CHAPTER I
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Artificial lighting is an integral component of modern life. Its use is not restricted to nightime. Even during daytime, when plenty of natural day light is available outdoor, artificial light supplements inadequate daylight indoors. Light permits visibility in darkness making it possible to perceive and mentally organise diverse elements of the environment. In other words, light is central to all visual experience and sensitivity.

Light is a form of energy radiating from a luminous body and it produces the sensation of sight. The early modern scientists like Galileo, Johannes Kepler, Willebrord Snell and Rene Descartes made contributions to the understanding of light. During the late 1600's Sir Issac Newton's particle theory and Huygenes wave theory were propounded. Maxwell's theory of electromagnetism was strengthened by Max Planck's theory of quantum which was explained further by Einstein who suggested that a photon's energy was related to its frequency. The radiant energy causing sensation of sight is a part of the whole spectrum of electromagnetic waves which travel through space at a speed of 186,000 miles per second. The spectrum of light encompasses a narrow band of radiant energy to which the human eye is sensitive, the same being of wave lengths between 4000 and 7000 Angstrom units. Sources of light radiate energy at one or more wavelengths within this visible radiation. The colour of visible radiation varies from violet at 4000 Å merging through blue, green, yellow and orange to red at 7000 Å. In daylight, energy at all visible wavelengths are radiated as it has 'continuous spectrum' and hence it

produces the sensation of white light (Encyclopaedia Britannica, 1993-1997).

For centuries, human race had depended on daylight for visibility. Once darkness sets in, visibility declines sharply making it impossible to pursue any visual task. Primitive men freed themselves from the bonds of darkness when they captured the art of building fire. From the days of torches of dry leaves to incandescence from animal fats and vegetable oils and inexpensive illuminants like kerosene lamps and gas mantle since 1859, human race emerged into the era of electric lighting devices. Initial arc lamps gave way to carbon filament lamps of Thomas Alva Edison in 1879. The development of fluorescent tubes in 1940 was another land mark in the history of electric lamps and artificial light.

Light is an environmental stimulus and man's response to this stimulus takes the form of physiological reactions, and ecological and social behaviour including his concepts and relationships with other people (Compton, 1972). Light is one of the most significant facets of a given space as it infuses the appropriate mood to human environment. Each aspect of man's growth, development and performance is influenced by the luminous aspect of his environment. The physiological, psychological and aesthetic responses of man are affected by his light environment. These responses bear directly on human performance and productivity. Mental and physical responses are slower and less precise when lighting is not suited to the visual tasks being performed. The space brightness contributes heavily to how people react to interior space. In aesthetic terms, light is a key visual element of interior and exterior design that accentuates shape and its plasticity, and its spatial relation with other objects. The application of artificial

lighting is recognised as one of the most important and pleasurable elements of creative lighting design, and is effectively used in orchestrating the environment.

Today 'lighting design' has evolved as an independent discipline and the technologists, engineers, architects and interior designers have outdone themselves in product designing and planning of efficient lighting schemes for interior space. The last decade has shown an evolutionary face of lighting in development of lighting systems and schemes that fulfill the requirements of quality and quantity of illumination without sacrificing the energy conservation goals (Smith, 1987; Audin, 1991 and Benya, 1991). Lighting interiors of industries, commercial set ups like offices and shops, theatres and hospitals is accepted as an integral part of the overall design project. The need to efficiently use lighting design to fulfill the requirements of functionalism, aesthetics and health is also increasingly recognised. One of the most important spheres of lighting which demands far more attention than it has hither to received is the lighting of residential units. Residential lighting, though small in terms of number of installations per unit, is of great significance due to the impact good lighting can have on general well-being (Hewitt, 1952). The smooth functioning of home depends upon the daily performance of a variety of household chores, recreational and social activities which are dependent on efficient visibility. Activities like reading and studying are much the same visual problem in home as in offices and schools. Sewing, handcraft hobbies and many meal preparation activities are no less exacting, though perhaps less continuous, than visual tasks carried out in industry (IES, 1954).

