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Effect of The Different Types of Dust on The Performance of Photovoltaic Panels in Iraq

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ABSTRACT

Iraq is characterized by an atmosphere that contains dust particles most of the time. In this study, a detailed investigation was conducted on the effect of dust particles of different types on the performance of the photovoltaic (PV) model. Data were collected for samples of four types of dust (chalk powder, brick powder, Sand, Cool powder) and different weights (30,60,90 and 120 g/m2) with the change in the energy loss of the PV module at four levels of solar radiation (500, 600, 700 and 800 W/m2). In this study the effect of environmental dust particles on energy loss as well as electrical efficiency was evaluated. The minimum and maximum power value of (43.58, 101.95W) respectively, was observed during dust accumulation on the photovoltaic unit. It was also noted that the efficiency and power were inversely proportional to the increase in weight and directly to the size of the dust particles.

1. Introduction

Dust is small, broken particles with a size very small in a micrometer. Dust is made up of particles that either float in the atmosphere or fall off. Dust sources are as varied as unclean air, factories, construction sites, industries, and dust storms. The degree of efficiency degradation depends on the specific mass and size of dust particles deposition on the surface of the PV module. As the dust deposition mass increases, the power output and efficiency of the unit decrease, and as the volume decreases, the power output decreases because smaller particles block more radiation on the surface of the PV unit. Deposits of various pollutants may include red soil, ash, sand, calcium carbonate, silica, etc. The presence of air pollution may significantly degrade the energy production of PV panels; Even after a short period of external exposure to the panels without cleaning, this can cause the energy output to drop by approximately 6.5%. [1]. An analytical model for dust impact on PV performance in terms of dust components was put forth by Kazem *et al.,* [2]. In Sohar, Oman, a 1.4 kW PV system with ten monocrystalline PV modules with rated output equal to 140 W was erected. A 1.4 kW PV system was created by connecting the PV modules. The impact of dust on the effectiveness of the system has been researched. In addition, samples of dust gathered from six different places have

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been examined. The effect of the component was discussed once it was examined. In Oman, the proposed approach is utilized to examine both organic and synthetic dust. Using the appropriate mathematical indicators, the proposed model was verified. As opposed to the analytical model in Ref. [3], the proposed model in the current study is ANN. The artificial neural network, on the other hand, is employed in numerous disciplines for prediction applications. An ANN was used by Ziókowski *et al.,* [4] to forecast how much fuel a car would use. Modeling and prediction are done using MLPs, or multi-layer perceptron's. The accuracy and precision of predictions are assessed using performance parameters including MAPE, r, and R_2. Neural network auto regression (NNAR) and MLP were employed by De Silva *et al.,* [5] to forecast Brazil's industrial sector's electricity usage. The accuracy of the predictions is assessed using MAPE.

The outcomes demonstrate that the MLP model makes the most accurate forecast. Elsheikh et al reviews of ANN methods are in [6]. The study includes a comparison of several methodologies and is a thorough revision. It is important to note that, as has been mentioned, ANN is applicable to model and assess various solar energy applications, including photovoltaic design, solar thermal collector, PV/T, solar water heater, etc. Different statistical standards for judging ANN models were also considered. Two ANN models were suggested by Elsheikh *et al.,* [7] to forecast the water yield of a solar distiller integrated with the evacuated tube. The ideal internal parameters of the hybrid long short-term memory are found using ANN and moth-flame optimizers. The performance of the PV panels is mainly depending on its operating temperature. Therefore, to maintain the electrical performance of the PV module at an acceptable level, it is essential to utilize an appropriate cooling technique to lower its surface temperature, thereby prolonging its lifetime [8]. The maximum enhancement in electrical efficiency was 23.9% for nano-fluid-based PVT/PCM case, 22.7% for water-based PVT/PCM case, and 9.1% for PV/PCM case as compared to conventional PV. Hilo *et al.,* [9-10] The aim of the current study is to show the effect of some four types of dust and four different weights on the capacity and efficiency of the photovoltaic panel.

