Final Report
on
Monitoring the performance of Solar Pipe light installed in an Ice-cream factory by GSM based Light Luminosity Logger

Submitted
To
Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Submitted By

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Introduction

Solar pipe light or light pipes are physical structures used for transporting or distributing natural or artificial light for the purpose of illumination. They can be a en energy efficient lighting option for industrial sheds where the requirement of day time lights are very high. Keeping this in mind a NGO named Change has designed a pipe light using low cost materials with the financial assistance from the GIZ. Three proto type lights are insatllaed in an ice-cream factory in Dhamrai area.

In order to monitor the performance of the lights, a datalogger has been designed by a team from BUET. The data logger measures and stores the illumination levels of sun on the roof and that of the centre of the diffuser of the pipe. These dara are sent to a data server in each evening by GSM modems. The data logger has been working in the field for last one year. GIZ has requested the BUET team to monitor and comment on the performance of the pipe light.

Task and Deliverables

The activity in the contract is as follows

No. of Activity	Description of the tasks
Activity-1	Designing the Auto Lux Logger Setup
Activity-2	Installation and Commissioning of the auto lux logger setup
Activity-3	Provide Training to the Contractor / Factory staffs on the use of auto lux logger
Activity-4	Periodic monitoring and technical guidance of the performance of Auto Lux Logger

System Design

The designed system log data of the solar light luminosity whole day long. There are two light sensors to measure outside light luminosity and inside solar light luminosity. The data are taken for every 5 minutes interval and stored in a memory card. The data are saved in CSV(Comma Delimited File) format. At night, the saved CSV file is sent via GSM Module to an FTP server. The whole system is be controlled by an Arduino Uno Development Board. The block diagram of the developed data logger is given in Fig 1.

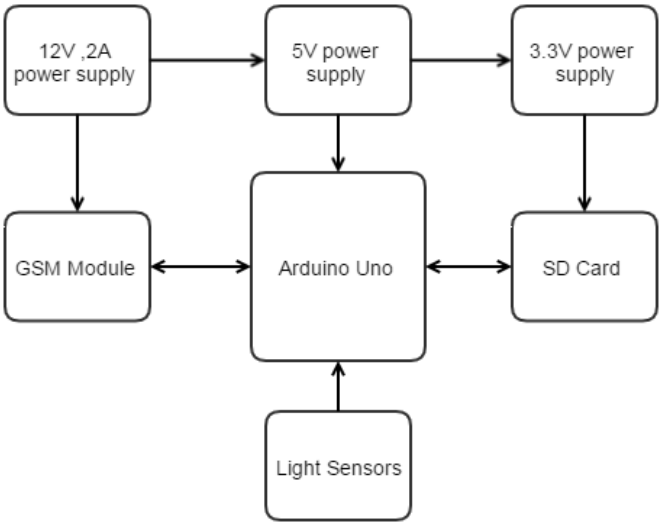


Fig 1: Block diagram of the data logger

Fig 2: Solar pipe lights installed within the factory.

Visit & Observations

The BUET team installed the system in the ice cream factory and monitored the data recorded by the logger. They also had several visits to monitor its performance. The installed pipe lights are used to illuminate factory sheds as shown in Fig 2.

The illumination level was quite satisfactory and the lights have very good feedback for the workers. The workers rather complained about the excess brightness in the sheds. 65 watt Compact fluorescent lamp (CFL) are used inside the factory in absence of the solar irradiance. In visual observation, the amount of lights is much higher for the solar pipe lights compared to that of the CFLs.

Measurements and Discussion

The BUET team measured illumination levels in various loations with in the factory floor. Different optical parameters like Color rendering index and Color temperature and color spectrum of the lights were also measured by handheld Spectrometer Uptrek MK350N.

Color Rendering Index (CRI) measures the ability of a light source to accurately reproduce colors and is measured on a scale from 0 to 100. Natural light has a CRI of 100 and all light sources strive to replicate this value. The CRI of the CFL was in the range of 70 to 85 where as that of the solar pipe lights is more 98. This proves that the installed solar pipe light has excellent color representation capability.