The major challenge of lighting a home lies in the large number of requirements which the lighting must satisfy. The requirements for each area of the residential set up are unique and demands individual attention. Residential lighting has to fulfill a variety of task - oriented functions apart from adding to the decor of the rooms. For utility areas like kitchen and bathroom, functionalism may hold prime importance, while in a living room, with the diverse activities taking place, lighting has to fulfill the requirements of the variety of visual tasks that are performed therein like casual reading, writing, watching television, eating and conversation along with an enhanced appearance. The 'traffic zones' in and about the home, which include the entrance doors, halls, landings, passages and staircases need special attention as far as the lighting is concerned. This is more so as many accidents attributable to poor seeing conditions occur in these zones. Inadequate lighting, glare or harsh shadows may obstruct the field of view and adversely affect the safety of the inmates of the house (International Lighting Review, 1985). In any given space where visual tasks are performed, provision of good seeing conditions and a comfortable visual environment is of paramount importance. The visual environment should be such that essential task details are easy to see and adverse factors which may cause visual discomfort are excluded or appropriately controlled (International Commission on Illumination, 1986). Insufficient lighting may cause abnormal strain on the brain and nerve system. As a result work may be done less smoothly, taking more time and frequently resulting in headaches and fatigue.

Researches have been undertaken to assess the association between physiological responses and artificial lighting. Industrial and commercial lighting drew the attention of researchers as early as the 1960's. The physiological, photobiological and psychological

responses to lighting have been undertaken. It has been found that the two vision problems of strain that arose through sharp contrasts of light were 'after image' and 'glare' which caused physical discomfort and could lead to accidents (Garrett, 1964) . 'Eyesore' and 'nightmare' were common problems of improperly maintained lighting systems (Merz, 1982; Orfield Associates, 1991 and Rea, 1992). The photobiological effects of lighting on human physiology have been experimentally demonstrated, establishing that exposure to bright light led to enhanced visual capabilities, increased alertness level and cognitive performance, and improved sleep pattern (Boyce, 1997). The psychological response related to lighting, visual stimulation, comprehension, motivation and distraction, and their effect on visibility and performance of both cerebral and visual tasks have also been studied (Maitreya, 1977; Boyce et.al., 1989; Knisely, 1991; Benya, 1992 and Flynn, 1992).

Most of the researches are aimed at industrial and commercial lighting. In spite of drastic advancement in lighting research and technology, the inadequacies of lighting in residential sector has remained more or less static. Review of researches revealed extremely poor conditions of lighting in Indian homes, that could be attributed to low wattages, improper mounting heights, and poor maintenance of lamps and reflectors (Chandapilla, 1964; Abraham, 1970; Desai, 1977; Saxena, Kumar and Pal, 1980; Luthra, 1987; Thakkar, 1989). However, relationship between residential lighting and human health and safety, effect of lighting on sustained performance of visual tasks and lighting for the aging population have drawn minimum attention. Residential lighting remained neglected with little focus on laboratory research, field research or product designing or planning lighting schemes for interior space.

Residential lighting is seldom given the importance it requires in the Indian context. Lighting is often left as an unbudgeted item with the lowest priority and buyers accept meekly what is provided by the builder or the contractor (James, 1985). There appears to be a lack of acceptance on the part of the families to channelise their financial resources to create well-lit spaces in their homes. Indifference and lack of adequate information could be responsible for neglect of lighting in the home. Often lighting designing is delegated to electricians who base their plans arbitrarily on past experiences. The stereotyped formula typically reduces lighting to an electrical system chosen almost solely on the basis of the lowest possible initial cost. Besides, families that attempt to create a favourable luminous environment in the homes face the impulsive blows of the changing technology. There is a great deal of change, not just in the types of lighting equipment manufactured, but also in the lighting design philosophy itself. Market, is characterised by repletion of lamps, luminaires and lighting systems. The flood of novelty in the market has crashed down upon the families and has placed unprecedented strains on their purchase decisions.

1.0 STATEMENT OF THE PROBLEM

Families are purposive goal oriented units. The house or residential unit provides the arena for growth and development of its members who are of varying ages and who hold different values and goals. In pursuit of development, families indulge in varied tasks. Good lighting is imperative for efficient functioning of the family. It assists vision ; bad lighting hampers vision and damages sight in the long run. Good lighting does not imply only adequate amount of light ; it involves quality of lighting as well. Of the various activity

areas of a residential unit, kitchen is the area where majority of life supporting activities are carried out.

