

Minor to Chronic Eye Disorders Due to Environmental Pollution: A Review

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Abstract

Eye is the most vulnerable organ to atmospheric and environmental insults. Though, naturally eyes are structured to protect itself from foreign objects such as, dust, wind, and very bright light, for the purpose of vision they need to remain open. Chronic exposure to toxic pollutants via air and water damages the eye from minor irritation to retinal bleeding. Taking a shower in water contaminated with chemicals can degrade eye health and vision slowly over the time. Exposure to increased noise, flood light sources, global warming, intense infra-red and UV radiations too damages our vision. Since eyes need protection from these hazardous environmental pollutants, this review recommends further detailed scientific study to understand the ways and means for protection.

Keywords: Infra-red; UV radiations; Xenoestrogens; Air pollution

Introduction

In addition to the skin, the other sense organ, the eye, on human body is constantly exposed to the atmospheric components; therefore, the eyes are also vulnerable and can easily be damaged due to the ill effects of several pollutants present in the environment. The eye is made up of different types of tissue some of them are more delicate than others and therefore they are situated deeper e.g. retina. The eye as an organ is sensitive to light and atmospheric pressure and therefore its functions, to a large extent depend on the quality of the environment [1]. The most important function of the eye is to provide three-dimensional vision and colored image in daylight. If the environmental conditions are not conducive, its functions are hampered. Chronic exposures to toxic pollutants present in air, water as well as in soil can damage the eye in various ways.

Environmental pollutants, airborne toxins, poorly ventilated buildings had a profound toxicological effect on the on the ocular surface of human eye [2-4]. Environmental factors like pollutants, temperature variations, ultraviolet radiations, toxic gases, chemicals, bacteria, smoking, various drugs, variable humidity, and cosmetics affect the various parts of eyes like cornea and conjunctiva in several ways leads to plenty of eye disorders like cataract, conjunctivitis, glaucoma and dry eye [5].

The Effects of photochemical air pollution on the human eye were epidemiologically investigated by Okawada et al., [6] and the results shows that the human tear lysozyme [HTL] and the tear pH were varied by means of eye irritation and the corneal epitheliopathy.

Indoor fuel exposure, in particular biofuel triggers an increased frequency of lens opacities. In addition, exposure to styrene affects the color vision, chronic exposure to carbon disulfide leads to retinal vascular changes and retinopathy, exposure to carbon monoxide [CO] leads to retinal and choroidal haemodynamics, and the exposure to carbon di-sulphide caused an increase in retinal venous diameters and CO caused an increase in arterial and venous diameters, retinal blood flow velocity, and fundus pulsation amplitude [7].

Literature Review

The present review deals with minor and temporary irritation to chronic disorders in the eye due to polluted atmosphere and surroundings by microbes and/or and toxic particulate chemicals and gaseous substances.

Natural protection to the eye

Eye is an important sense organ and nature has protected it utmost by providing eyebrows, eyelashes, eyelids and the protective layer of oil from the external atmosphere. Eyelashes keep foreign pollutants particles away from the eye by acting as a physical barrier and by causing the person to blink reflexively at the slightest sensation. As far as eye lids are concerned the upper and lower eyelids are thin flaps of skin and muscle that can cover the eye, and they reflexively blink to form a mechanical barrier that protects the eye from foreign objects, dust wind, and very bright light [8,9].

The conjunctiva provides cellular defense and protects the sensitive tissues underneath it from pollution, where on the moist back surface of the eyelid, the conjunctiva coils around to cover the visible surface of the eyeball and up to the edge of the cornea [1,10].

The eyelids help to spread tears uniformly over the surface of the eye when it got blinked. Small glands at the edge of the upper and lower eyelids secrete an oily substance that contributes to the tear film and keeps tears from evaporating. Tears contain three components, e.g., water, mucous, and oil. The tear glands are responsible for the production of water layer. Mucous glands in the conjunctiva produce mucus, and oil [lipid] glands in the eyelid margin produce oil. The mucus and oil mix with the watery portion of the tears to create a more protective tear film [11]. Tears constantly cleanse the surface of the eye and keep the cornea transparent. The cornea gets oxygen and nutrients through tears by keeping the surface moist. In the absence of moisture, the cornea becomes dry and opaque; in turn can easily injured and infected. Tears also trap and sweep away small pollutant particles that enter into the eye. Moreover, tears are rich in antibodies that help prevent infection. The eyelids and tears shield the eye while undesirable light rays entering the eye [12].