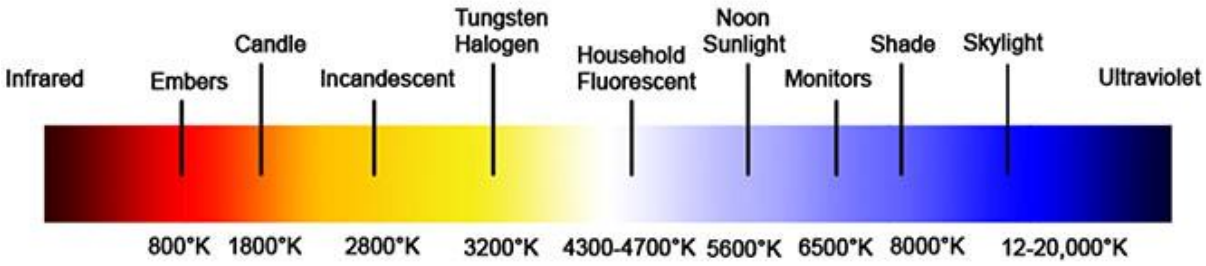


Fig. 3: Correlated color temperature (CCT) values.

The correlated color temperature (CCT) is a specification of the color appearance of the light emitted by a lamp, relating its color to the color of light from a reference source when heated to a particular temperature, measured in degrees Kelvin (K). It is a characteristic of visible light that has important applications in lighting, photography, videography, publishing, manufacturing, astrophysics, horticulture, and other. Fig. 3 shows the CCT range for different

color light. The CCT of a fluorescent light is around 5000-6500K. The measured CCT of the solar pipe lights is within the range of 4000-6000K.

The reason that some light sources are better (higher CRI) at showing color has to do with the light spectrum that it produces. An object can only reflect the light spectrum that is present. So if certain color is present in the spectrum, the light will be able to show it properly. The team checked the color spectrum of the solar pipe light. Fig 4 shows the color spectrum of different light source and Fig 5 shows the spectrum of the solar pipe light.

