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Exposure to Non–Ionizing Radiation of Solar Origin: Measurements in Patagonia

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ABSTRACT

This article aim is to measure the exposure to non-ionizing radiation of solar origin in Patagonia, in order to provide information that to date almost does not exist and serve as a basis for future research on the subject. The measurements were made in the XI Region Aysén, Chile; more specifically in the town of Chile Chico. A UVR meter was used. The measurements were made during the months of September and October, the measures were made each day, with 1-hour intervals. The data were compiled and tabulated to be later analyzed and presented in this study. The URV averages are presented considering those days with the highest temperatures and the general average for the months of September and October. The highest measurement obtained was 3,7 mW/cm^2 and it was at 12 p.m. on October 10. The highest measurements were recorded between 10 a.m. and 4 p.m., which is consistent with studies conducted on the subject. The Sun safety at work questionnaire, Solar UV Radiation Risk Assessment for Outdoor Workers: Operational review, was also applied to workers in the area, managing to evaluate 4 jobs positions, three of these job positions received an overall medium risk level and the fourth received a high risk level. Further studies are needed in Patagonia in order to establish more precise standards to reduce the risks associated with exposure to non-ionizing radiation of solar origin.

Keywords: Non–ionizing radiation, Non–ionizing radiation measurements, Solar radiation, Ultraviolet radiation

INTRODUCTION

Non-ionizing radiation refers electromagnetic radiation with photons energy less than 10 eV, corresponding to frequencies less than 3 × 1015 Hz and wavelengths longer than 100 nm (ICNIRP, 2020). Non-Ionizing radiation originates from various sources: Natural origin (such as sunlight or lightning discharges) and manmade (seen in wireless communications, industrial, scientific and medical applications) (Ng, 2003). Sunlight is the main source of ultraviolet radiation (UVR) (Gallagher et al., 2010) and it is defined as radiation between 100 and 400 nanometers (nm) length (WHO, 1994). UVR is subdivided into ultraviolet "A" [UVA (315–400 nm)], ultraviolet "B" [UVB (280– 315 nm)] and ultraviolet "C" [UVC (100–280 nm)] (Narayanan et al., 2010). UVC radiation, unlike UVA and UVB radiation, is almost completely absorbed by the ozone layer. Approximately 90–99% of UVR reaches the earth's surface is UVA, and only 1–10% is UVB (Miller et al., 1998; Pastila & Leszczynski, 2007). UVA and UVB rays reach the earth in sufficient quantities to damage skin structures (Silveira & Pedroso, 2014; Bosch et al., 2015). UV radiation can penetrate the skin interacting with skin cells (Gilchrest, 2013). Quality (spectrum) and quantity (intensity) of terrestrial UV radiation vary with the sun elevation above the horizon, or solar altitude (Diffey, 2002). Clouds redistribute and generally reduce the UVR reaching the Earth's surface, but often not nearly as much as the average person would expect, as sunburns can occur on overcast days (ICNIRP, 2010). The destructive mechanism of UVB and UVA action on DNA molecules differs, which is related to the amount of energy absorbed by base pairs in the DNA chain (Almeida et al., 2015). Changes arising as a result of UVB radiation are visible mainly within the epidermis, but it also penetrates the upper part of dermis (Debacq-Chainiaux et al., 2012; Zhang et al., 2014). Overexposure to UV radiation increases the formation of reactive oxygen species (ROS), which at higher concentrations can damage the main proteins that make up the skin, collagen and elastin (Ryu et al., 2014; Pérez-Sánchez et al., 2014; Rinnerthaler et al., 2015; Ngan et al., 2015; Gromkowska-Kępka et al., 2021). High levels of exposure to UVR increase the risk of all three major forms of skin cancer, and approximately 65% to 90% of melanomas are caused by UV exposure (Glanz & Mayer, 2005).

There are different devices to measure UVR, these can be radiometers, capable of measuring instantaneous UV intensity, or dosimeters, capable of measuring accumulated UV dose over time (Banerjee et al., 2017).

