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Effect of bird dropping deposition on photovoltaic (PV) module performance at different sites

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Abstract

Bird dropping deposition on the front glass plate of a Photovoltaic (PV) module is a critical challenge for output power generation. This research article is proposed to investigate the impact of bird dropping accumulation on PV surface at different sites. The current study includes the effect of bird dropping deposition in terms of physical parameters like gravimetric, electrical and transmittance analysis. The obtained results show how bird dropping settlement at the different sites affect the PV performance through output power generation. Gravimetric analysis depicts the maximum amount (51gm) of bird dropping deposition that occurs on the rooftop and the minimum (21gm) along the roadside, which is a replica of the bird's behavior. As a result, the average maximum power loss (22.1%) on the rooftop while the minimum (12.1%) along the roadside.

Keywords: Bird dropping; Soiling; PV sites; Shadow effect; Power loss; Transmittance loss

1. Introduction

All things that are to be accumulated on the surface of the PV panels are termed as soiling, and it can be in the form of dust, dirt, pollen, leaves and bird excrement [1, 2]. Nowadays, the performance degradation caused by bird dropping deposition on PV modules is one of the most common issues. A PV system can become severely dirtied by bird droppings deposition so that it can reduce the output electric power generation. Incoming solar radiation is the most essential factor for energy production utilizing photovoltaic panels. Settlement of soiling on the front glass plate of the PV module lowers the transmission of falling solar radiation. Therefore, a regular cleaning of the front glass plate is essentially required for ensuring optimum performance and maximum power yield [3, 4]. It is commonly identified that the impact of bird dropping deposition is much more serious than dust soiling [5]. Because bird guano material is highly adhered to glass cover. It is well known that rain is only the single cleaning agent for soiling in outside environmental conditions. Therefore, it not easy to detach from the front glass plate by water cleaning. A great level of power loss can be found especially when rain is absent for a long period and a small rain event is unable to clean the bird dropping from glass cover completely [6]. A thicker layer of bird droppings, snow and leaves are concerned with hard shading conditions, meanwhile soft shading conditions due to like dust, pollen or a thin layer of snow [7]

1.1. Effect of bird dropping

Generally, PV modules are to be installed under outside environmental conditions where they face numerous obstacles in nature. As the bird dropping adheres to the smooth glass surface of the PV module, it extends over the entire front surface of the panel combining dropping materials. This bird dropping matter is more prone to the horizontal surface i.e., 0° tilt angle [8]. A serious condition of the PV module can be clearly visualized in figure 1 below.

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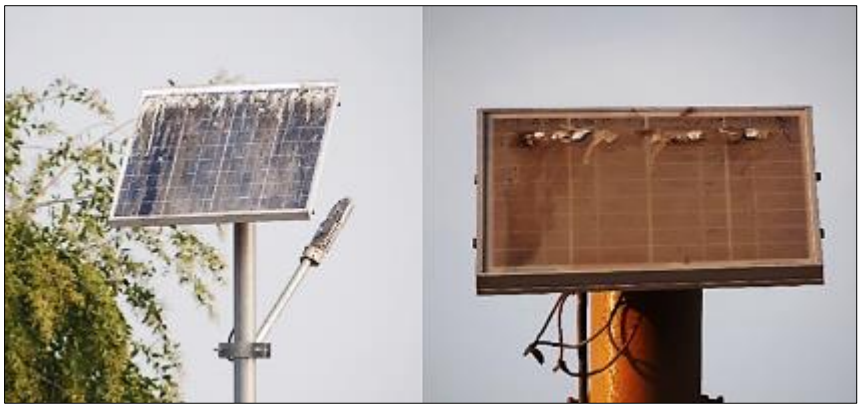

Figure 1 Vulnerability of bird droppint in an open environmental condition

2. Experimental methodology

In experimental studies, output power (%) and optical transmission have been assessed to measure the effect of bird dropping deposition on PV module surface at different locations.

