Mineralogical and optical characterization of soiling and its impact on the performance of six photovoltaic technologies in Arequipa, Peru: a preliminary study: a preliminary study

R. J. Quispe-Andrade[1], L. A. Montoya[1], E. Palo-Tejada[1], A. Paxi[1], D. Amado[1], and J. Neira[1]
[1] Faculty of Natural and Formal Science, National University of San Agustin (UNSA), Arequipa 04000, Peru
Email: rquispeand@unsa.edu.pe

Abstract. The crystalline phases of a soiling sample collected in Arequipa were identified using X-ray diffraction, revealing illite (I), hornblende (H), quartz (Q), and labradorite (L). Concurrently, the relative direct spectral transmittance of soiling deposited on commercial glass samples under two tilt configurations was monitored over three weeks. Energy losses were simulated across six photovoltaic technologies, revealing that all of them experience a comparable global impact, with perovskite and amorphous silicon being slightly more vulnerable.

I. Introduction

The expansion of photovoltaic energy in arid and high-radiation zones faces a critical challenge due to soiling, a phenomenon that alters the optical properties of module surfaces and reduces their energy yield. In regions with particular atmospheric conditions such as Arequipa, understanding the physicochemical nature of this particulate matter is essential to evaluate its impact.

II. Methodology

A soiling sample was extracted from the roof of the Professional School of Physics at UNSA. It was analyzed using a Rigaku Miniflex diffractometer with the acquisition parameters mentioned in [1].

Concurrently, two soda-lime glass samples under two tilt configurations (0° and 15°) were exposed to natural soiling for three weeks. The relative direct spectral transmittance was measured weekly using a Shimadzu UV-1800 spectrophotometer. Transmittance data were fitted to a modified version of Ångström's turbidity equation [2]. Using the fit with the best performance metrics, four solar irradiance spectral distributions generated in SMARTS, and the spectral response of six photovoltaic technologies, the soiling loss was predicted for each studied configuration [3].

III. Results and Discussion

When estimating the energy losses across six photovoltaic technologies, it was observed that all of them experience a comparable global impact (Fig. 3), with perovskite and amorphous silicon being slightly more vulnerable compared to monocrystalline silicon, a subtle difference attributable to the spectral response of each technology against the ultraviolet attenuation of soiling (Fig. 2). However, given that a rigorous physical model must consider hemispherical transmittance for these calculations, quantifying precise absolute losses will require subsequent complementary studies.

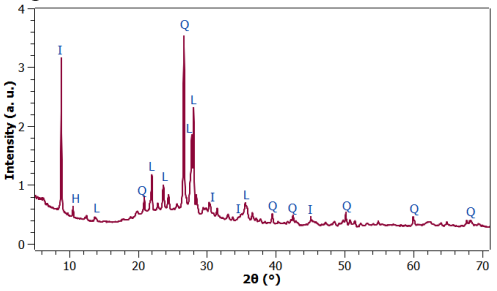


Fig. 1. *X-ray diffraction pattern of the soiling sample.*

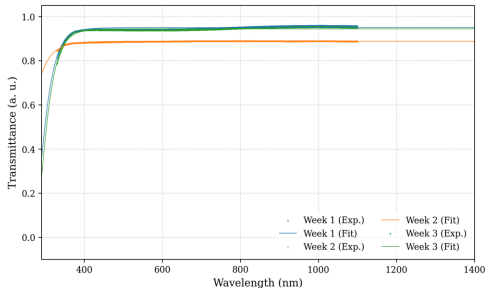


Fig. 2. *Measured and model-fitted relative direct spectral transmittance of soiling over a three-week exposure period.*

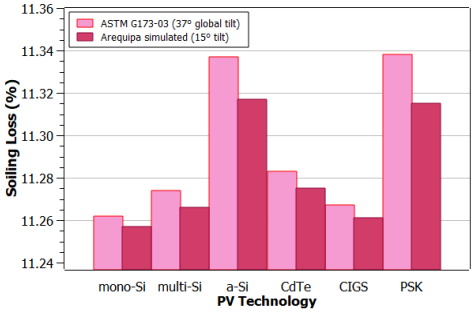


Fig. 3. *Estimation of soiling loss for each PV technology considered in this study.*

References

[1] Aïssa B, Isaifan R J, Madhavan V E and Abdallah A A 2016 Scientific Reports **6** 31467
[2] Smestad G P, Germer T A, Alrashidi H, Fernández E F, Dey S, Brahma H, Sarmah N, Ghosh A, Sellami N, Hassan I A *et al*. 2020 Scientific reports **10** 58
[3] Micheli L, Caballero J A, Fernandez E F, Smestad G P, Nofuentes G, Mallick T K and Almonacid F 2019 Energy **180** 376–386