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Significance of UV Irradiance Measurements in Biological Safety Cabinet

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ABSTRACT

Biological safety cabinets (BSC), have a wide distribution in biological laboratory. Safety management of using BSC based on two systems working in each cabinet one is ventilation system the other is Ultraviolet (UV) disinfection system. This work is focusing on measuring the UV dose aiming to reach the best benefits of it. Two groups of BSC using UV lamps in differ designs of where are the UV lamps are installed inside the cabinet. Design (A) based on one UV lamp while design (B) depends on multiple UV lamps. Irradiance versus position plots show that design based on one lamp provides the better irradiance homogeneity nearly double than that obtained using design (B). Also shows how workers with BSCs can get the best benefit of using UV irradiance in BSCs by using UVC irradiance meter and scan the irradiance levels at different points covering the working bench surface. Easily calculate the dose in J/cm^2 through the measured irradiances in W/cm^2. Determining of UV dose requirements and subsequent reliable delivery of the required dose ultimately establishes the real disinfection results.

Key words: UV lamps, Biological cabinets, Biological safety, germicidal irradiation, disinfection.

1. INTRODUCTION

1.1. Biological safety cabinet (BSC)

Microbiological safety cabinet is an enclosed, ventilated laboratory workspace for safely working with materials contaminated with (or potentially contaminated with) pathogens requiring a defined bio-safety level. Several different types of BSC exist, differentiated by the degree of bio containment required. BSCs first became commercially available in 1950.

Artificial ultraviolet source emitting ultraviolet radiation in the C range UVC are the common source used in Biological safety cabinets (BSC).

Because of there are many parameters affecting the UV effectiveness as Temperature, lamp Cleanliness, and lamp Aging. Many centers and institutes agree with the recommendation, which states that UV lamps are not required in BSCs nor are they necessary and while others recommend that the lamps should be checked weekly with a UV meter to ensure that the appropriate intensity of UV light is being emitted [1,2,3,4].

So agreement or difference recommendations of using ultraviolet source in BSCs in comparison with confirmed significant effect of UV on microorganism, raising the importance of accurate and periodical measuring of the UV irradiance level to catch the benefit of using the UV lamps.

1.2. Properties of Ultraviolet Light:

The International Commission on Illumination (CIE) divided the UV spectrum into three wavelength bands primarily due to biological effects. The 315-400 nm wavelength band is designated as UV-A, 280-315 nm is designated as UV-B, and 100-218 nm as UV-C. Wavelengths below 180 nm are of little practical biological significance since the atmosphere readily absorbs them. Sources of UV-A are used for dentistry and tanning, UV-B is used for fade testing and photocuring of plastics, and UV-C is used for germicidal purposes. All wavelengths less than 320 nm are actinic meaning they are capable of causing chemical reactions. [6]

1.3. UV disinfection process:

Ultra-violet germicidal irradiation (UVGI) utilizes short-wavelength ultraviolet radiation (UV-C) ranging 225 to 302 nanometer is mutagenic to bacteria, viruses and other micro-organisms. In other words UV radiation with wavelength range centered at 254 nm is harmful to microorganisms.

Since the first UVGI system was successfully implemented for disinfecting the municipal water system in Marseilles, France, in 1909, the disinfection of medical equipment using UVGI has been a common and reliable practice.[5] It is effective in break the molecular bonds within micro-organismal DNA, producing thymine dimmers in their DNA thereby destroying them, rendering them harmless or prohibiting growth and reproduction. This removes their reproductive capabilities and kills them. Although UV can disinfect an empty BSC, it will only disinfect the outer surface of any material stored in a BSC. The minimum acceptable irradiance in a BSC is 40 $\mu W/cm^2$, it takes 12.5 minutes to reach the 30,000 $\mu J/cm^2$ found to inactivate spore forming organisms.[7]

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Many tables have been published for the UV doses in Ws/ cm^2 or µJ/ cm^2 in different log factor to simplify the doses values. Table 1 summarizes the most common log used in presenting the UV dose.[8]

Table 1: UV required doses in mJ/ cm^2 for different microorganisms at different logs.

Log	Bacteria UV dose (mJ/cm^2)	Protozoa UV dose (mJ/cm^2)	Virus UV dose (mJ/cm^2)
1.0	1.3 - 24.3	13 - 45	2.6 - 240
2.0	2.5 – 46.2	22 - 92	6.6 - 440

2. Experimental measurements:

The irradiance levels inside two major designs ware measured using National Institute For standards (NIS) reference radiometer (UDT –S370) with 268-UVC detector whose maximum response is located at 254 nm.