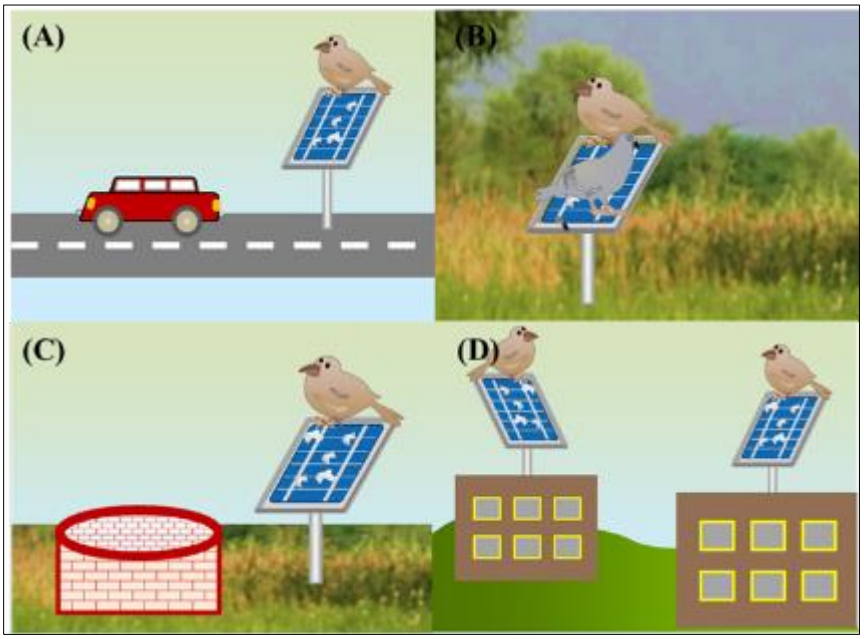

Figure 2 Different sites of bird dropping sample collection: (a) along the roadside (BDS#1); (b) in an open farm house (BDS#2); (c) deserted place (BDS#3); and (d) at the rooftop (BDS#4)

For this purpose, we have selected four different locations for the sample collection, i.e., along the roadside (BDS#1); in an open farm house (BDS#2); a deserted place (BDS#3); and on the rooftop (BDS#4) as shown in Fig.2. Because the gravimetric volume of deposited bird poop matter depends directly on the bird movement at the particular sites. The detailed experimental study was conducted in winter (from December to March) i.e., peak time of bird dropping deposition in a year. For assessing the impact of bird dropping deposition on panel's surface, four glass plates were attached to a wooden frame and placed at the different sites as mentioned above in Fig.3. Samples were kept close to the sites.

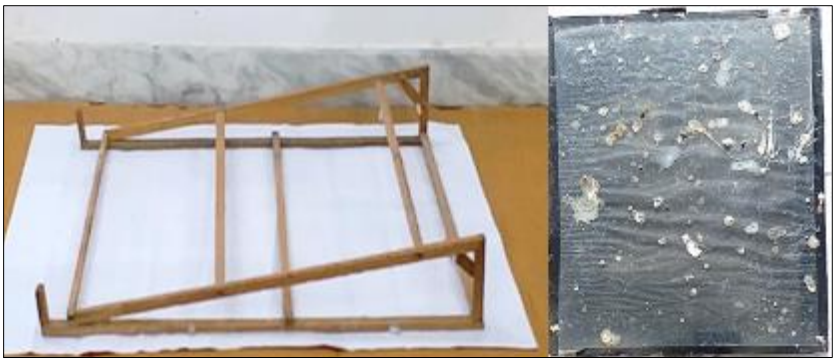

Figure 3 A wooden frame covered by a panel size of glass plate samples dirted with bird poop under an natural environmental condition

3. Result and discussions

3.1. Gravimetric analysis

In gravimetric analysis, the weight of accumulated bird dropping matter has been determined at the different sites as shown in Table 1 below. The weight of the collected dropping matter is determined by using a PHOENIX high precision electronic balance (GOLD 600P, Min 0.2 gm) and then, the bird dropping samples weight was measured using the equation (1):

$$w_{bird\ dropping} = w_{dirt} - w_{clean} \quad \ldots\ldots\ldots(1)$$

Where, w_{clean} is the initial weight of clean glass plate, and w_{dirt} is the final weight of dirted glass plate with deposited bird droppings.

Table 1 Gravimetric analysis of bird dropping deposition at the different sites

Different bird dropping sites	BDS#1	BDS#2	BDS#3	BDS#4
Weight (gm)	21	32	40	51

3.2. Electrical study

The impact of bird's poop deposition on PV module surface can be found in terms of power loss by comparing maximum output power P_{max} before (clean) and after (dirtied with bird dropping) by using Solar Module Analyzer PROVA 210 stated as follows (equation 2) [9]:

$$\Delta P(\%) = \frac{P_{max}(bird\ dropping) - P_{max}(clean)}{P_{max}(clean)} \quad \ldots\ldots\ldots(2)$$