MATERIAL AND METHODS

Non-ionizing radiation of solar origin was measured in Patagonia, Chile Chico town, XI Region - Aysen - Carlos Ibañez del Campo (46°34′53″S 71°41′12″W). An UV meter UVA - UVB radiation meter PCE-UV34 were used on a static lectern at 1 meter height in each measurement, this device operates at 290 to 390 nm wavelength, it has two measuring ranges:

Range 01 $0,000 \ to \ 1,999 mW/\text{cm}^2 \ or \ 0,000 \ to \ 19,9 \ W/\text{cm}^2$

Range 02 $1,999 \ to \ 19,99 mW/\text{cm}^2 \ or \ 19,99 \ to \ 199,9 \ W/\text{cm}^2$

The second range was mostly used. Measures were made every day until September 11th and then every other day until the end of October. All measurements were made from 8 a.m. to 5 p.m. at one-hour intervals.

In every measurement the maximum and minimum temperature, humidity percentage and wind speed and direction were in addition recorded. No measures were made on rainy days due to the practically zero exposure of the people in this condition.

The measurements were entered into an excel spreadsheet for further analysis.

Averages were obtained hourly considering the high temperatures days for each month.

The Sun safety at work questionnaire, Solar UV radiation risk assessment for outdoor workers: Operational review, was also applied to workers at

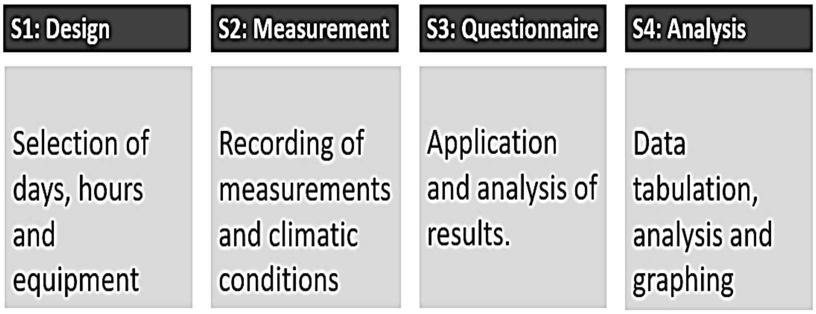

Figure 1: Outline of the study's methodology.

the "Normalization of the Chile Chico Hospital" construction site. Four job positions were evaluated: (P1) Warehouse assistant (unloading material); (P2) Daily Laborer (Concrete Mixing) (P3) Master builder's assistant (concrete distribution) (P4) Daily Laborer (Pit Excavation).

A brief outline of the study methodology is shown in Figure 1.

RESULTS

An example of a daily sampling record is shown in Table 1.

All the results obtained are expressed in mW/cm^2, which is the unit of measurement of the intensity of non-ionizing radiation of solar origin. The highest measurement obtained was 3.7 mW/cm^2 and it was at 12 p.m. on October 10, and the respective distribution of measurements is shown in Figure 2.

The averages were calculated for one hour measurement, considering only days exceeding 11°C. Averages distribution and standard deviations are shown in Figure 3.

Table 1. Example of a daily sample record. (Saturday 3 September 2022.)

Temperature	9/2
Weather	*Cloudy*
Wind speed km/h	15
Wind direction	*W – NW*
Humidity %	8
8:00 a.m mW/cm^2	0.46
9:00 a.m mW/cm^2	0.53
10:00 a.m mW/cm^2	0.83
11:00 a.m mW/cm^2	0.96
12:00 a.m mW/cm^2	1.05
13:00 a.m mW/cm^2	1.11
14:00 a.m mW/cm^2	1.21
15:00 a.m mW/cm^2	1.05
16:00 a.m mW/cm^2	0.79
17:00 a.m mW/cm^2	0.68