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Discussion

Environmental pollution contributes many problems to the human eyes; in addition to this natural inherited disease and ill health may also cause severe damage to our eyes [13]. Xenoestrogens which are present in pesticides, herbicides, and fungicides, plastic goods, creams and cosmetic, etc. can reach us through air, water and food. These weak synthetic estrogens bind to the steroid receptors of our eyes and can cause diseases such as dry eye syndrome, uveitis, retinal bleeding and cataracts [14-16] (Table 1).

A study performed by the scientists from AIIMS, New Delhi, India during 2015 has proved that 10-15% of people in Delhi suffer from chronic irritation and dry eye syndrome [10] due to constant exposure to a high level of air pollutants. Long term exposure to air pollutants can damage the outer layer of the eye. It can also alter lipid profile and water contents of tears leading to chronic irritation.

Air pollution

Exposure to air pollutant generally causes ocular symptoms ranges from minor eye irritation to severe chronic discomfort, nevertheless detrimental effects of long term exposure to air pollutants on eyes are still not well known [17-19].

According to WHO, air pollution is the single largest environmental health risk. A particulate polluted environment may influence cause or some eye diseases. Ozone [O₃] is a secondary pollutant which is generated by the primary pollutants such as NO and NO₂, are known to be carried to long distances and can cause long range severe adverse effects on human health. A study conducted by Bourcier et al. [20] has indicated the existence of a strong relation between air NO, NO₂ concentrations and conjunctivitis, the increased levels of air pollution resulted in an ophthalmological emergency among the people of Paris. Lal and Patil [21] have stated that according to Schwela [22] these pollutants can create a change in the lacrimal pH and could exert irritant effect on the ocular surface. The harmful ultraviolet rays generated by air pollutants especially CFC or chlorofluorocarbons emitted by air conditioners, refrigerators and aerosol sprays not only deplete the ozone layer but also can damage the eyes.

Environmental Pollutants	References
Exposure to airborne toxins and poorly ventilated buildings	[2-4]
Exposure to photochemical air pollutants	[6]
Exposure to carbon monoxide and carbon disulphide	[7]
Xenoestrogens	[8-10]
Bisphenol A (BPA)	[17]
Tobacco smoke exposure	[19-22]
Particulate Matter	[34,35]
Acrolein and formaldehyde and aldehydes	[18, 37-39, 41]
Exposure to noise level beyond 115db	[23]
Ultraviolet radiation from Sun por artificial light source	[24-25]
Mobile phones, lap tops and TV screens	[26-29, 55-56]
An average rise of ambient temperature of 3°C	[30-32]
Welding process, Bursting firecracker, House hold cooking	[33-39]
Waterborne pathogens	[40-42]

Table 1: List of environmental pollutants causing chronic eye disorders.

Parameters such as humidity, atmospheric pressure and wind strength may directly affect tear film stability and can also cause ocular surface complaints [23,24]. Hydrogen sulphate in the air when come in contact with aqueous humour, the fluid of the eyes can cause dizziness, even blindness in extreme cases. Acute and chronic exposures to household air pollution [HAP] during cooking and heating in developing countries has resulted not only in eye irritation but also caused blinding in majority of population, and the usage of biomass fuels especially kerosene can cause nuclear cataract for women but not for men in India [25]. Gupta et al. [15], stated that air pollution can leads to dry eye syndrome, conjunctivitis and can make the eyes sensitive to bright light, the increased urbanization induces 16 times increase in the particulate matter pollutant level at the capital city of Delhi which has adverse effect on the eye health of the public. During 1950, in Los Angeles and 1970s in Tokyo photochemical pollution has caused Urban eye allergy syndrome and the incidence of eye problems among the urban public includes dryness, burning sensation, watering, redness, allergic conditions, roping discharge, eyelid swelling, and inability to open eyes, vision problem and severe irritation of the eyes. The sources of air pollutants in those two cities were carbon monoxide, nitrogen dioxide, water vapor, particulate matter, sulphur dioxide, asbestos, arsenic, benzene, lead, dioxin chlorofluorocarbons, etc. [25].

Bisphenol A [BPA] is being recognized as an endocrine-disrupting chemical [EDC] and it has been proved that BPA affects the central nervous system [CNS] of *Xenopus laevis* [African clawed frog] though the molecular mechanism is not well known [26]. Abnormalities such as eye dysplasia, and loss of pigments were also noticed among their larvae.

