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Lighting Intensity Monitoring at Inspection Workstations in Electronics Assembly and Manufacturing

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Abstract The working processes of electronics assembly and manufacturing include machine operation, assembly and fine work inspection of products with a microscope. This study aimed to assess lighting intensity at the inspection, operation, and assembly workstations of the electronics assembly work process. A total of 167 electronics workstations in one electronics assembly and manufacturing site were analyzed. The measurement of lighting intensity was performed with a lux meter by spot sampling, and a three-zone measurement method was used. The zones were zone 1 (eye-focusing zone), zone 2 (within an arm's length) and zone 3 (outside an arm's length). Zone 2 and zone 3 refer to the materials pick-up distance next to zone 1 and zone 2, respectively. Four types of job function, i.e., machine operation, assembly of parts, and two inspection types, namely, moderate fine work under a lamp or with a monitor/ profile projector and very fine work under a microscope, were measured. The results show that insufficient lighting intensity was found in the highest proportion in very fine product inspection with a microscope, followed by inspection with a monitor/ profile projector. Insufficient lighting intensity was mostly identified within an arm's length (zone 2), followed by outside an arm's length (zone 3), when the eye-focusing zone (zone 1) was adjusted to >2,000-5,000 lux (81.12%), followed by the site of inspection with a monitor (64.29%). The light monitoring method will be useful for identifying solutions to lighting requirements regarding future eye-focusing zone adjustment of fine product inspection workstations.

Keywords Lighting Intensity, Inspection, Eye Focusing, Electronics

1. Introduction

Electronics manufacturing and numbers of assembly plants are in an upward trend at the present time, particularly in the northeast of Thailand, which has the largest workforce and highest number of factories for assembling electronic components for both electrical equipment and automotive circuit boards; there are around 14 such factories across the region [1]. This production requires both machine work (to produce tiny workpieces) and inspection of workpieces (the last part of the production process). These processes require that a high resolution be provided, so enough light must be supplied for working. In addition, other work characteristics include the need for specific eye focusing of more than 2 hours continuously in a 10-hour work period each day [2]. In addition, a previous study found that electronics manufacturing and assembly workers were at high risk, involving persistent standing to control the machine, material input into the machine, assembling of parts, and persistent sitting for inspection of fine products [2]. Consequently, the employees felt uncomfortable and had experience of perceived musculoskeletal pain, which was predominantly in the shoulders, neck, and back [3].

Moreover, the highest prevalence of pain was reported in the shoulders, and its associated risk factors were working posture and work environments [3].

The previous study reported that insufficient lighting was associated with neck, shoulder and back disorders among staff who always worked with a computer or screen [4]. It was also found that insufficient lighting intensity at workstations and a sound pressure level which did not meet the standard were significantly associated with stress among automotive industrial workers [5]. In addition, the activities of a production line of one electronics manufacturing and assembly site led to a noise level higher than the safety limit [3]. Furthermore, the workers had to work crudely (controlling machines and performing assembly work) or perform very fine work (inspection of finished pieces of products) by looking through a lamp, microscope, or magnifying glass. It is important that light monitoring is compared to the labor safety standards of all job characteristics according to those set by the Department of Labor Protection and Welfare, Ministry of Labor [6].

Up until now, there has been little evidence of reports on lighting intensity assessment at inspection workstations following the standard [6] for electronic assembly workstations, particularly in the group of electronics manufacturing and assembly workers, who have a high risk of musculoskeletal disorders according to a previous report [2]. This study was designed as a baseline survey for assessing the lighting intensity at workstations of electronics manufacturing and assembly workers. The results of a study into problems found with lighting intensity at the electronics inspection workstations could be used to suggest a specific measurement method for implementation, and to suggest protection against eye fatigue, particularly among those who perform inspection tasks during long working hours.

2. Materials and Methods

2.1. Study Design and Recruitment of Participants

The lighting intensity of workstations was surveyed in the working process of electronic assembly at manufacturing sites of the electronic circuit boards of electric appliances and automotive manufacturing sites in the northeast of Thailand. The sample size, which was calculated using proportion estimation in the case of a small population of known number, was 282 workers. The proportion in the previous study of electronics manufacturing and assembly workers, where results of ergonomic risk assessment showed a high risk at a level which required implementations, was 56.0% (p=0.56) [7], so the required sample size was at least 162 workers/workstations. Therefore, the number of workers at workstations, which had to be assessed for lighting intensity in this study was a total of 167 workers at 167 workstations. Simple random sampling was performed to include subjects with the characteristics of electronics manufacturing and assembly.

