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Assessment Of Illuminance and Related Health Effects in Some Departments Within a University Environment.

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Abstract
Workplace safety is dependent on numerous factors within the work environment and light intensity (illuminance) is vital in ensuring this, as inadequate lighting is not unrelated to varying deleterious health effects. This study was undertaken to measure the level of illuminance in laboratories and offices of a selected Faculty in the University, in order to ascertain if the lighting conditions in the work environment are in compliance with illumination standards (500 lux), set by the Occupational Safety and Health Administration (OSHA), and to identify the potential hazards that may arise from exposure to lighting conditions that are not in compliance with set standards. A digital lux meter was used to measure light intensity in the different locations. The results obtained revealed that the mean illuminance levels of most of the measured offices and laboratories were below 500 lux. The maximum illuminance level recorded in the assessed offices was 478.6 lux in the Department of Statistics and a minimum of 288.1 lux in the Department of Computer Science. Maximum Illuminance level from the assessed laboratories was 408 lux from the Department of Geology and a minimum of 164 lux. The health effects associated with such poor illuminance levels includes: eyestrain, blurred vision, eye pain, eye fatigue and in general eye discomfort. Poor illuminance may also be linked to the prevalence of headaches. This will subsequently result in poor students and teachers performance, and reduce productivity. In order to improve the lighting situation of the faculty, a suitable day lighting plan should be incorporated into the architecture of buildings in general and workspaces in particular.

Keywords: Eye strain, Hazards, Illuminance, Lux, Workplace safety

INTRODUCTION
Illuminance level covers the minimum amount of good quality light obtainable within a work environment that falls on a work surface creating a visual environment that enables people to perform their visual tasks effectively (Lee *et al*., 2014). The Occupational Safety and Health Administration (OSHA) and United States General Services Administration have set standards for the minimum level of illumination within workplaces. For workplaces where activities such as reading, writing and typing takes place, the minimum level of illumination should be 500 lux. The uniformity of lighting within a work environment is also paramount

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hence the uniformity parameter as stated in ISO8995-1 should be followed strictly within work environments. It is stated that the uniformity level should not be less than 0.5 (ISO8995-1, 2002). Many works of literature have reported on the impact of lighting on the performance of school students and on the productivity of workers (Al Horr *et al*., 2016; Aigbavboa and Thwala, 2019; Dunleavy *et al*., 2020; Sadick *et al*., 2020, Bao *et al*., 2021). It is now widely accepted that lighting in the learning environment impacts on students' learning experience and school achievement (Sun *et al*., 2019; Singh *et al*., 2020). Sufficient and adequate lighting is strongly recommended in work spaces but in spite of the benefits of adequate lighting some lighting intensity may be associated with glare which has its consequences, hence adhering to set standards is paramount in achieving the maximum benefits of a well-lit work environment (Lamb *et al*., 2016). The presence of these problems (glare) in the work environment significantly reduces visual sharpness; exert teary eyes, and causes visual fatigue (Rosenfield, 2011; Bellia *et al*., 2013, Wangsan *et al*., 2022).

The effect of light on school students may be dependent on their personalities as a study carried out by Silvester and Konstantinou (2010), reported differences in the response of students to light exposure. Some reported feeling lethargic when the light was not bright enough as they could concentrate better under bright light whilst others reported feeling nervous and fidgety under bright light but concentrated more under dim light.

