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Dust accumulation on photovoltaic panels: a case study at the East Bank of the Nile (Beni-Suef, Egypt)

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Abstract

This article presents an evaluation of the electrical performance of Photovoltaic (PV) panels after exposure to natural dust accumulation. The present article is considered to be the first practical case study at the region of the East Bank of the Nile, implemented in Beni-Suef University (Egypt). After exposing two PV panels to the outdoor environment and letting the dust to be naturally accumulated for three months on their surfaces, a significant reduction in the performance of the dusty PV panel has been noticed compared to the performance of the other PV panel (reference) that has been cleaned regularly. Through analyzing the corresponding literature review, it has been found that it's not applicable to compare the results of the different studies, as many differences were found between them regarding many aspects, such as the testing methods, parameters, geographic locations of the experiments, and the adopted experimental procedures. Hence, in order to deal with those differences, a novel concept is introduced herein, which is the Photovoltaic Soiling Index (PVSI).

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Keywords: soiling; photovoltaic (PV); dust; photovoltaic soiling index; PVSI

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1. Introduction

Generally, the main target of the research concerning Photovoltaic (PV) systems is to ameliorate their performance so that they can produce more electricity with higher efficiency and in an environmentally friendly manner [1–6]. Many research works in literature focus on comparing the electrical performance of distinct PV technologies within different operating conditions; taking into consideration their degradation [7]. One of the most essential and critical factors in that sense is the impact of dust accumulation (soiling) on PV panels, where numerous studies have been achieved [8–32]. In a previous related study, K. Menoufi [33] conducted an extensive literature survey on the international scientific publications that are related to studying the impact of dust accumulation on the performance of PV panels during the last ten years. After analyzing the corresponding studies, it has been found that it is not applicable to compare their results, due to several reasons; first of all, although most of the studies were found to be concerned with the electrical performance of the PV panels, different demonstrations and correlations between the measured parameters were used. In addition to that, the PV panels used in the experiments of the studies were found to be different in their electrical and thermal specifications. Regarding the dust accumulation process, the specified period for accumulating the dust over the tested PV panels was different in each study. Besides, some studies deposited the dust artificially on the surface of tested PV panels without exposing the panels to natural dust accumulation outdoors. Moreover, there has been a variety in the electrical evaluation testing environments (indoor and outdoor testing environments), in addition to the diversity in the experimental equipment used. In addition to that and most importantly, each study conducted its corresponding experiment in a different zone/region, where there are unique geographical, meteorological, and environmental profiles for each location. Finally, despite the spotted increased interest regarding the studies that examine the impact of dust accumulation on the performance of PV panels, very few studies have been found from Egypt and no studies have ever been found within the region of the East Bank of the Nile. In the same context, very few percentage of the surveyed studies was found to be coming from the countries of the African continent.

Hence, the present research is presented in order to deal with two specific issues, first: presenting the first practical case study of studying the impact of dust accumulation on the electrical performance of PV panels at the region of the East Bank of the Nile in Beni-Suef (Egypt), second: highlighting a new concept that would help in dealing with the differences between the studies concerned with the impact of dust accumulation on the performance of PV panels, which is the Photovoltaic Soiling Index (PVSI). The PVSI is a novel concept that has been recently introduced by K. Menoufi [33] in order to encourage deriving an index to be applied as an indicator for the performance of the PV panels under the effect of dust accumulation for specific defined periods of time and in specific locations around the globe.

Nomenclature

SEM	Scanning Electron Microscope
EDX	Energy Dispersive X-Ray
PV	Photovoltaic
PVSI	Photovoltaic Soiling Index

2. Case study

Two 10 watt multi crystalline PV panels were used for the corresponding experiment (Fig. 1), where the complete specifications of the panels are listed in Table 1, as per the manufacturer data. The two panels were tested before conducting the experiment (The open circuit voltage – V_{oc} , and the short circuit current – I_{sc}) in order to make sure that the two panels produce exactly the same output voltage and current without any bias referred to any potential manufacturing defects or mismatch.

Starting the experiment, the two PV panels were exposed to the outdoor environment on the roof of the Renewable Energy laboratory of the Faculty of Postgraduate Studies for Advanced Sciences of Beni-Suef University (Beni-Suef, Egypt) for three months, during the summer period from 19 July 2016 until 19 October 2016. One of the panels was left for continuous dust accumulation without cleaning (The dusty PV panel), and the other panel was cleaned daily

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