2.2. Lighting Intensity Measurement

The equipment used for measuring work lighting intensity at workstations was a lux meter. The machine, whose serial number was Q431675, had been approved according to machine standards and calibration by following ISO/CIE 10527 [8] and a corrected recording from measurement by following the regulation of the Ministry of Labor, B.E. 2561 [9]. For quality control, the lux meter was adjusted by zeroing the photometer every time before measurement, and by covering the lighting receptor cell with a black object and then turning it on. While the cell was covered, the read number had to be zero as there was no lighting impact on the receptor.

Lighting measurement was performed at the workstations of electronic assembly workers at two production sites: one site was for circuit board control assembly, and stand switch and micro switch assembly for motorcycles, and another site was for circuit board assembly for electronic cookware and electrical equipment manufacturing, including the manufacture of metal parts, pressings, molds, and processed plastics. The adjusted range for the meter was calibrated by choosing a lighting intensity of the lighting source in a range up to 2,000 lux. If a lighting intensity result in that area was over 2,000 lux and could not be read, the range was readjusted to be up to 20,000 lux so that the value would appear normal. The selection of workstation areas with representative characteristics of light intensity at stations was applied from the previous study [10].

During normal shift work (day shift), the measurement was performed by using two methods, which were spot measurement and area measurement based on the notification of the regulation of the Ministry of Labor, Thailand.

1. The spot method was measurement at 1-2 points representing the workstation area, such as at a computer workstation, namely, the middle point between the eyes and the monitor screen or the eyes and the keyboard while a document is being typed, or under a lamp, or at a spot where eyes were focused while working. For a spot measurement, the lighting receptor cell was placed at a plane level with the impact surface of the eye looking at workpieces or the point of work. Then, the lighting receptor cell was laid at a plane level with the table or workstation, computer monitor or impact surface of the eye, and then values were read in lux units.
2. In area measurement, the whole room was divided into 2 m x 2 m areas, and the receptor cell was held at a high level 30 inches from the floor (75 cm) and then read (during the process, light had to be measured without the interruption of the staff's shadow) and these results were used to calculate the average min-

max in the cases of machine control in processing and lifting materials for input into the machine. For this measurement, the lighting receptor cell of the receptor should be held at around 30 inches (75 cm) from the floor and then the lighting intensity value should be read. During measurement, it was carefully observed that without the interruption of the staff's shadow, which might result in an inaccurate value, the lighting receptor cell appeared to persistently provide the same value for a second time before the result was recorded.

Observation and recording of associated factors, i.e., ceiling condition of the room, lighting defects, working climate, etc., were done while measuring the lighting intensity. The recorded results were compared to the standards of the regulations of the Department of Labor Protection and Welfare, Thailand [6], and the workstation type was selected with consideration given to the following task characteristics;

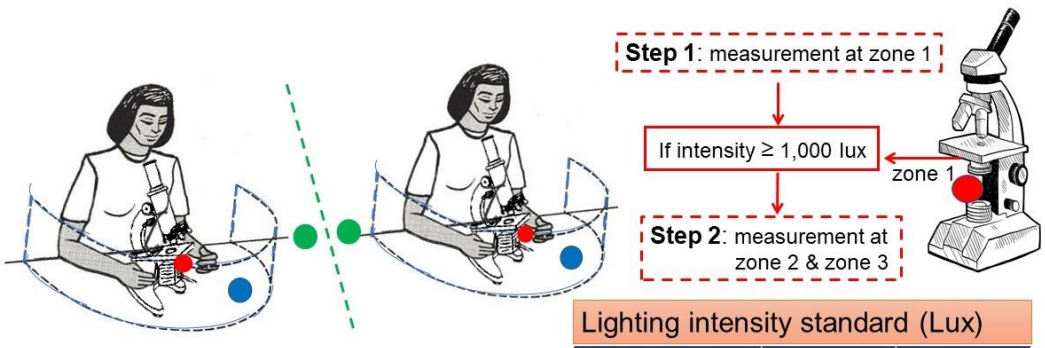
1) The tasks of machine operation and material input into the machines, which were controlling machines in which elastomers were used, were block molding, cutting, stamping, bending, pressing, and plastic forming. Those tasks were measured by using a one-spot measurement method to compare to the standard (200-300 lux).
2) The tasks of material assembly included gluing, marking, packing, tape tapping, and soldering, which were measured by using spot measurement to compare to the standard (400-500 lux).
3) General inspection tasks with a computer monitor or profile projector were measured by performing 1-2 spot measurements. Those measurements were representative of the light of a workstation where workers looked at impact light, and they were compared to the standard of lighting intensity (500-600 lux).
4) The task of inspection with a lamp was measured in the inspection area by using a spot measurement method to compare to the standard of lighting intensity of medium fine work (500-600 lux).
5) Inspection with a microscope is where the lighting intensity depends on lighting intensity adjustment, and the results of this task were compared with the standard of fine work at 800 to 1,200 lux. If the lighting intensity in this zone of eye-focusing work (zone 1) was adjusted to be 800-1,200 lux, it means it met the standard of fine work in zone 1 [6, 10].