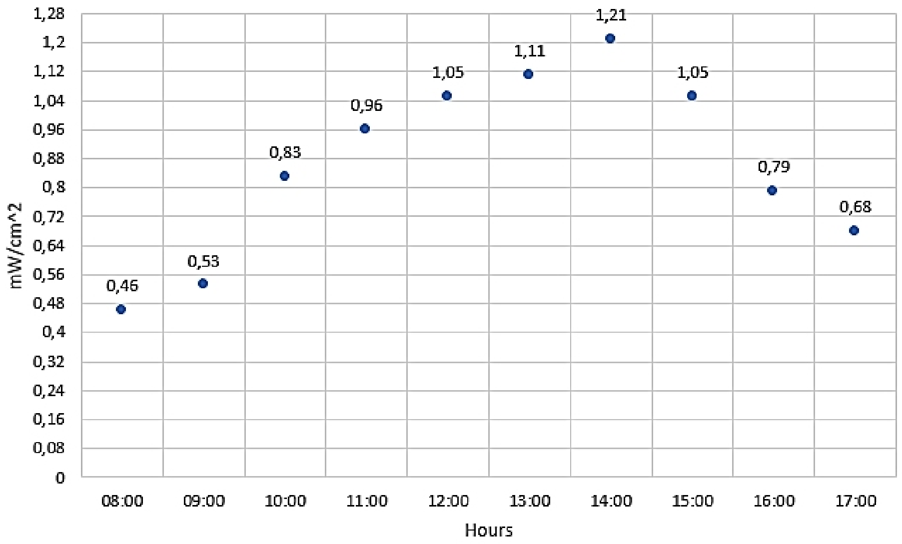

Figure 2: Distribution of measurements Saturdays September 2022.

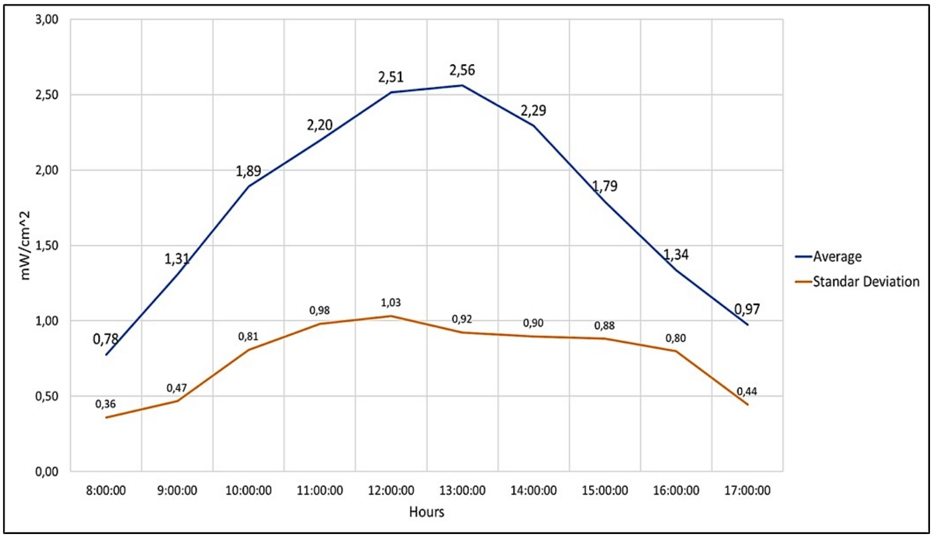

Figure 3: Average on days with high temperatures.

Averages were also obtained for all days sampled in September and October, respectively which are shown in Figure 4.

The results obtained from the application of the questionnaire are shown in Figure 5, together with the overall risk ranges.

DISCUSSION

The results show the greatest irradiance periods are between 10 am and 4 pm, It is congruence with the evidence shown so far. It is also possible to appreciate the relationship between higher radiation levels and days exceeding 11°C.