Lighting is reported to be amongst the components of the work environment that can impact a person's performance (Tähkämö *et al*., 2019). Accordingly, there should be an appropriate level of light falling on the surface on which students and other employees are working. Excessive contrast, strong glare and light flickering in their field of vision are also inappropriate as they have their consequent effects on productivity (Stefani *et al*., 2017). The performance of the human body system depends to some extent on the level of comfortability in our work environment. Deviations from the comfort threshold will cause functional changes that will ultimately affect the physical and mental health of both students and workers (Konstantzos *et al*., 2020; Brink *et al*., 2021). Environmental quality factors that encourage concentration and productivity will create a sense of comfort and health. Controlling and managing environmental aspects such as noise, temperature, and illumination are issues that must be taken seriously and addressed on a regular basis. Shishegar and Boubekri (2016), in his study in certain subjects assessed such as in Mathematics, students with adequate amount of light progressed 20% faster than those in classrooms with less or inadequate lighting. The same trend was recorded for those who participated in a reading test where there was a 26% better progress rate for those in well-lit classrooms compared to those in inadequately lit classrooms. A study in Norway indicated that seasonal sleep disruptions accompanied by depression and subsequently, anxiety and fatigue characterized periods with a shorter duration of daylight (e.g., December) (Friborg *et al*., 2014).

Lighting assessment in the lab can be done by lighting measurement or by conducting a checklist. The checklist approach involves comparing observable attributes with defined standards (Schlangen and Price, 2021). It involves spotting lighting problems such as contrast, flicker and glare. Lighting measurement approach involves conducting in situ measurements with the use of a lux meter. A lux meter is a handy instrument with a sensor for light detection; the measured light intensity is displayed in lux (lx) or foot candles. A well-maintained illuminance level, increase occupants' mood and alertness (reduce sleepiness) which are essential factors for increasing occupants' performance (Van Bommel, 2004), there is need for a comprehensive assessment to understand the occupants needs and preferences in workstations and the related health effects. It is against this background that this study seeks

to assess the level of illuminance in offices and laboratories in the Faculty of Physical Sciences University of Benin and also identify related health effects in cases of poor illuminance.

MATERIALS AND METHOD

The checklist approach, which involves comparing observable attributes and accurately recording the lighting conditions in the laboratories and offices at a certain time, and comparing with set standards was used. The major instruments used in this study were a digital lux meter model: Lx1330B to measure the luminance and a GPSMAP 64x Handheld GPS Device to determine the location of the offices and laboratories.

Study area

The University of Benin formerly called the Institute of Technology is a Federal Government funded public institution, located in Benin City, Edo State, Nigeria. It was founded in 1970. The School currently has two campuses (Ugbowo Campus and Ekenwan Campus), with fifteen faculties including a central library called the John Harris Library. This study was carried out at the Ugbowo Campus of the University. This campus houses a number of Faculties, one of which is the Faculty of Physical Sciences which has six (6) Departments (Departments of Chemistry, Physics, Geology, Computer, Mathematics and Statistics). Illuminance measurements were taken from the Chemistry laboratories, Physics laboratories, Geology laboratories, Offices in Computer Science Department, Offices in the Department of Mathematics and Offices in the Department of Statistics.

Figure 1: Map of the study area, Faculty of Physical Sciences, University of Benin.

Method of data collection

The location of the laboratories and offices was determined using a GPSMAP 64x Handheld GPS Device. Data was collected using a Digital Lux meter model: LUX1330B. The sampling was done according to a standardized method as described by (Mercy *et al*., 2021), with minor modifications. To maintain the accuracy of the data, the rooms were divided into ten boxes readings were taken at the ten different observation points in each laboratory and office room with all the artificial light sources turned on. The path between the light source and the point of measurement was unobstructed as far as practicable. Illuminance measurements were taken at the center point of these boxes to record the illuminance level at that point by placing the sensor of the lux meter horizontally on the surface where tasks are usually carried out during practicals and in office work stations. After repeating this process in all ten boxes, the mean of the recorded measurement was taken as the illuminance level recorded in that particular office or laboratory. The recommendations by OSHA were regarded as an acceptable standard for evaluating office lighting levels due to its clarity (Mercy *et al*., 2021). Data were collected between the hours of 8am to 4pm. As set by OSHA, an illuminance level of 500 lux is suitable for the performance of visual tasks of high contrast and small size, or low contrast and large size, typical of such exercises involving chemicals and biological specimens. Inadequate lighting or lux values below 500 lux will impair visual functions resulting in inaccuracies of the data gathered and also causing fatigue, stress, and diminished alertness, which are among the non-visual effects of poor lighting (Almarez and Nawang, 2020).