2. Materials and Techniques

2.1 Description of The Apparatus

A Photovoltaic (PV) is a device that converts solar energy into electricity about 20% and the rest is wasted as heat energy [1]. The experimental system included a variety of tools, such as a (1) 250-watt polycrystalline PV unit that was positioned beneath a complex of artificial lighting composed of a total of 20 100-watt lightbulbs. Figure 1 depicts the entire experimental setup with all of its components. samples of dust There are four different categories of dust samples, as follows: (chalk powder, brick powder, sand and coal powder). Tables 1 provide an overview of the technical details of the solar photovoltaic module and the measurement equipment utilized in this investigation. The performance parameters listed below were evaluated. 1. The weight of each dust sample in the experimental setup setting (g.) 2. Voltage (V) 3. Current (A) 4. Power (W) 5. Power Loss (%) 6. Efficiency (%).

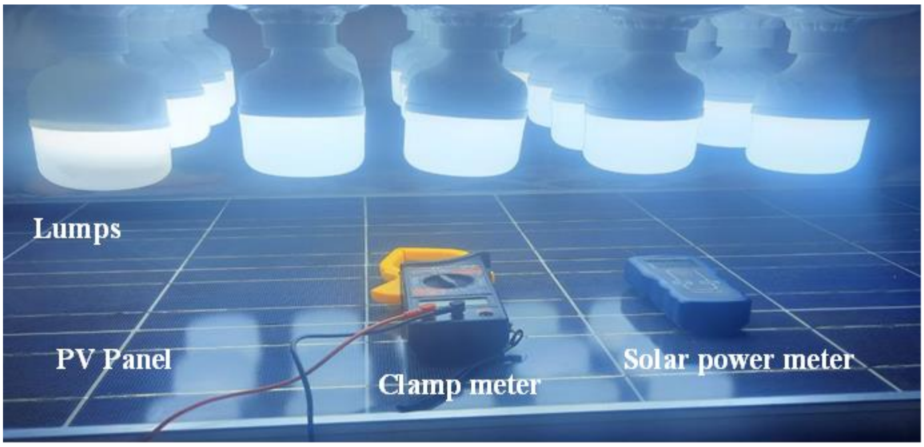

Fig. 1. Experimental set-up for the current study

Table 1
PV module specifications at STC

Parameter	Specification		
Power	250W	Temp. Co-eff. Power P_m (P_T)	-0.4% / ^{0}K
Open circuit Voltage (V_{oc})	37.74V	Temp. Co-eff. Voltage V_{oc} (a_T)	-0.34% / ^{0}K
Short circuit Current (I_{sc})	8.74A	Temp. Co-eff. Current I_{sc} (K_i)	+0.005% / ^{0}K
Voltage at maximum Power (V_{mp})	30.5V	Weight	18.0Kg
Current at maximum Power (I_{mp})	8.2A	Dimension	16.45 x 9.92 x 4.2 cm

2.2 Dust Sample Analysis

The samples used in the current study were collected from various sources such as construction sites, coal plants, educational institutes, and others. Figure 2 shows the types of samples used in this study which are (A) chalk powder, (B) brick powder, (C) Sand, (D) Cool powder. The current study was conducted in Iraq. As solar energy grows exponentially, it has many environmental factors that affect the performance of photovoltaic (PV) cells, such as dust and temperature. A 250W PV module was used for the pilot project. In order to disseminate each dust sample evenly across the unit surface and conduct a thorough examination of the impact of dust on PV modules, a fine filter with a fine sieve size of approximately 25–30 mm is utilized. Real-world experimental conditions are used to design the experimental setup and measure the performance outcomes in terms of current, voltage, power, and efficiency. To measure the change in various radiative values, the unit was built in the presence of an artificial lightning source. The results were combined into four radiance values of (500, 600, 700, and 800 W/m^2).