If the lighting intensity of zone 1 was adjusted to reach a value higher than 1,000 lux, it means that further measurement of zone 2 and zone 3 areas should be carried out. Zone 2 refers to the zone next to the main working zone of an employee, or within an arm's length (material pick-up distance), and the standards of zone 2, which were compared in the ranges of >1,000-2,000, >2,000-5,000 and >5,000-10,000 lux, were 300, 600, and 1000 lux, respectively. Zone 3 refers to the area surrounding zone 2, or outside an arm's length of the worker, and the area next to the co-worker's area, and measurements were taken in order to compare to the standards of zone 3, which were 200, 300, or 400 lux, as shown in Figure 1.

2.3. Data Analysis

The descriptive statistics used were min, max, number, and percentage of workstations from the results of the comparison to the standards of the Department of Labor Protection and Welfare, Thailand [6].

This study obtained ethical approval from Khon Kaen University Ethics Committee in Human Research, Thailand, No. HE582213. All participants gave informed consent prior to entering into the study.



Lighting intensity standard (Lux)

zone 1	zone 2	zone 3
1,000 – 2,000	300	200
> 2,000 – 5,000	600	300
> 5,000 – 10,000	1,000	400
> 10,000	2,000	600

Figure 1. The lighting intensity measurement of zones 1, 2, and 3 at the microscope station

3. Results

3.1. Workstation Characteristics

The lighting measurement was done in October and November, between 9 and 12 p.m. and 1 and 3 p.m., during normal shift work. The weather on the day of light monitoring had to be sunny, clear, and not cloudy. Spot measurement was performed in the area where the employee looked at the materials, and additionally, in the case of eye focusing, it was also measured in the surrounding area, and results were recorded within an arm's length (zone 2) and outside an arm's length (zone 3). This method was applied according to the notification of the standards of the Department of Labor Protection and Welfare [6] for electronics inspection work. Recording for all environmental conditions was done in the surrounding work area of workstations, such as lamp installation, defects, or associated conditions like switching on/off the lamp during work. The numbers of workers who performed each processing task during comparison to the standards of lighting intensity and used each type of equipment or tools during work production, such as a lamp or microscope, were recorded, as shown in Table 1.

Table 1. Number (%) of the electronics assembly manufacturing workers, classified by type of workstation (N = 167)

Type of workstation	Number	%
Machine operation or materials input into machine	55	32.93
Assembly work with hand tools	28	16.77
Inspection with monitor, magnifying glass, or profile projector	14	8.38
Inspection with lamp	12	7.19
Inspection with microscope	58	34.73

3.2. Lighting Intensity at Electronics Assembly Manufacturing Workstations

During general observation of the light/lamp installation on the ceiling of the electronic equipment circuit board manufacturing site, double light bulbs at a 4-meter height from the floor were observed. The type of double light bulb observed was bare without covering, and it was mostly found at workstations of machine monitoring and assembly line work with hand tools such as forming plastic pieces, which is crude work. All light bulb installations were directly above the machine. For the sitting workstations of inspection, there were covered light bulbs with thick light coverings.

At all inspection stations with a monitor, profile projector, or microscope for fine inspection, light bulbs installed in rows over the seat line of production were not in the same plane, which led most lighting intensity in the working area to be lower than usual.

Moreover, usage of thickly covered light bulbs decreased the efficiency of illumination.

Moderate fine work of inspections with a monitor or profile projector was performed at a lighting intensity between 160-806 lux. This is different from stations with additional lamp installations to increase the light to be between 2,770-7,650 lux, which was very high when compared to workstations without a spotlight installation. The lighting intensities in surrounding areas (zone 1 and zone 2) met the standards of zones.