Kitchen is one of the most essential functional space of the home where the housewife and other workers in the home spend many hours in pursuit of visual tasks ; it is the place more than any other demanding good light. In a kitchen variety of tasks related to meal preparation are performed at different work areas or centres. These range from the ones requiring high visual acuity to those requiring low visual acuity. Tasks, where visual inspection becomes critical like washing intricate cut work glass with fine design and crevices or washing small kitchen tools for chopping and churning may lay heavy visual demands on the worker; while tasks like cleaning dishes or rolling 'chappati' or kneading dough or cutting potatoes can be performed with relative visual ease. The cleaning tasks such as cleaning of cereals, pulses, spices, condiments, leafy vegetables and herbs are carried out in the kitchen. Close inspection of fresh food items and foods under process on fire is integral part of cooking tasks pursued in the kitchen. Work in the kitchen should lead to safety in food consumption, good aroma and flavour in cooked food and retention of specific colour and texture in processed food. Proper visibility in a kitchen is crucial requirement for safety reasons, especially with reference to handling of sharp tools and searching and locating stored items. Adequate lighting aids in minimising accidents that occur due to inability to spot spilt oil and water on the floor of an ill-lit kitchen. Good lighting apart from other things is a prerequisite for effective and efficient functioning of a worker in the home as in other work places.

Kitchen the domain of the women, where traditional and modern fuels are burnt, where oil smokes, and unburnt volatiles and

suspended particulate matter are thrown into the air, is a neglected area in terms of lighting. The human eye has a high degree of adaptability that makes seeing possible under very bad lighting conditions without any immediate or violent protest. This may be one of the reasons why most of the housewives, in spite of working under poor lighting condition in the kitchens, do not have any complaints. Poor lighting in kitchen could be due to the desire of the family to keep fuel bill low wherein kitchen becomes the first area where a compromise is reached by relegating safety, efficiency, health, comfort and perfection in processed items to the background. Apathy and resignation to accept the minimal facility to carry on with vital tasks in a traditional manner might also have attributed to kitchen remaining a poorly designed area from lighting perspective.

However, working under inadequate light for long periods of time results in definite strain on the sight. Poor lighting conditions in residential kitchens may have deleterious effects causing eyestrain, fatigue, and listlessness in individuals, and loss of output both in terms of quantity and quality of tasks accomplished. Kitchen requires a luminous environment that would cater to the needs of the worker with regard to work efficiency, visual comfort, safety and also aesthetics. The visual effort involved in perceiving the details of various visual tasks performed in the kitchen provides the basis for determining the lighting levels in the kitchen. Standards on illuminance required for pursuing kitchen activities have been established at national and international level. These standards have undergone considerable change over the decades varying from one part of the world to another (Appendix I.1). The American standards on illuminance are much higher than those recommended by United Kingdom, Australia, New Zealand, India and China. International standards (Philips Lighting Manual, 1993) recommend illuminance as

high as 500 lx for task lighting and 300 lx for general lighting in the kitchen. The Bureau of Indian Standards (ISI, 1966) recommend illuminance of 200 lx in the kitchen with additional lighting at the working areas. Literature survey revealed that the data available on the feasibility, applicability and acceptibility of these standards in practical field conditions were scanty. Work efficiency, visual comfort, health and safety in relation to different illuminances are concepts that have drawn least attention in kitchen lighting.

The concern of the present investigation was to probe into questions like what is the status of existing artificial and natural lighting conditions in residential kitchens ? Is there any relationship between existing illuminances under artificial lighting in kitchen and knowledge of housewives and their spouses and lighting values held by housewives ? Are the recommended levels of illuminance available in residential kitchens ? Is there really a need to have such high illuminances to carry out the meal preparation activities in the kitchen ? Will illuminance levels lower than the recommended values adversely affect the visual performance and visual comfort of the housewives ? Given a choice, what kind of lighting installations in the kitchen will enable to provide the required illuminances, not only to achieve functional efficiency but to fulfill the goals of energy conservation and economy in lighting as well ? Though a few studies were undertaken on assessing the existing lighting conditions in homes, not much research has so far been devoted to further explore the effects of varying illuminances on the visual performance and visual comfort of the housewives while performing meal related tasks or their equivalent paper-pencil tests. The present study was an attempt to fill the lacunae in regard to researches on residential lighting. It is envisaged with the hope that it would make valuable

contribution to the knowledge base concerning the effects of illuminance on visual performance and visual comfort of subjects while working in kitchen and the associated factors.