Fig. 2. Dust samples for current study: A. Chalk powder, B. Brick powder, C Sand, D. Coal powder

3. Results and Discussion

A number of dust samples with various weights, four radiation levels (500, 600, 700, and 800 W/m^2), and several voltage and current values in the solar photovoltaic unit were used in the investigation. Analysis was also done on how particle size affected the solar PV module's ability to produce power. By keeping track of the voltage and current measurements, it is possible to determine the power output, efficiency, and highest and lowest capacity of the solar photovoltaic module for four different dust samples, each with a weight of (30,60,90 and 120 g/m^2) The study revealed the average voltage and current readings from four measurements of the PV module's output power. Equations (1 and 2) are used to compute power and efficiency [11–12].

$$P = I \cdot V \tag{1}$$

$$\eta = \frac{P}{G \cdot A} \tag{2}$$

3.1 Electrical Power and Efficiency of PV Module

In the current investigation, four dust samples of four different weights were compared, and the findings at four radiation levels (500, 600, 700, and 800 W/m^2) are reported in Table 2 and 3. The power of solar energy and efficiency decreases as a result of the accumulation of dust particles on the solar photovoltaic systems, which leads to blocking the sun's rays The assumption that "solar energy is the nearest future" results in the accumulation of dust from different sources, such industrial areas, construction sites, agricultural lands, etc. will affect the solar energy systems in the future. The data obtained in Table 2 and 3indicate lower power and efficiency due to dust accumulation.

According to the results of the current study, which are presented in Table 2, the maximum energy losses for a 200 g sample of chalk powder were (75.75, 74.88, 72.00, and 74.00%), respectively, at irradiance levels of (500, 600, 700, and 800 W/m^2). In the case of taking a sample of 200g brick powder for the study, the maximum energy loss was observed as (49.43, 45.77, 45.55, and

46.12%) at the same previous irradiance levels. However, for a 200 g sample of sand, maximum energy losses of (37.87, 37.7, 39.06, and 47.42%), respectively, were noted at radiation intensities of (500, 600, 700, and 800 W/m^2). Furthermore, it was discovered that at the same irradiance levels employed, the greatest energy loss in a 200 g sample of coal powder was (44.37, 48.94, 47.51, and 48.12%). However, looking at the data in Table 2 shows that employing chalk powder at the four radiation levels was shown to result in the greatest energy loss.

This could be as a result of the Chalk powder high molecular density, which increases energy loss. Based on the information in Table 2, it can be concluded that the energy of a solar PV module can be lowered by up to (16.56) % when a uniform 50 g layer of dust accumulates on it, and by (74.00) % when a uniform 200 g layer of dust does so. Reading the data in Table 2 reveals that the power loss remains constant for various sample weights and radiation situations. However, under all conditions, the chalk powder sample showed the most energy loss. Therefore, it can be concluded that the efficiency of solar panels and modules as well as energy losses are inversely related to the particle size. This shows that particle size significantly affects energy loss and, consequently, efficiency in solar panels.

Table 2
How various types of dust affect a solar PV module's loss of power

Chalk Powder			Brick Powder			Sand			Coal Powder		
Weight (g/m^2)	Power (W)	Power loss (%)	Weight (g/m^2)	Power (W)	Power loss (%)	Weight (g/m^2)	Power (W)	Power loss (%)	Weight (g/m^2)	Power (W)	Power loss (%)
500 W/m^2			500 W/m^2			500 W/m^2			500 W/m^2		
30	87.36	25.62	30	75.46	15.81	30	69.52	16.56	30	74.75	22.4
60	83.56	36.67	60	60.36	32.68	60	65.96	24.12	60	68.02	26.37
90	77.53	56.00	90	51.66	42.37	90	55.50	31.37	90	61.52	38.06
120	67.10	75.75	120	45.33	49.43	120	43.58	37.87	120	58.38	44.37
600 W/m^2			600 W/m^2			600 W/m^2			600 W/m^2		
30	94.28	25.37	30	79.56	21.11	30	77.81	23.55	30	77.05	22.83
60	87.24	39.38	60	70.61	30.00	60	73.30	28.22	60	72.40	27.27
90	82.03	55.53	90	57.23	43.22	90	61.82	33.94	90	66.60	38.66
120	75.41	74.88	120	54.67	45.77	120	51.46	37.7	120	62.79	48.94
700 W/m^2			700 W/m^2			700 W/m^2			700 W/m^2		
30	99.01	27.60	30	85.27	24.80	30	83.42	26.15	30	82.72	25.55
60	90.21	39.36	60	80.51	32.70	60	75.83	29.1	60	79.42	32.29
90	85.00	56.77	90	71.76	41.75	90	70.78	34.89	90	72.91	36.8
120	79.12	72.00	120	60.68	45.55	120	58.78	39.06	120	68.24	47.51
800 W/m^2			800 W/m^2			800 W/m^2			800 W/m^2		
30	101.95	28.60	30	89.34	27.5	30	85.73	28.5	30	84.50	28.5
60	92.28	40.36	60	83.12	37.45	60	79.63	39.45	60	81.88	38.45
90	87.00	58.77	90	78.45	39.3	90	71.76	40.3	90	74.39	40.3
120	81.82	74.00	120	71.21	46.12	120	62.09	47.42	120	70.86	48.12