In very fine work of inspection with a microscope, with eyes focused at a point on the microscope, workers adjusted the lighting intensity freely depending on their eye characteristics, so the resulting lighting intensity of zone 1 (under the microscope) varied from 329 to 6,200 lux. Besides that, the lighting intensities in surrounding areas (zone 2 and zone 3) were found to be 235-1,320 lux (Table 2).

Table 2. The lighting intensity at workstations classified by work type (N = 167)

Workstations	Number	Min (lux)			Max (lux)		
Machine operation / material input	55	33			840		
Assembly work	28	137			3,150		
Inspection with monitor / profile projector	14	160			806		
		zone 1	zone 2	zone 3	zone 1	zone 2	zone 3
Inspection with lamp	12	2,770	>600	>300	7,650	>1000	>400
Inspection with microscope (lux)*	58						
zone 1 adjusted to <1,000	19	329	-	-	985	-	-
zone 1 adjusted to 1,000-2,000	15	1,057	465	265	1,925	1,180	1,043
zone 1 adjusted to >2,000-5,000	22	2,025	325	235	4,900	1,130	976
zone 1 adjusted to >5,000-10,000	2	5,560	767	274	6,200	1,320	920
Total	167	33			7,650		

*Zone 2 and zone 3 were reported of the measurements when zone 1 was adjusted to be ≥ 1,000 lux.

Table 3. Lighting intensity of workstations compared with the standard of each workstation characteristic (N=167)

Measurement area	n	Standard [6] (lux)			Insufficient n (%)	Sufficient n (%)
Machine operation / materials input	55	200-300			18(32.73)	37(67.27)
Assembly work	28	300-400			12(42.86)	16(57.14)
Inspection with monitor / profile projector	14	500-600			9(64.29)[2]	5(35.72)
Inspection with lamp	12	500-600			0	12(100)
Inspection with microscope (lux)	58	zone 1	zone 2	zone 3	30(51.72)	28(48.28)
zone 1 adjusted to <1,000	19	800-1,200	-	-	11(57.89)[3]	8(42.11)
zone 1 adjusted to 1,000-2,000	15	800-1,200	300	200	0	15(100.0)
zone 1 adjusted to >2,000-5,000	22	800-1,200	600	300	18(81.82)[1]	4(18.18)
zone 1 adjusted to >5,000-10,000	2	800-1,200	1,000	400	1(50.00)	1 (50.00)
Total	167				69(41.32)	98(58.68)

[1,2,3] refer to 1st, 2nd, and 3rd in order of workstations that did not meet the required standard.

3.3. Lighting Intensity at Inspection Workstations

When comparing the lighting intensity of each job to the standard according to three-zone measurement, it was mostly found that inspection work with microscope did not meet the minimum lighting requirement standard of zone 2 or zone 3 of inspection work. The highest percentage was indicated in very fine work inspection under a microscope with eye focusing, particularly when the focused point of the working zone was adjusted to have a lighting intensity of between 2,000 and 5,000 lux (81.82%), followed by inspection stations with a monitor or profile projector (64.29%), and times when the lighting intensity of zone 1 was adjusted to be within 1,000 lux (57.89%).

On the other hand, the highest numbers of workstations with a lighting intensity which met the required standard were found in inspection with an additional lamp, or working under a microscope if zone 1 had been adjusted to have a lighting intensity of between 1,000 and 2,000 lux, followed by the machine operation stations and material input workstations, as shown in Table 3.

4. Discussions

Measurement of work lighting intensity in this study was classified according to three job characteristics, i.e., crude work of machine operation and workpiece assembly, moderate fine work, and very fine work of inspection, and it was shown that 41.32% of all workstations had a lighting intensity which did not meet the standard. One reason for this was that there was a mismatch between the light installation line on the ceiling and the line of the workstations, particularly with light bulbs above the stations of inspection with a monitor or profile projector, and there was thickly covered lighting also installed. Those things might have decreased the lighting intensity at the stations, and the lower efficiency of light bulbs with casing may have led to a lighting intensity under the safety standard [6]. It was observed that bare light bulbs were used on the process line, in the machine control and assembly areas, where a crude type of work mostly took place and most of the lighting intensity at the stations met the required standard. The additional installation of lamps at the inspection stations of medium fine work could solve their problem by increasing the lighting intensity of all stations to reach the required range.