2.0 OBJECTIVES OF THE STUDY

The specific objectives drawn to give proper direction to the investigation were to :

(1) Study the existing status of residential kitchens with reference to (i) artificial lighting and (ii) natural lighting.

(2) Develop a scale to measure appropriately values of housewives with reference to artificial lighting in kitchen.

(3) Develop a scale to appropriately assess the knowledge of housewives and their spouses in relation to artificial lighting.

(4) Ascertain interrelationship between existing general ambient illuminance in residential kitchens under artificial lighting and selected situational, personal and family variables.

(5) To assess the visual performance and perceived visual comfort of selected subjects under varying illuminances in a simulated kitchen through laboratory experimentation.

(6) To ascertain the effect of selected independent variables (illuminance, brightness contrast and age of subject) on the level of visual performance and perceived level of visual comfort of the subjects in simulated kitchen.

(7) To compare the economics of different lighting systems and to recommend lighting installations for selected size of kitchen to ensure lighting for effective task performance.

3.0 ASSUMPTIONS

The study was based on the assumption that :

(1) Families are unique and differ from each other, therefore have differential levels of illuminance under artificial and natural lighting in their kitchens.

(2) The goals held by housewives in regard to artificial lighting is reflected in the existing conditions of artificial lighting in their kitchens.

(3) The impact of illuminance can be ascertained from differential levels of performance of subjects on given experimental tasks and their perceived visual comfort in doing those tasks.

(4) The laboratory experimentation using landolt's rings of varying sizes would provide scope for application of result to varied tasks pursued in the kitchen.

(5) The performance of subjects in the laboratory can be related to performance of visual tasks by workers of varying ages in the actual field kitchens.

4.0 HYPOTHESES

HAI : There exists a relationship between average general ambient illuminance under artificial lighting in residential kitchens and the selected situational, personal and family variables.

HAII : There exists a difference in the order of significance in association between the selected situational, personal and family variables on average general ambient illuminance under artificial lighting.

HBI : There exists a difference in the level of visual performance of subjects of different age groups on standard visual acuity test i.e., landolt's ring test against different brightness contrasts under varying illuminances in the simulated kitchen.

HBII : There exists a difference in the level of visual performance of subjects on brownness discrimination test under varying illuminances in the simulated kitchen.

HBIII : There exists a difference in the perceived level of visual comfort of subjects under varying illuminances in the simulated kitchen.

5.0 DELIMITATIONS OF THE STUDY

The study was limited to :

(1) graduate mothers (home makers / housewives) of 208 students enrolled in the Faculty of Home Science who could read, write and express fluently in English language and their kitchens.

(2) ascertaining the interrelationships between level of average general ambient illuminance under,

(i) artificial lighting in 208 residential kitchens and the following variables:

Situational variables : tenure of housing, age of house, floor area of kitchen, room index, effective ceiling and floor cavity reflectances, maintenance factor and utilisation factor.

Personal variables : knowledge level of housewives and husbands, artificial lighting values held and discomfort experienced by housewives.

Family variable : family income.

(3) laboratory experimentation in a simulated kitchen designed on the basis of mean values of middle 50 per cent lying between the first and third quartiles by floor area of 208 field kitchens.

(4) computation of level of visual performance as a dependent variable using performance scores on test objects, namely, A, D, F and G representing each of the four visual sizes (angle) viz., large object (6 minutes of arc or more), medium object (less than 6 but not less than 3 minutes of arc), medium-small object (having a lower limit of 1.5 minutes of arc) and small object (less than 1.5 minutes down to a limit of 50 seconds of arc) against three brightness contrasts namely ; .89, .61 and .57 and under each of the six selected illuminances namely ; 500, 300, 166, 100 , 72 and 17 lx and; (ii) brownness discrimination test, under the six selected illuminances with artificial lighting in the simulated kitchen.