Table 4
The lowest and highest power measured with various types of dust samples

500 W/m^2			600 W/m^2		700 W/m^2		800 W/m^2	
Dust type	Pmin (W)	Pmax (W)	Pmin (W)	Pmax (W)	Pmin (W)	Pmax (W)	Pmin (W)	Pmax (W)
Chalk powder	67.10	87.36	75.411	94.28	79.12	99.01	81.82	101.95
Brick powder	45.33	75.46	54.67	79.56	60.98	85.27	71.21	89.34
Sand	43.58	69.52	51.46	77.81	58.78	83.42	62.09	85.73
Coal powder	58.38	74.75	62.79	77.05	68.24	82.72	70.86	84.50

3.2 Graphical Analysis to Display the Weight-Dependent Strength and Effectiveness of All Examined Dust Types

The results obtained in this work were taken for four various dust sample kinds with various weights (30, 60, 90 and 120 g/m2) Based on these dust samples, the energy loss and efficiency of the solar PV module were evaluated at four irradiance levels (500, 600, 700 and 800 W/m2). The results of the analysis of the data are illustrated in Figures 3A to D and 4E to H.

Figures 3A to D and 4E to H. illustrate the data. This shows that the smaller particle blocks more solar radiation than the photovoltaic module since it takes up more space. The graphical representation of energy and efficiency in the previously submitted study supports this notion. From Table 4, it shows the minimum and maximum energy value with different dust weight. From the results in Table 4, it is clear that the range of power value of 43.58, 101.95 W respectively is obtained during the accumulation of Sand and Chalk powder on the PV module. The graphs of Figure 4E-H indicate that the efficiency decreases with the increase in the weight of the dust and is less valuable if the dust particles are smaller because it prevents more radiation falling on the solar panel. We conclude from this that the efficiency is inversely proportional to the dust particles and directly with the weight of the dust.