In most of the areas of very fine work of inspection under a microscope, the light had mostly been adjusted to be in the range of 2,000-5,000 lux. Although the lighting intensity of the eye-focusing area (zone 1) had been adjusted sufficiently, the surrounding area within an arm's length of the worker (zone 2) and outside an arm's length (zone 3) was affected by poor illuminance when compared to the standard. This is consistent with previous studies, which explained that insufficient lighting occurred mostly in areas of fine work tasks [10,11] and that was associated with the poor lighting intensity in the zone within an arm's length of the worker or the zone surrounding the point of focus [11]. The light bulb installation line should be designed to directly match the line of seated workstations of moderate fine work and, in particular, very fine work with eye focusing, where insufficient lighting was significantly associated with musculoskeletal discomfort in the neck, shoulders and back due to poor posture [4] and probably related with the poor movement of bending the trunk/neck forward/downward to reach their task [12].

Insufficient lighting intensity affecting the quality of production was previously reported in a study on electronics and jewelry manufacturing. The workers in that study experienced at least one eyesight malfunction and health problem, and 48.3% of those workers had a work efficiency defect. In cases of insufficient illuminance, the effectiveness in performing a production task was decreased to 24.5% of the usual effectiveness [10]. That effect, which was due to lighting insufficiency in relation

to work inefficiency, was statistically significant in textile manufacturing workers [13]. Among electronics manufacturing workers, insufficient lighting intensity was significantly correlated with adverse symptoms like dry eyes and eye fatigue. Lighting intensity improvement combined with enough time spent resting the eyes was correlated with increasing productivity and eye comfort among workers working in microscopy [12].

From the results of the lighting intensity of the three zones subjected to the measurement method, it was seen that the electronics workers had sufficiently adjusted the lighting intensity of the focus point according to their work characteristics, which was sometimes a very high intensity that caused a contrasting level of insufficient lighting in the surrounding area that was lower than the standard [6]. The method of three-zone measurement can indicate problems with the working environment better than a single spot measurement in the eye-focusing zone.

The previous study could not show a significant correlation with lighting intensity because of other spot measurements used, which measured lighting intensity at the eye-focusing point (zone 1) and usually met the standard. However, this study was able to describe the inappropriate lighting intensity of areas surrounding the inspection workstations of fine work, which probably caused discomfort due to the contrast between the focusing zone and the zone within an arm's length of the worker, where materials were picked up. That is consistent with a previous report stating that insufficient lighting intensity was correlated with shoulder pain [4] and musculoskeletal disorders among industrial workers [5].

In another previous study, it was found that working in areas where the lighting intensity was at least 1,000 lux could increase the work performance of workers [14, 15]. That was consistent with a previous study which found that good lighting in the textile industry reduced fatigue and health effects related to eye problems and the nervous system [15]. Moreover, it was found that a consistent level of lighting intensity in the surrounding work area, such as workspace on the table, could increase the work performance and comfort of healthy workers with statistical significance [16]. Besides that, from the results of a previous study of lighting in the textile industry, it was shown that good illuminance provided both an adequate and balanced level of benefits for improving the satisfaction and morale of employees [15]. Additionally, an experimental study of the redesign of many work environments, which included setting the light of a home office in India in a new and better position, reduced fatigue and increased the production output after intervention to be more than 60 percent higher than it was before [17]. Therefore, it is essential to take care of the health of electronics assembly workers, especially those who work in a sitting zone in conditions with covered light bulbs and inappropriate lines of light bulb installation, to prevent work-related shoulder pain or fatigue and increase the work performance.

5. Conclusions and Implications

The results of the assessment of lighting intensity showed that inspection tasks requiring moderate fine work to very fine work which did not meet the regulation of lighting intensities were found in the highest proportion at microscope stations (81.12%). The insufficient lighting was mostly identified within an arm's length of the worker (zone 2) of very fine work. Thus, the suggested implications from these findings are as follows:

1. In the case that there is very fine work which requires specific light intensity in some working zones surrounding the eye-focusing point of inspection, the lighting intensity should be monitored by using a method of three-zone measurement.
2. Usage of thick light coverings which reduce illumination should be avoided, and the light bulbs or other equipment should be inspected often and always allow workable lighting conditions for all of the working area.
3. Training should be provided to workers, and lighting intensity adjustment of a microscope lamp to be not over 2,000 lux is recommended to prevent glare and a contrast of lighting between the area of eye-focusing work and the area within an arm's length of the worker. Moreover, it is recommended that workers protect against eye fatigue by taking a short break of at least 20 seconds every 20 minutes.
4. For future studies, musculoskeletal disorders and their association with risk factors, including discomfort, light intensity, ergonomic factors and other related factors, should be further investigated among electronics inspection workers.