Statistical analysis

One-way analysis of variance (ANOVA) and Dunnett's multiple comparison post-hoc test were used. The level of statistical significance was set at $p< 0.05$. The graphs were plotted using Graph pad prism 5 software. Data shown graphically are mean ± Standard deviation.

RESULTS AND DISCUSSION

Comfort at workplaces and in learning environments is dependent on the indoor quality of such environment, which is rated on the basis of certain parameters such as, indoor air quality, lighting, acoustics, and thermal condition (Luo *et al*., 2023). Previous studies have shown that there is a direct relationship between the output of workers and the lighting condition within a work or learning environment (Hafeez *et al*., 2019; Sun *et al*., 2019, Konstantzos *et al*., 2020). Also it is asserted that good lighting conditions, allows for the speedy completion of tasks thereby enhancing productivity (Cajochen, *et al*., 2019). Learning outcomes are also a reflection of the conditions of learning as exposure to good lighting during practical exposures will also impact on the outcome of such sessions. Hence it is important to assess periodically the lighting conditions in these environments to ensure their suitability at all times. Hence in this study we carried out a physical assessment of the lighting intensity in offices and Laboratories in the Faculty of physical sciences, University of Benin to ascertain its compliance to set standards (OSHA, 500 lux). Results from the first study area which were the Laboratories in the Department of Chemistry, as shown in Figure 2, indicated that the measured light intensity was below the OSHA standard for light in such an environment. This marked insufficiency in the lighting of the Laboratories was significant ($p<0.05$) in four (4) four of the measured laboratories (Lab I-IV) (230 lux, 256 lux, 280 lux and 274 lux). The luminance level in Lab V (342 lux) was below the recommended standard although it was insignificant ($p>0.05$) when compared statistically. This result is similar to results from other studies in which illuminance levels lower than the recommended standards were seen (Mercy *et al*., 2021).

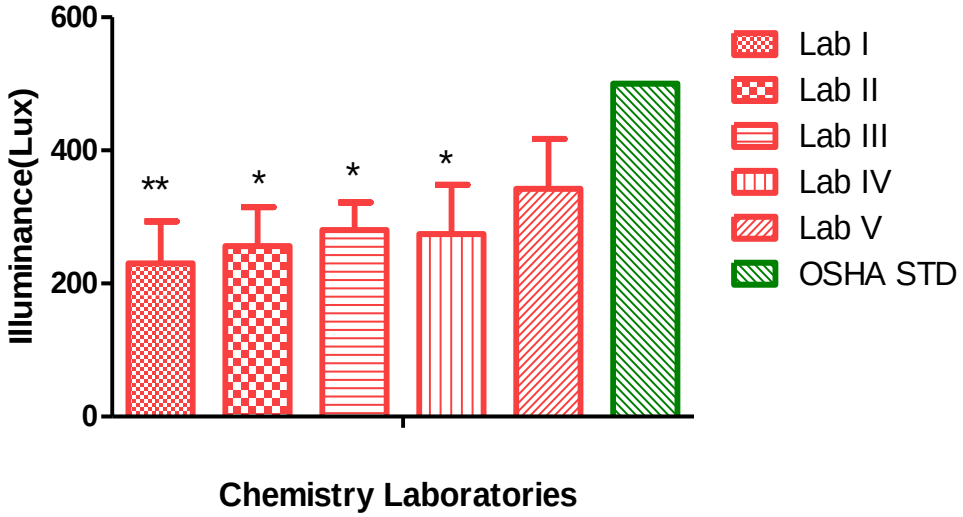

Figure 2: Mean Illuminance readings from Laboratories in the Department of Chemistry, University of Benin. (Values are mean±SD of ten (10) readings).