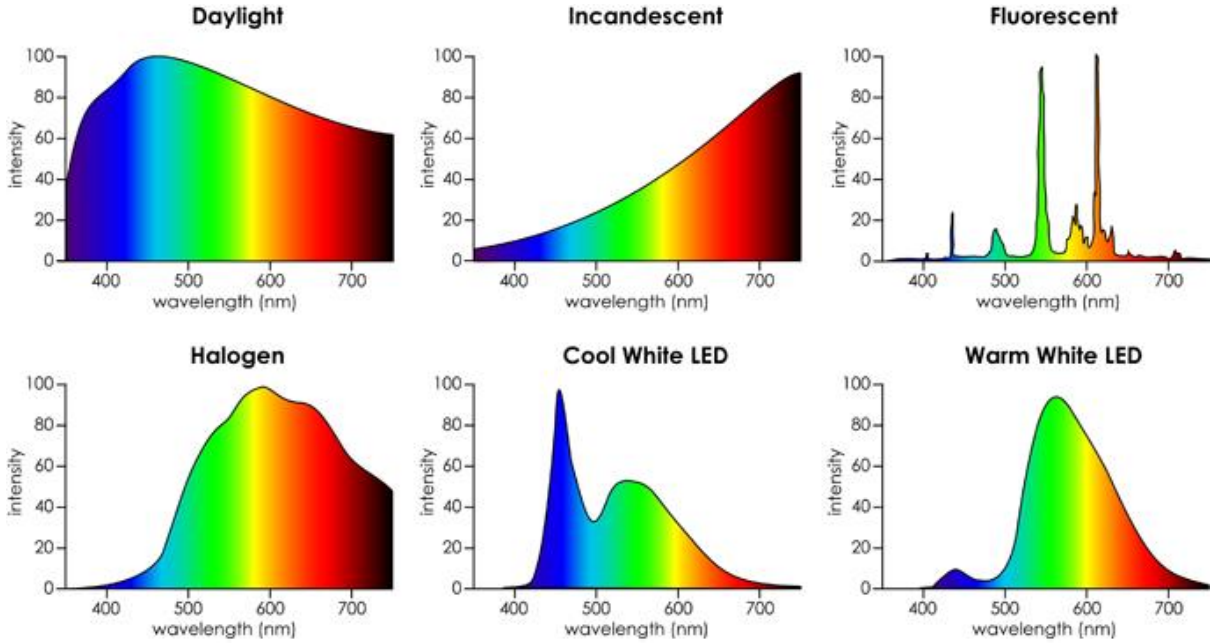


Fig. 4: The light spectrum of different light source

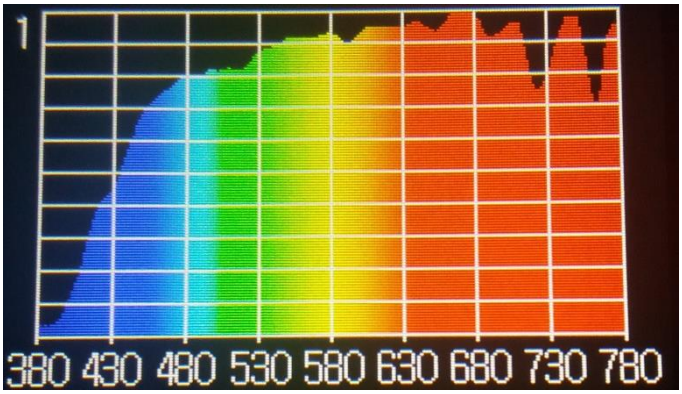
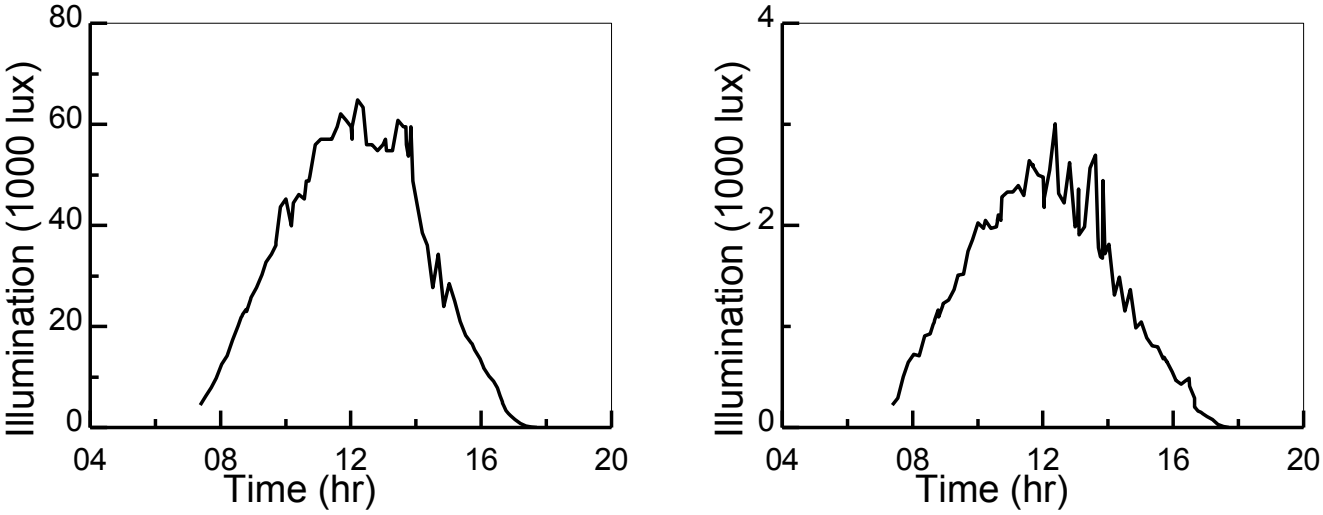


Fig. 5: The light spectrum of solar pipe light. Measured by Uptrek MK350N

Form the measured data it is clear that the solar pipe light is similar to day lights so it has very good color representation capability.