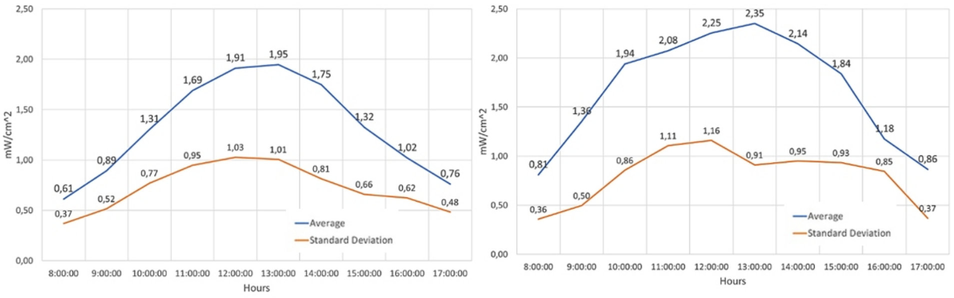

Figure 4: Average on September and October 2022 respectively.

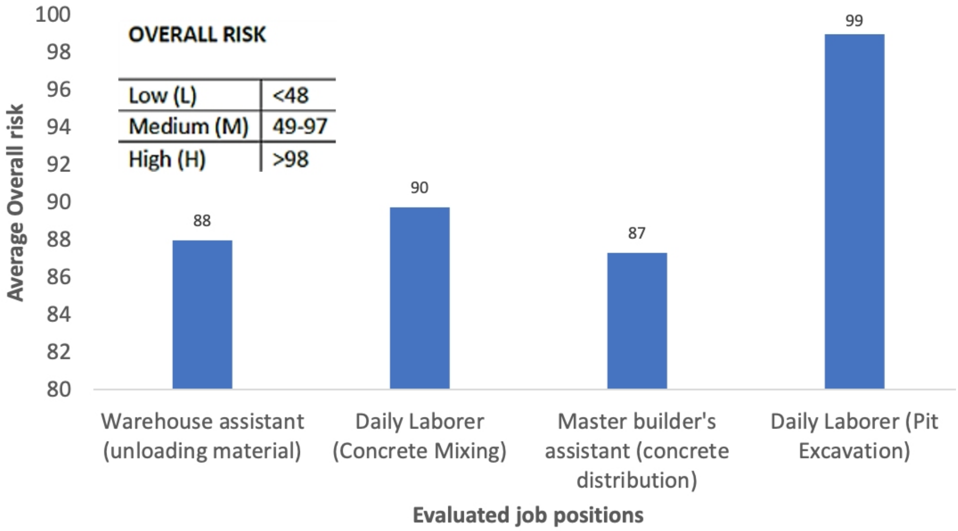

Figure 5: Average global risk of evaluated jobs.

Comparing October and September, the latter shown a higher hourly UVR averages measured. With regard the questionnaire application, although only 4 job positions could be evaluated, interesting results were obtained, three workstations obtained a medium overall risk (warehouse assistant (88); Daily laborer (90); Master builder‘s assistant) and only one obtained a high level (Pit Excavation (99)). A more detailed analysis showed the main aspect affected the evaluation was the lack of shade at the workstation.

CONCLUSION

This study presented the results obtained by measuring solar radiation in Chile Chico town during September and October 2022. Measuring one-hour intervals, the daily irradiance evolution and the highest and lowest intensity hours were clearly shown. The highest measurement obtained was 3.7 mW/cm^2 and it was at 12 p.m. on October 10.

The Sun safety at work questionnaire, Solar UV radiation risk assessment for outdoor workers: Operational review, was applied to workers at the Construction site. There were 3 jobs positions with a medium overall risk and one with a high risk, the latter with a score of 99, which is only 1 point above what the questionnaire states.

The results presented both measurements and of the questionnaire are important because there was no information, on the other hand it coincide with other research, but are far from being a sufficient source of information regarding exposure to non-ionizing radiation of solar origin.

Some recommendations that could mitigate the effects of exposure to non-ionizing radiation are: a) Inform the UV index on a daily basis to workers b) Provide physical barriers against radiation (gloves, sunglasses, helmets, appropriate clothing, sunscreen among others) c) Promote personal self-care through talks, training and seminars.

FUTURE WORKS

More research and analysis are required in Patagonia in order to establish more precise standards to reduce the risks associated with exposure to non-ionizing radiation of solar origin.

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