eye cosmetic. *British Medical Journal,* **13**: 117.

West WL, Knight EM, Edwards CH, Manning M, Spurlock B, James H, Johnson AA, Oyemade UJ, Cole OJ, Wesney OE, Laryea H, and Jones S (1994). Maternal low level lead and pregnancy outcomes. *The Journal of Nutrition,* **124**(Supp. 6): 981S-986S.

Wetherill GW, Rabiowitz M and Kopple JD (1975). Sources and metabolic pathways of lead in normal humans. Proceedings of the International Conference on Health Effect of Environmental Pollution. *CEC Consultants,* Paris (through: Healy *et al.,* 1982, p. 169-173).

Yursil. http://www.yursil.com/blog/2007/05/Kohl-Surmah-Lead-Concerns.

Zaheer BH, Mahmood ZA and Zoha SMS (1991). Therapeutic evaluation of surma (Kohl) formulations. *Pak. J. Sci. Ind. Res*., **34**(9): 335-338.

Zhang F, Chen Y and Jiang X (2001). A study on relationship between blood lead level in children and fetal umbilical cord. *Zhonghua Yu Fang Yi Xue Za Zhi.* **35**(1): 42-43.