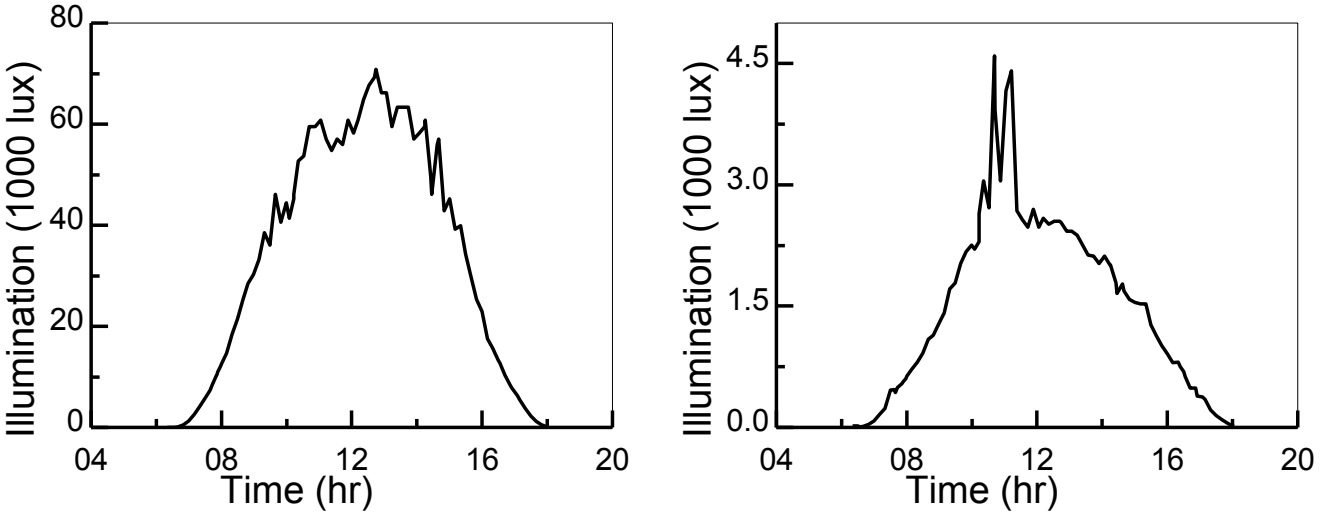
The illumination level in the factory floor vary from 20 lux to 147 lux. The auto lux logger shows that the illumination level at the center of the diffuser of the solar pipe light is about

5-10% of the illumination level at the roof. Fig 6, 7, 8 and 9 shows the illumination levels on the roof and at the center of the diffuser of the solar pipe light in thousand lux for a typical day in four different months. The data is provided form 6 am to 6pm in day,



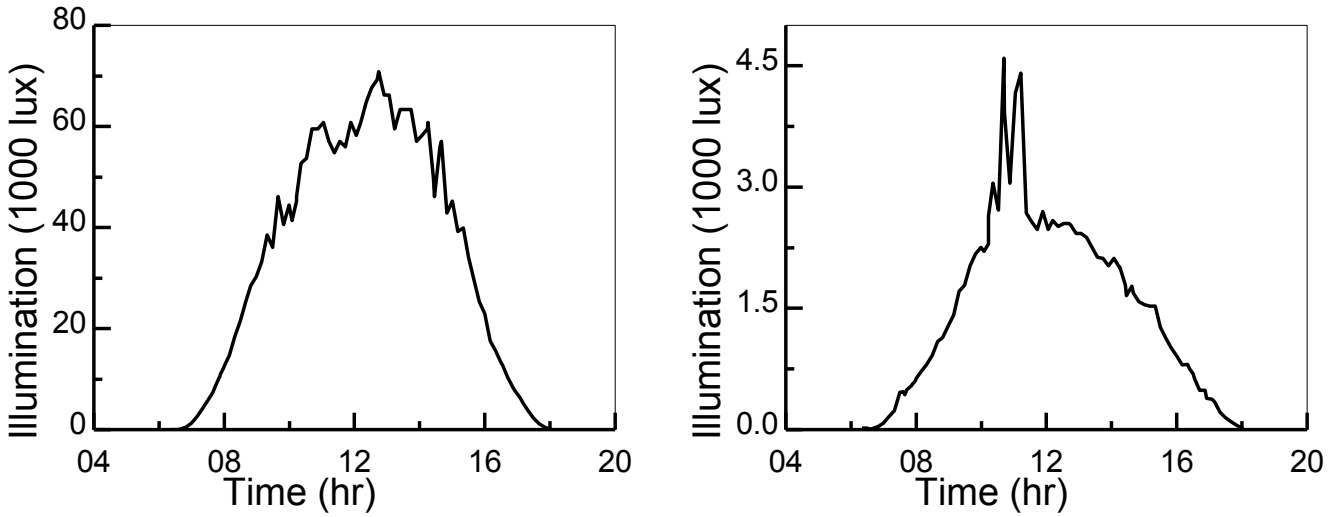
(a) (b)

Fig. 6: Measured Illuminstion level in thousand lux in a typical day in December 2016 at (a) roof top (b) center of the diffuser of the solar pipe light.