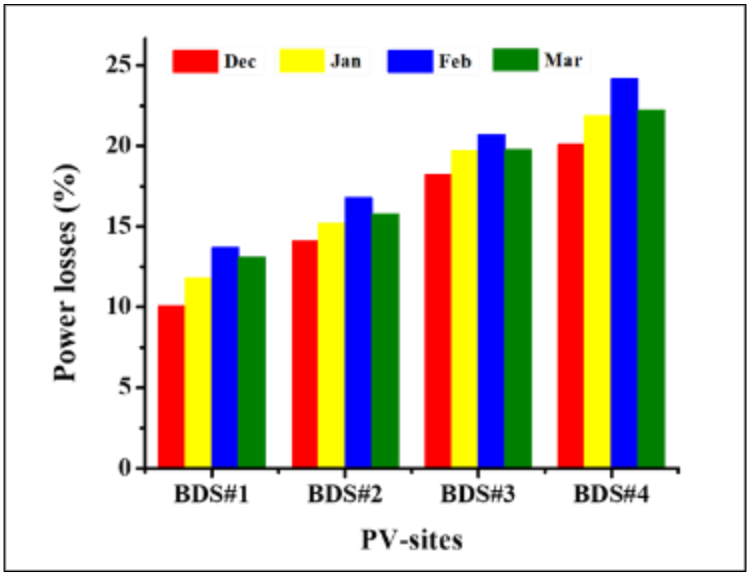

Figure 4 The impact of the bird droppings deposition on the average monthly output power obtained from PV module at the different sites

The experimental work is performed by attaching the dirtied glass cover to standard solar PV module. The output dc power (average power loss %) is measured every month and analyzed for the four months (December to March). The electrical power). The electrical power was measured under the natural sunlight as explained in Fig. 4.

3.3. Optical study

The presence of bird poop material on the PV-glass cover affects the optical values. In this contaxt, the optical transmittance losses of sunlight caused by bird dropping deposition on a smooth glass plate was determined as shown in Fig. 5. A significant reduction in transmittance caused by bird dropping accumulation can be calculated by the average transmittance losses (%) as follows:

$$\Delta\tau(\%) = \frac{\tau_{max}(bird\ dropping) - \tau_{max}(clean)}{\tau_{max}(clean)} \quad \ldots\ldots\ldots(3)$$

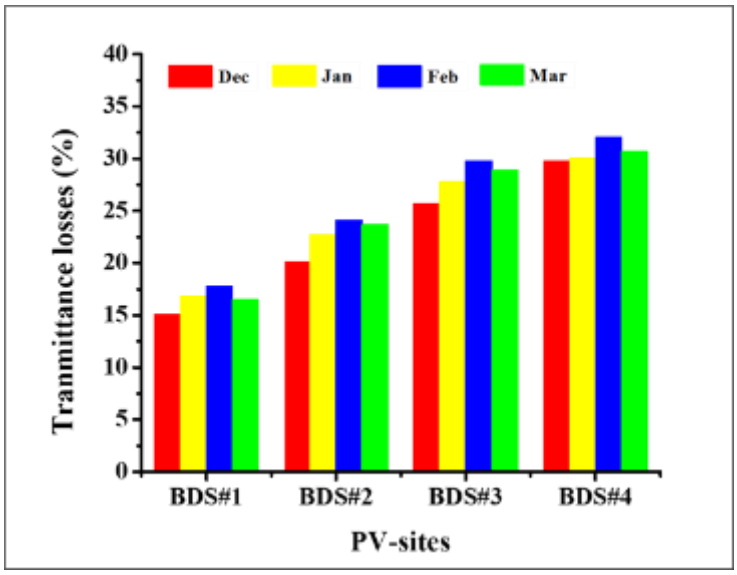

Figure 5 The impact of the bird droppings deposition on the average transmittance loss (%) obtained from PV module at the different sites

In this regard, transmittance intensity of the dirtied glass plate samples was studied [10]. The average transmittance intensity of light (W/m^2) was determined by using a MECO solar power meter corresponding to each section of the glass plate, i.e., the area of glass plate is divided into 192 sections and each section of the glass plate is characterized as $16cm^2$. In this experiment, the equipment contains a yellow halogen light (similar to sunlight) in the visible spectrum range [8, 11]. Moreover, an average power loss (%) and transmission loss (%) is presented in Table.2 as below:

Table 2 Reduction in average output power (%) and transmission (%) at the different PV sites

Different bird dropping sites	BDS#1	BDS#2	BDS#3	BDS#4
ΔP (%)	12.2	15.5	19.6	22.1
Δτ (%)	16.6	22.7	28.1	30.7

4. Conclusion

According to obtained results of gravimetric, electrical and transmittance analysis, the maximum amount of accumulated bird dropping matter has been obtained for the rooftop site (BDS#4) while minimum at the roadside. It means that the rooftop side is more prone to bird dropping deposition on PV glass surface. Because the process of bird dropping deposition is directly related to the bird's activities and their behavior. Birds are likely to sit far from human approach and deserted places. Therefore, more birds tend to like the rooftop of any site. Moreover, fewer birds have the chance to find themselves close to the roadside. Hence, more bird dropping deposition will occur on the rooftop and less along the roadside. As a result, maximum power losses (%) exist at the rooftop site & deserted land, while less along the roadside and moderate level at the open farmhouse.

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