Very high levels of subclinical ocular surface changes among persons travelling in highly polluted areas and toxins have direct access to these ocular structures and can abnormally affect cornea due to the constant contact of the pre-ocular tear film with the surrounding air and the study conducted by Thornton et al. [27] suggested that the quality of environmental air can result in premature break-up of the pre-ocular tear film and corneal epithelial damage and can lead to significant ocular irritation and discomfort.

Environmental tobacco smoke exposure increases risk of ophthalmopathy in Grave's disease. A direct correlation exists between thyroid eye disease and amount of smoking [28] and the eye diseases and conditions associated with exposure to tobacco smoke in children include strabismus, and the maternal smoking during pregnancy is associated with 6.55 times increased risk of strabismus amongst children. Endotoxins formed in tobacco smoke induce inflammatory response, acute uveitis and age-related macular degeneration [29-31] Smoking affects the ocular surface, which results in symptoms like itchiness, redness and irritation of eyes and the changes on ocular surface associated with smoking include alteration in lipid layer of tear film, reduced tear secretion and decreased corneal and conjunctival sensitivity and cause disorders including atopic kerato-conjunctivitis and allergic conjunctivitis [30].

Air pollutant in the form of particulate matter [PM] as small as 10 nm has an adverse effect on human eye. PM can be found in significant amounts in tobacco smoke, soot, or smog [32,33]. In addition, the World Health Organization [WHO] designated airborne PM as a Group 1 carcinogen, and the reported symptoms caused due to the exposure to PM are eye itching, burning eye irritation, sensory irritation and allergic rhinitis [34,35].

Apart from this another indoor air pollutant such as second-hand smoke releases an increased level of PM 2.5 which is 10 times higher

than non-smoking homes [36], and the exposure to these pollutants induces lipid oxidative stress on eyes and alter the cytokine content of tears and ocular surface, subsequently leads to inflammation and development of dry eye disease as they are rich in acrolein and formaldehyde [37-39]. These organic vapours [formaldehyde, acrolein] are usually respiratory irritant and predominately secondary reaction products from photochemical reactions in air of hydrocarbons with nitrogen oxides [40]. Generally, 20% of the total formaldehyde, acrolein and aldehydes are mainly emitted in combustion processes, which is sufficient to cause eye irritation [41].

Formaldehyde [HCHO] is the most abundant carbonyl compound in the atmosphere which is emitted from incomplete combustion processes such as combustion engines, biomass burning, produced by photo-oxidation of hydrocarbons, unrefined cooking oils, under high temperature cooking conditions, trace amounts from vegetation, and especially from the furniture made up of hardwood plywood wall paneling, particle board, fiber board can cause severe eye irritation, corneal and conjunctival sensitivity in humans [42-46].

Noise pollution

According to studies, noise pollution can also affect the eyes, and the environment of loud noises for a long time causes eye strain, eye pain, blurred vision, tearing, abnormality in color vision and eye shot. Noise decreases the sensitivity of human visual receptor cells above 90db and results in lengthening of the reaction time for faint light, whereas noise above 95db can lead to mydriasis and blurred vision which has been proven among 40 % of the exposed population. Most people have difficulty in responding to lightness when exposed to noises of 115db [47].

Radiation pollution

Exposure to harmful radiation such as electromagnetic radiation at workplaces can influence human vision and ocular physiopathology [48]. A study by Johnson in 2004 has stated that global warming and ultraviolet radiation as the two commonest cause of the human blindness, where global warming is the prominent factor for the early onset and rapid progression of cataract. While, increased Ultra violet radiation due to the depletion of ozone is the causative agent for acute photo keratitis, photoconjunctivitis, climatic droplet keratopathy, pterygium and trachoma disorders. Van Kuijk [49] revealed that ultraviolet radiation either from The Sun or artificial source of light can also be lead to eyelid cancer, whereas the skin cancer is basal cell carcinoma of lower lid but can occur anywhere on the eyelids including the eyebrows and skin around the eyes.