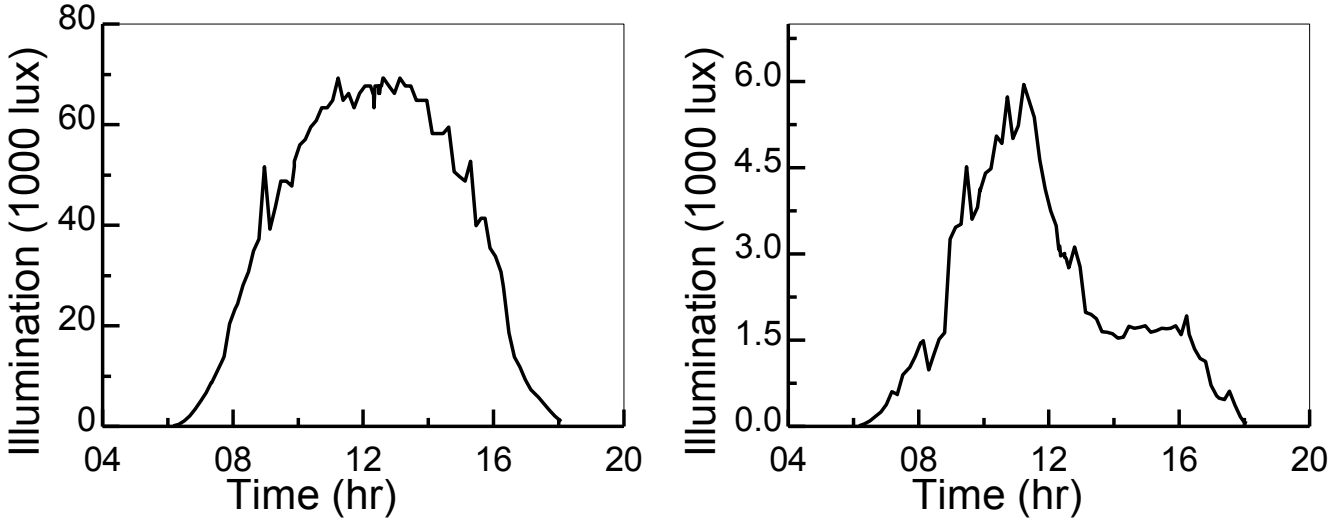
(a) (b)

Fig. 7: Measured Illumination level in thousand lux in a typical day in February 2017 at (a) roof top (b) center of the diffuser of the solar pipe light.



(a) (b)

Fig. 8: Measured Illumination level in thousand lux in a typical day in March 2017 at (a) roof top (b) center of the diffuser of the solar pipe light.



(a) (b)

Fig. 9: Measured Illumination level in thousand lux in a typical day in April 2017 at (a) roof top (b) center of the diffuser of the solar pipe light.

The inverse square law of light defines the relationship between the irradiance from a point source and distance. It states that the intensity per unit area varies in inverse proportion to the square of the distance. Using this formula and measurement data, the illumination level in the factory floor directly below the solar pipe light was calculated. Fig. 10 shows the calculated illumination in the factory floor for four different months. The calculated values show that the illumination is more than 50 lux from 10am to 3pm for all the months. This is equivalent to a new better quality 85 CFL lamp. The illumination is much higher during noon.