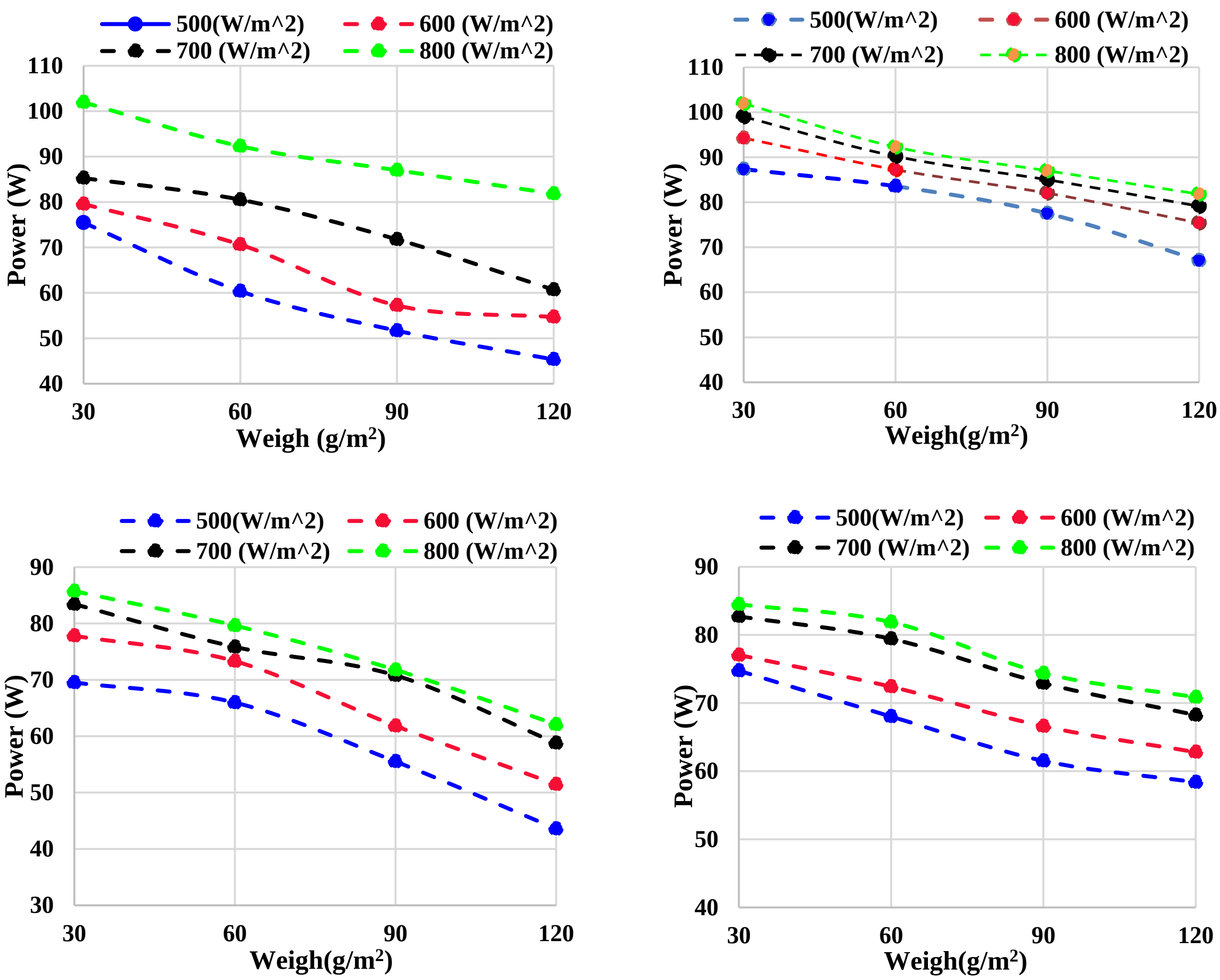

Fig. 3. The power-weight responses of several dust kinds. The following are examples of powders: chalk, brick, sand, and coal