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REFERENCES

[1] Department of Industrial Works, Ministry of Industry. "Registration of electronic assembly factory to operate in the northeast of Thailand." Online available from http://www2.diw.go.th/ factory /tumbol.asp.

[2] Chaiklieng S., Suggaravetsiri P., "Ergonomics risk assessment of electronic assembly workers in the industry." Arch AHS, vol. 31, no. 2, pp.150-161, 2019.

[3] Duangprom N., Chaiklieng S., "Recognition of musculoskeletal disorders among workers of the electronic industry in Udon Thani Province." Asia Pac J Sci Tech, vol.

18, no. 5, pp.880-890, 2017.

[4] Sirisuriyasunthorn S., Chaiklieng S., "Ergonomic risk with neck, shoulder and back pain among computer users at Tambon health promoting hospitals in Maha Sarakham Province." KKU J Public Health Res, vol. 8, no. 3, pp.54-63, 2015.

[5] Dehghan S.F., Mehrifar Y., Sayedabadi E., Aghl M.P., Mihambidi M.P., Motlagh A.T., Bahrami M., Mohammadi D.A., Balochkhane F.A., Golkhani F., "Investigating the relationship between exposure level to sound pressure level (spl) and light intensity with occupational burnout in an automotive parts industry." J Biochem Tech, vol. 11, no. 1, Special Issue 1, pp.18-24, 2020.

[6] Department of Labor Protection and Welfare, Thailand. "Notification of light intensity standard, B.E.2561". Government Gazette volume 135, special episode 39 (24 February 2018), pp.15, 2018.

[7] Untimanon O., Pacharatrakul W., Boonmeepong K., Thammagarun L., Laemun N., Theptakaporn S., V. Chongsuwiwatwong V., "Visual problems among electronic and jewelry workers in Thailand." J Occup Health, 48, pp.407-412, 2006. Doi: 10.1539/joh.48.407.

[8] International Standard /International Electrotechnical Commission. "ISO/CIE 10527: General requirements for the competence of testing and calibration laboratories."

[9] Department of Labor Protection and Welfare, Thailand. "Notification of rules, procedures of measurement and condition analysis, analysis of working condition related hot light or noise including period and type of business that must be performed B.E. 2561." Government Gazette volume 135, special episode 57 (12 March 2018), pp.1-6.

[10] Chaiklieng S., Suggaravetsiri P., "Low back pain (lbp) incidence, ergonomics risk and workers' characteristics in relations to lbp in electronics assembly manufacturing." Indian J Occup Environ Med, vol.24, no.3, pp.183-187, 2020.

[11] Parkpoom P., Boonruksa P., "Lighting assessment in workplaces during day and night shift at a motorcycle part manufacturer in Chonburi Province." KKU J Public Health Res, vol. 11, no. 1, pp.78-85, 2018.

[12] Lin K.H., Su C.C., Chen Y.Y., Chu P.P., "The effects of lighting problems on eye symptoms among cleanroom microscope workers." Inter J Environ Res Public Health, vol. 16, no. 101, 2019. Doi:10.3390/ijerph16010101.

[13] Paskanita M., Setyawan H., Qadrijati I., "The effects of lighting intensity on the productivity of textile workers in Surakarta." KEMAS, 2019. Doi:10.15294/kemas.v15i1.15448.

[14] Vimalanathan K., Babu T.R., "The effect of indoor office environment on the work performance, health and well-being of office workers." J Environ Health Sci Eng. vol.12, no.113, 2014. Doi: 10.1186/s40201-014-0113-7

[15] Uttam D., "Lighting in textile industry." IJAREAS, vol.4, no. 2, pp.17-26, 2015.

[16] Katabaro J.M., Yan Y., "Effects of lighting quality on working efficiency of workers in office building in Tanzania." Hindawi J Environ Public Health, 2019. Doi: 10.1155/2019/3476490.

[17] Sajiyo M.A., Prasnowo., "Redesign of work environment with ergonomics intervention to reduce fatigue." Int J Appl Eng Res, vol. 12, no. 7, pp.1237-1243, 2017, Online Available from http://www.ripublication.com