Illuminance readings from the Department of Physics (Figure 3) indicated that the five Laboratories measured for light intensity (259 lux, 219 lux, 280 lux, and 194 lux), had significantly lower readings when compared with the set standard (500 lux). A level of light sufficiency is required for Laboratory operations involving the use of chemicals and biological specimens as inadequate lighting will not only impair visual functions but will result in inaccuracies in the data generated. Inadequate lighting can also diminish concentration levels hence reducing performance and productivity (Al Horr *et al*., 2016).

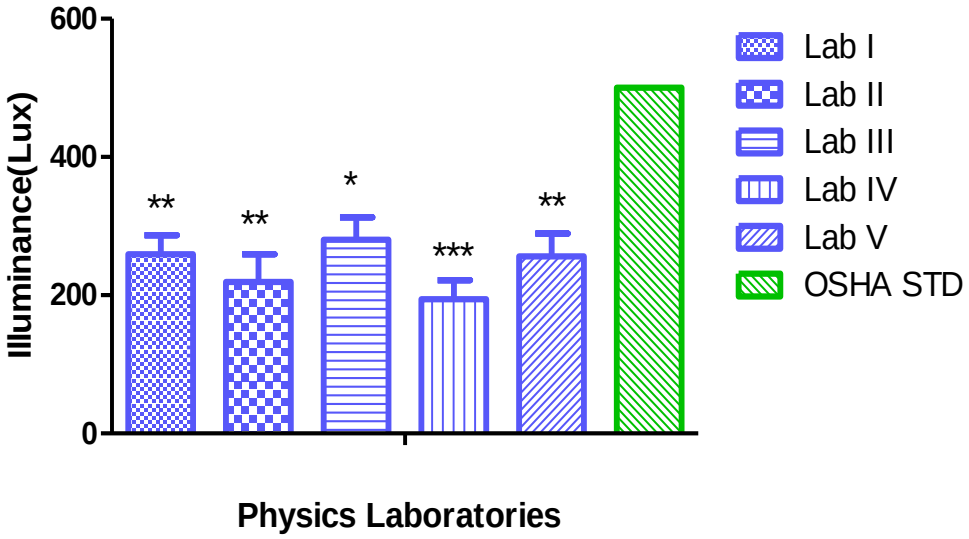

Figure 3: Mean Illuminance readings from Laboratories in the Department of Physics, University of Benin. (Values are mean±SD of ten (10) readings).

Results obtained from Laboratories in the Department of Geology were consistent with results from the previously studied departments in the Faculty of Physical Sciences. The illuminance levels in two of the measured Laboratories (Lab I and Lab III) (189 lux and 164 lux) were significantly lower than the recommended OSHA standard (500 lux), although the illuminance readings from Lab III (408 lux) were lower than the standard, the difference was insignificant when compared with control. Rana *et al*. (2021), in their study had similar results

in which there were low levels of illumination very much below the stipulated OSHA standards, thereby leading to varying associated health conditions such as poor vision, and general cognitive abnormalities.

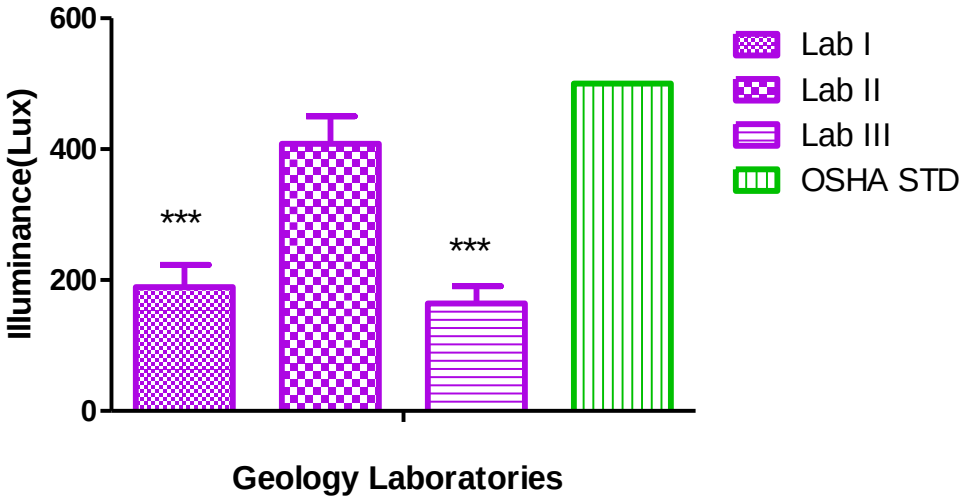

Figure 4: Mean Illuminance readings from Laboratories in the Department of Geology, University of Benin. (Values are mean±SD of ten (10) readings).