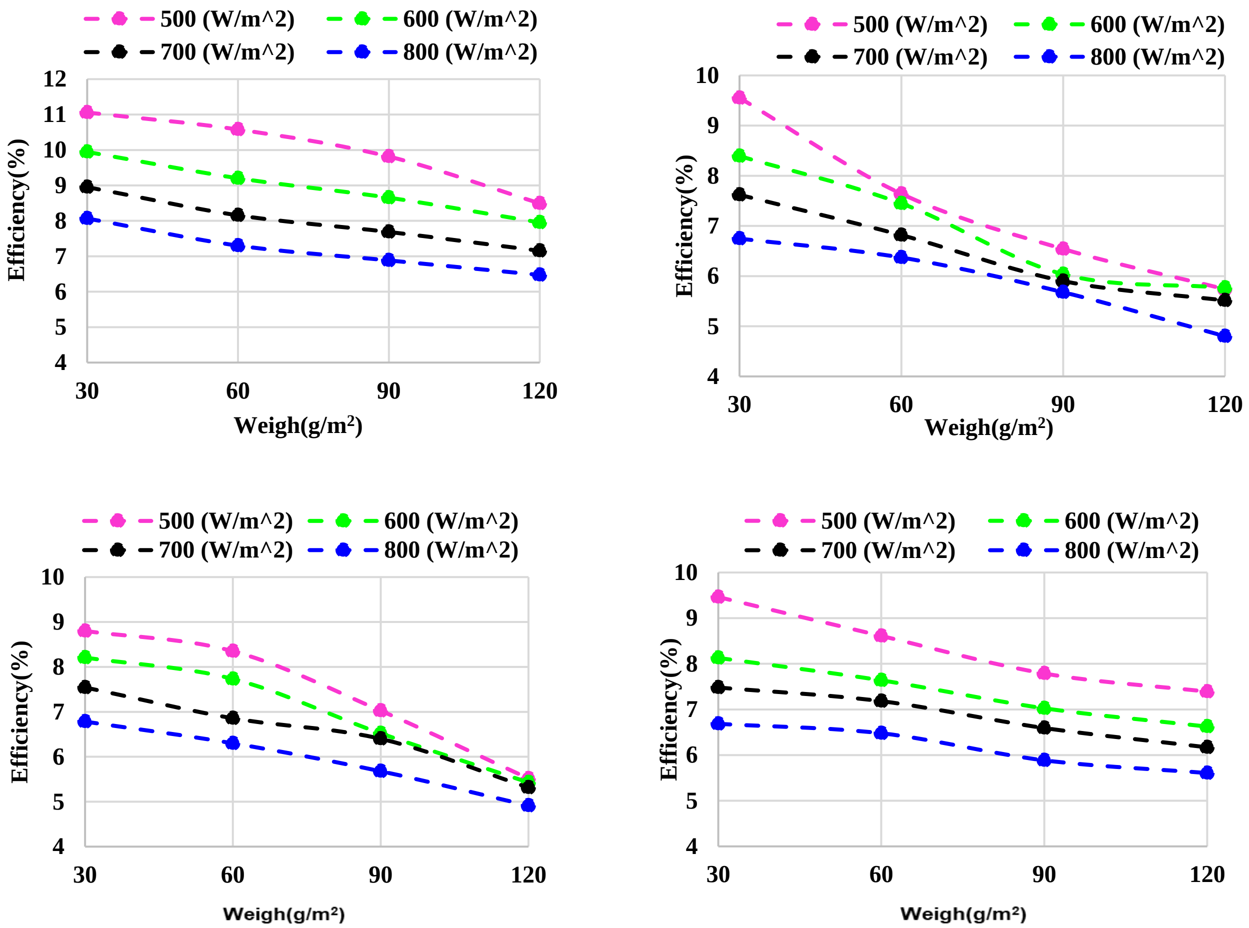

Fig. 4. The efficiency-weight responses of several dust kinds. The following are examples of powders: chalk, brick, sand, and coal

Table 5 shows some of the studies published in the literature and compares them with the current work. It is found that the photovoltaic energy loss based on the weight of dust accumulation has been investigated photovoltaic technologies, etc. However, the review literature indicated many multiple parameters affecting the functionality and power generation of the PV system, such as the location, dust and pollution characteristics of the county.

Table 5
Summary of some published studies in literature

Reference	Year	Country	% Reduction
Appels *et al.,* [13]	2013	Belgium	Ploss = 3% and 4%
Rajput *et al.,* [14]	2013	India	Ploss = 0.33%
Guo *et al.,* [15]	2015	Qatar	Ploss = 10-20%
Klugmann-Radziemska [16]	2015	Poland	Ploss = 6.24%
Saidan *et al.,*[17]	2016	Iraq	Ploss = 18.74%
Ali *et al.,* [18]	2017	Pakistan	Ploss = 20%
Gholami *et al.,* [19]	2018	Iran	Ploss = 21.47%
Chen *et al.,* [20]	2018	China	Ploss = 34%
Hachicha *et al.,* [21]	2019	UAE	Ploos = 12.7%
Kazem *et al.,* [22]	2020	Oman	Ploss = 0.05%
current work**.**	2022	Iraq	Ploss =Table 2

4. Conclusion

Four dust samples of four various weights were subjected to a comparison analysis (30, 60, 90 and 120 g/m2). (500, 600, 700, and 800 W/m2) at four radiation intensities. Solar PV system power and efficiency are drastically decreased as dust and its particles accumulate on the system's surface. Conclusion: The photovoltaic system's efficiency is significantly decreased by the same thin layer of dust. During the deposition of sand and chalk powder on the PV module, the minimum and maximum power values of 43.58 and 101.95 W, respectively, are achieved. The results showed that smaller particles simply prevent more sunlight, decreasing the performance of solar panels and modules. Additionally, it may be inferred that dust deposition can impair the energy-generating capacity of solar modules and panels, even in desert regions where the likelihood of exposure to sunshine is greatest and solar array schemes can be built. Additionally, it was shown that the link between capacity and efficiency is directly correlated with the size of the dust particles and inversely correlated with the weight of the dust samples.

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