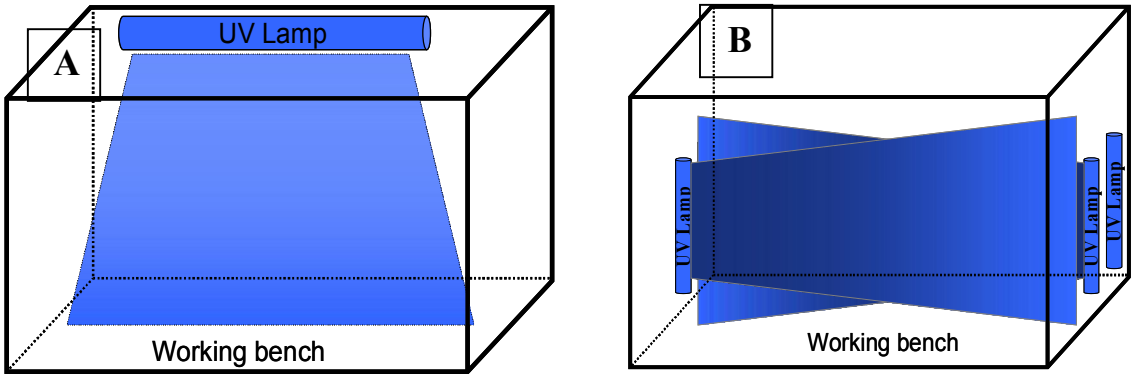

Figure 1 : Sketch diagram for BSC. (A) UV lamps installed at the upper rare wall of the cabinit, and (B) UV lamps installed at the lower lateral walls of the cabinet.

The first design is based on one lamp mounted horizontally on the top of either long sides of the cabinet. The other design based on two lamps mounted vertically at the lower part to the rear of the lateral sides of the cabinet shown in figer 1 (A and B) respectively. Six cabinets of design (A) and four of design (B) are studied in this work.

The working stage inside the cabinet was divided during the measurement process into three rows (front, middle and rear) and seven columns resulting in twenty one points. The lamps ware given enough time to worm up prior to recording the readings, then the irradiance levels have been measured at each of the above mentioned points. The readings, in µW/cm^2 are shown in the figures 2 and 3. Which show irradiance levels at the three rows mentioned above covering the working bench inside the cabinet. The variation in values of UV irradiance levels are due to inhomogeneous distribution of the UV irradiance.

3. RESULTS AND DISCUSSION

Each design follows its specific trend of irradiance distribution. Plotting the relation between the measured irradiance levels and their positions on the surface of the working bench. Figures 2 and 3 illustrate that the three rows recording different intensities according to the lamp position. For design (A) the distributions of the three rows are Gaussian. The maximum irradiance noticed at the row center and different row levels recorded according to the lamp position. The ratio between minimum to maximum intensities in the same row is about 65% while at design (B) about 30%. However at design (B) the irradiances at one row are nearly the same at the center and dramatically decrease towards the edges. Result a high difference in the irradiance records in the same raw.

The standard deviation of irradiance levels achieved for each row at the cabinet of design (A) was half of that at design (B). In other words the over all distribution uniformity at design (A) is nearly double that achieved at design (B). however design (B) providing high uniformity at the center of the working bench covering 60% of the working surface, while design (A) follow Gaussian distribution all over the working surface.