The results from the offices studied showed that the illuminance levels in the offices in the Department of Computer Science (Figure 5) were below the stipulated standard but these differences were statistically insignificant ($p>0.05$) when compared with the standards in most of the offices (office 1-3; 361 lux, 335.8 lux, 332.7 lux). Felgueiras *et al*. (2023), also reported incidences of poorly lit modern offices in their study when measurements were compared with set standards. The consequences of such poor luminance levels are associated with reduced concentration, leading to reduced productivity by workers.

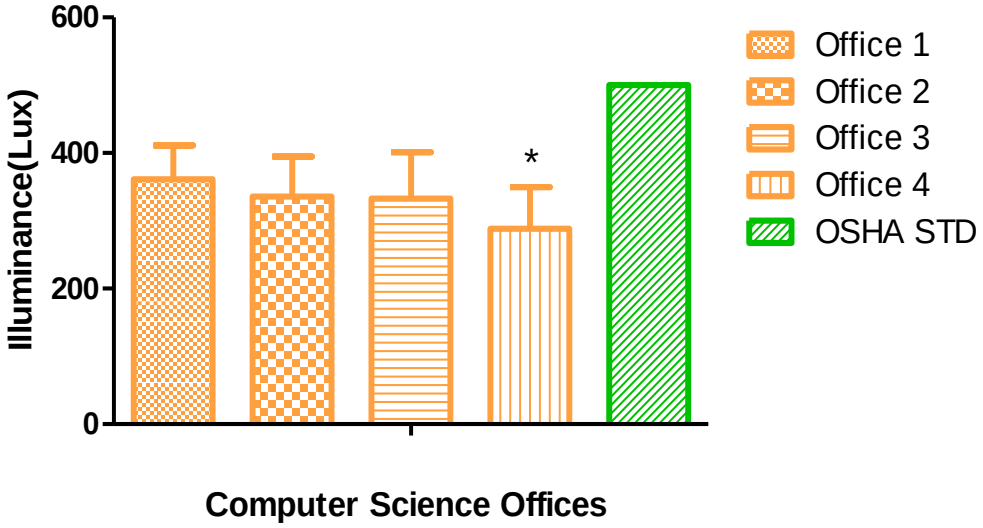

Figure 5: Mean Illuminance readings from Offices in the Department of Computer Science, University of Benin. (Values are mean±SD of ten (10) readings).

The results presented in Figure 6 and 7 shows illuminance levels in offices in the Departments of Mathematics (Office 1-4; 294 lux, 330.8 lux, 349.7 lux, and 292.8 lux respectively) and Statistics (Office 1-4; 478 lux, 314.4 lux, 426.3 lux, 306 lux). Measured light intensities in these

offices were significantly ($p<0.05$) below the set standard for lighting in offices, although office 1 and 3 of the Statistics Department had illumination levels that were not statistically different from the OSHA Standard.