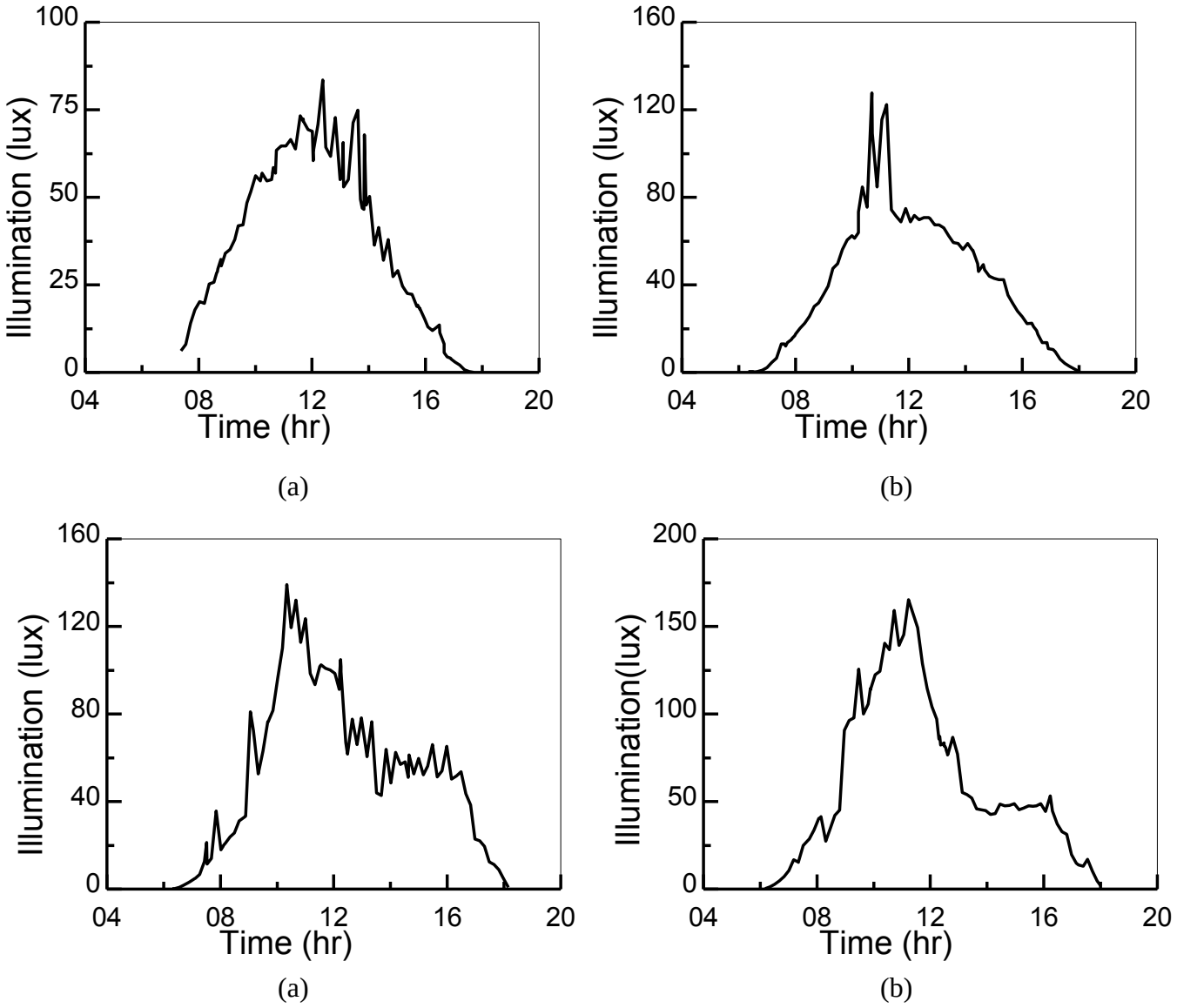


Fig. 10: Calculated Illuminstion level in the factory floor (6m from the light) directly below the solar light in a typical day in (a) December 2016 (b) February 2017 (c) March 2017, and (d) April 2017.

Conclusions

The performance of the installed solar pipe light is evaluated by using the autolux logger designed by the BUET team. It was found that the solar light has excellent color representation capability (CRI > 98) and can easily be used in place of an 85 watt CFL for the sunny days. This light is an good candidate for energy saving in the industrial sheds and warehouses where day lighting is essential. The prototype designed by CHANGE is locally manufactured and substantially cheaper than the commercially available solar lights in the market. So it should be commercially viable for local industries.