Light pollution

The progressive extension of the human activity into night-time, due to the availability of artificial light sources with low energy prices, has been identified as a likely cause of disruption of the circadian patterns of the population, with potentially significant health consequences on eyes [50]. The environmental illumination influences the human health where, photoreceptive retinal ganglion cells [pRGCs] are primary mediators of numerous circadian, neuroendocrine and neurobehavioral responses. Typical residential lighting is insufficient for optimal pRGC requirements in youth and it may leads to chronodisruption, caused by light deficiency [51]. Ophthalmologist identified that continuous use of mobile phones, lap tops and TV screens before bedtime in the dark can cause extensive strain to eyes which result in a condition called computer vision syndrome or digital eye strain [52]. Mobile devices emit high energy visible [HEV] light and it can be

responsible to cause changes in certain cells of eyes. It can initially cause dry eyes syndrome, and strain to eyes and continuous glare over half an hour can cause irreversible eye macular degeneration resulting in rapid deterioration of vision. Usage of smart phones may also lead to dry eye disorder especially among the young children [53,54]. The eyes having fewer number of vessels while comparing with other organs, so these radiations have much more impacts on eyes, they can cause heating effects, cataracts, lesions, irritation and stress on eyes, usually these can lead to early cataract in lens apart from affecting retina, cornea and other parts of eyes [55]. Our eyes surface was covered with a liquid thin layer called tear film, which will keep the eyes wet, and provide nourishment, the continuous exposure of computers monitor light reduces the blinking of eyes which cause irritation in the tear film and lead to eye dryness [56].

Thermal pollution

An average rise of ambient temperature of 3°C can able to increase in the incidence of fungal keratitis increase only 2-3% in London, whereas in southern Ghana it goes up to 50% as it is close to the equator [57]. During the late winter or early spring when there is still much snow on the ground, and the sun is already high in the sky, the chances of reflected UV radiations is likely to be much higher than at other times of the year causes UV damage to the eye during this time of the year [58].

The rate of direct chemical reactions, such as carbamylation or glycation, doubles whereas the rate of enzymic reactions increases by a factor of 10 with a 10°C rise in temperature. Harding and Rixon [56] have suggested the plausible biochemical mechanisms by which dehydration crises might affect the conformation of lens proteins which aids cataract formation.

Heat pollution

Welding process produces high levels of infrared and ultraviolet radiations along with intense visible light and therefore the process is potentially hazardous to the eye health, where mixture of flammable gases burns to produce intense heat and high intensity of light. Heat produced from welding may cause thermal damage to the eyes which may be permanent and sight threatening [57-60]. Bursting firecracker can also cause many ocular injuries including irreparable vision threatening problems [61]. It is possible that chronic heat exposure during household cooking and welding process and heating fires could induce cataract, nevertheless this would be difficult to distinguish from a household air pollution-induced effect [HAP] [62].

Epidemiological studies indicated that exposure to heat in bakeries can cause damage to the eye lens and that the damage is dependent on the length of exposure. Hence there exists a link between high temperature environment and cataracts [63].

In addition, food either fried or grilled at high temperature, can emit smoke and volatile organic compounds which can cause harm to the eyes [64]. The tears while cooking assessment [TWC assessment] stated that the exposure to household fuel combustion products brings higher rates of blindness, especially in females [58,65]. The children exposed to household fumes are also at higher risk of ocular diseases such as conjunctivitis, and refractive errors [66].

Water pollution

Pond [66] reveals that eyes are vulnerable to hundreds of diseases, some of which may be water born, the responsible bacteria and /or virus might be present in the water and enter the eye during bathing or

swimming at public places. Chlorine widely used for the treatment of public water supplies because of its toxic effects on waterborne microorganisms, however, there is scientific evidence to show that chlorine in showering and/or swimming pool water may actually pose greater long-term dangers to the eyes [67]. Pruss [68]. reported that increased rates of eye symptoms have been seen among swimmers, and the evidence suggests that swimming compromises the eye's immune defenses and leads to increased symptom reported in marine waters for divers. Hence this review made an attempt to bring down all possible environmental pollutants that cause serious damage to human eyes (Table 1).

Conclusion

Due to expanding industrialization and global warming environmental pollution is expanding at exponential rate. Chemical substances which are thrown out as industrial waste are found in the air, waters and the soil. Present day environmental conditions appear to have significant adverse effects on the ocular surface which is exposed to the atmosphere all the time. There were very high levels of subclinical and acute ocular disorders among humans, birds and also among the aquatic animals. The environmental factors such as particulate materials toxic gases, smoke and chemicals, biomaterials e.g. bacteria and viruses, climatic and natural changes such as, variable humidity, temperature variations, ultraviolet radiations affect the various parts of eyes like cornea, conjunctiva, etc. in several ways and leads to serious eye disorders like cataract, conjunctivitis, glaucoma and dry eye.

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