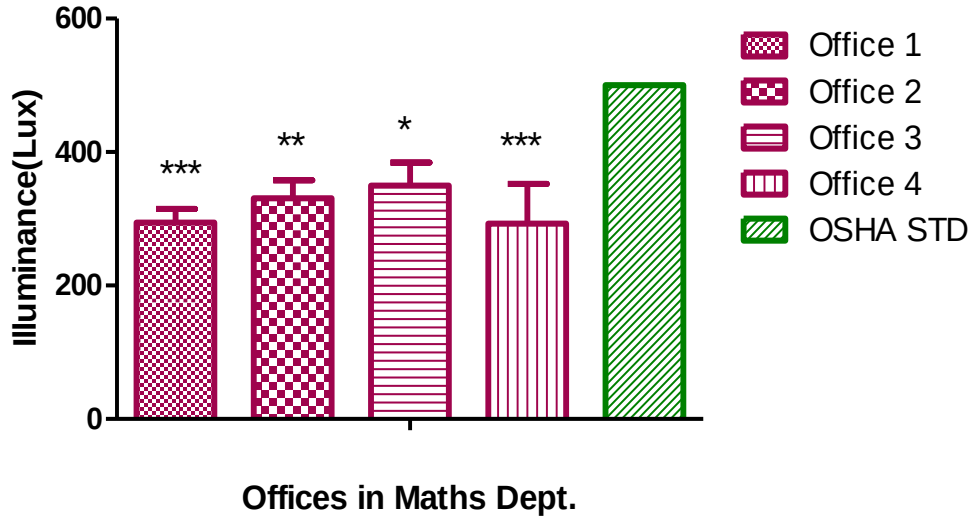

Figure 6: Mean Illuminance readings from Offices in the Department of Mathematics, University of Benin. (Values are mean±SD of ten (10) readings).

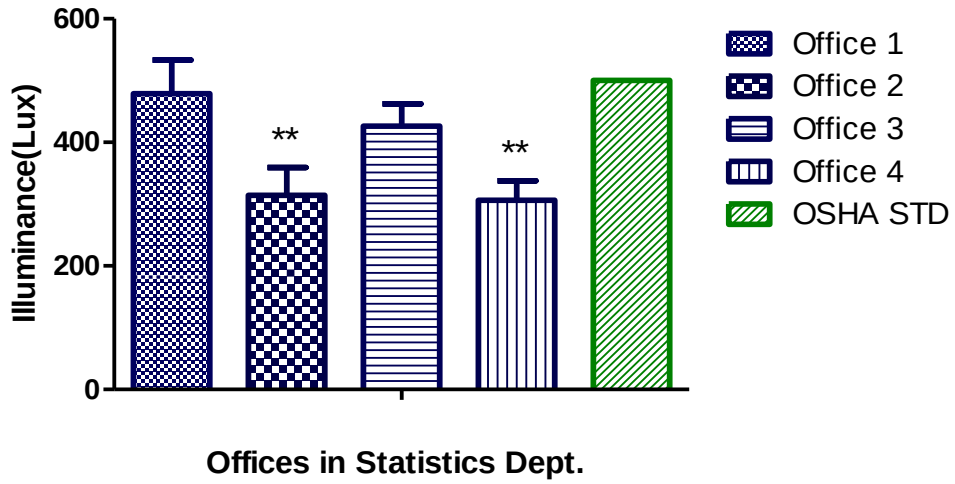

Figure 7: Mean Illuminance readings from Offices in the Department of Statistics, University of Benin. (Values are mean±SD of ten (10) readings).

Most works of literature have reported occupational health complaints from workers and students that are not unrelated to indoor environmental quality (Sadick *et al*., 2020; Awada *et al*., 2021; Bao *et al*., 2021). One determinant of indoor environmental quality is the lighting condition of the work environment and this can affect the wellbeing and health of workers and students. Some of the documented health effects include symptoms related to the sick building syndrome (SBS) (Felgueiras *et al*., 2023), damages to the eye and skin through other thermal and photochemical mechanisms, eyestrain, blurred vision, eye pain, eye fatigue and

general eye discomfort. Poor illuminance may also be linked to the prevalence of headaches as reported by both workers and students (Van Duijnhoven *et al*., 2019).

CONCLUSION

Overall, the studied locations had illumination levels mostly below the set statutory standard for lighting in work places. To enhance productivity, Management should deliberately implement measures to improve the lighting conditions of her employees and students which will go a long way in enhancing performance and productivity amongst staffs and students.

CONFLICT OF INTEREST

The authors unanimously declare that there is no conflict of interest whatsoever.

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