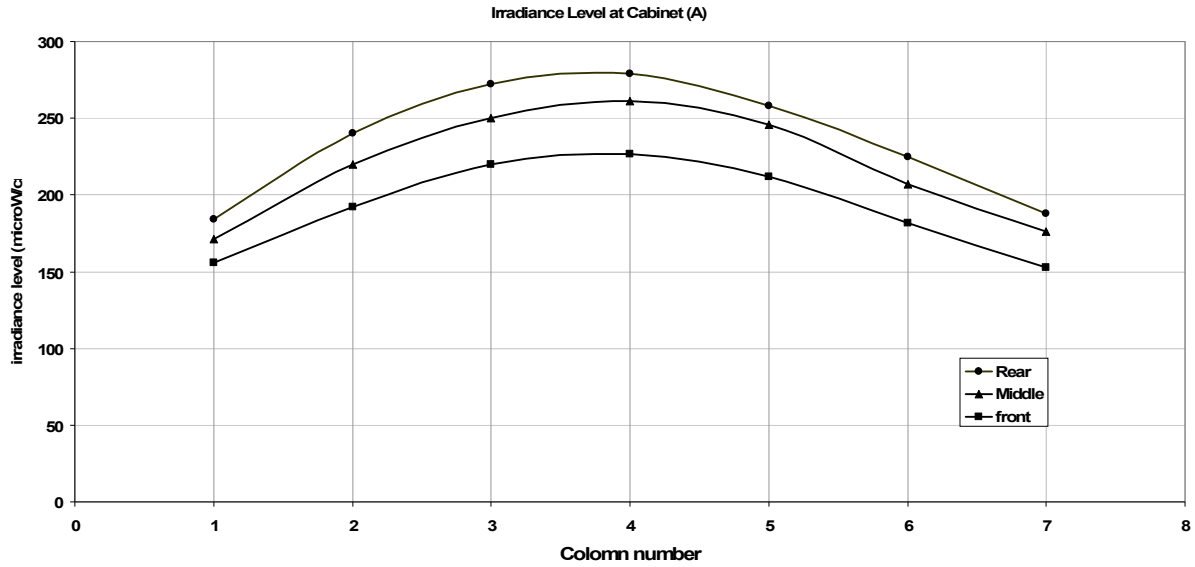

Figure 2: Irradiance levels at the working bench of cabinet with design (A).

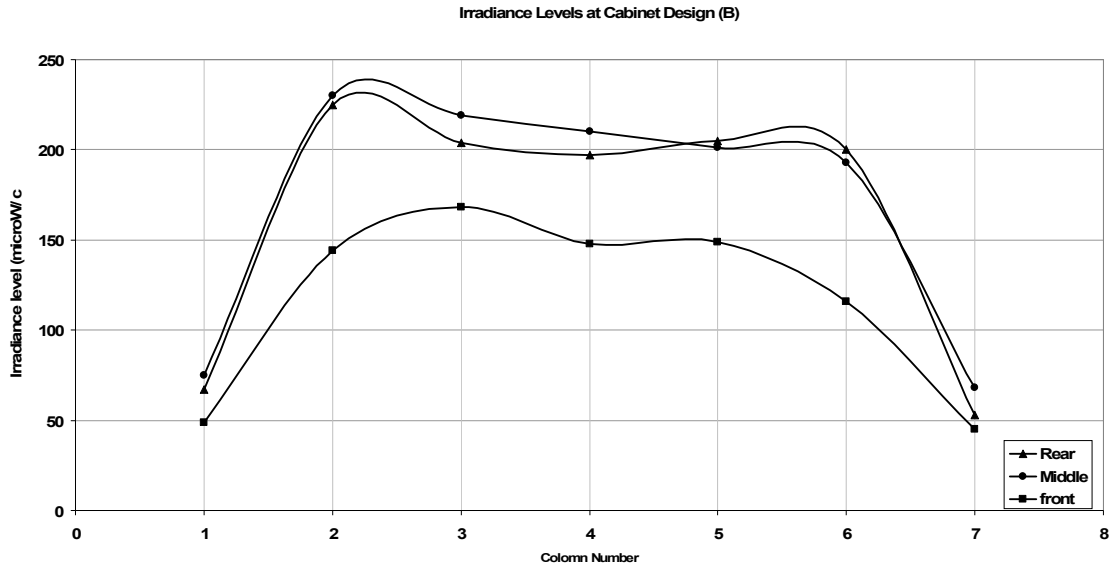

Figure 3: Irradiance levels at the working bench of cabinet with design (B).

4. Conclusion:

Different designs of the UV sources inside BSCs have high effect on the homogenous distribution of the irradiance levels reaching the working bench surface. It is found that design (A) covering the whole working bench area of the BSC, provides homogenous distribution two times better than that obtained using design (B). While design (B) provides homogenous irradiance distribution covering 60% of the whole area at the center of working surface and dramatically decreases at the borders. Accurate determination of UV dose requirements and subsequent reliable delivery of the required dose ultimately establishes the real disinfection results. So workers can easily calculate dose in J/cm^2 by multiplying the measured irradiances in W/cm^2 by time of exposure in seconds so the proper dose for disinfection for different microorganisms can be accurately achieved. Plotting the relation between the irradiance levels and there positions at the cabinet work bench show how to get the benefit of using UV irradiance in BSCs by using UVC irradiance meter and scan the irradiance levels at different points.

This work is insisting that UV lamps must be turned off when using the BSC to protect eyes and skin from UV exposure, which could result a burnt cornea and skin cancer, and use UV protection tools when measuring the irradiance levels.

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