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The impact of the dust of three Iraqi cities on the performance of photovoltaic cells

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Abstract: The consumption of fossil fuels has reached its peak, and most of the oil reserves are beginning to wane with the demise of the oil era. If all this adds to the impending climate change, the result will be a shift towards the adoption of clean renewable energies, notably solar PV as a sustainable and environmentally friendly alternative. All the research teams in this field are working to increase the efficiency of switching commercial PV units to a large extent. Dust is an important factor affecting the performance of photovoltaic installations, especially for a country like Iraq bordered by deserts from every side.

In this study, accumulated dust was collected from three Iraqi cities (Basra, Baghdad and Mosul) and a laboratory tests on the performance of photovoltaic cells. The results showed that Basra dust loaded with hydrocarbon particulates matters resulting from oil exploration and production had the worst effect on the cell's productive power, which caused a reduction of by 40% and 45.7% for the accumulation of 100 and 200 g, respectively. The study found that periodic cleaning is very important to maintain the productive power and the quality of cleaning materials to be used varies according to the city.

Keywords: Photovoltaic module, Iraq, Basra, Baghdad, Mosul, dust accumulation

1. Introduction

The sun is the source of all energies on the globe; it causes the movement of air (wind) and biomass and the heat of ocean water and other renewable energies and even non-renewable, such as oil and natural gas. Man has always relied on the light and heat of the sun in various applications. Also, he still to this day depends on it in several applications, perhaps the first heating water for household purposes [1, 2]. Water distillation for drinking purposes is one of the oldest applications of human existence. Today, this solar application is adopted in many cities around the world [3, 4]. Air heating for comfort purposes has been used for decades in some countries and is efficient and reliable [4-8]. Warming up to give warmth to homes and ventilating the so-called Trombe wall has become a global trading technique [9-11]. The use of gradient salty solar ponds to provide the heat needed for various applications began to take its place in solar applications [12-14]. Electricity can also be produced using solar radiation energy either by using solar chimneys [15-17], concentrated power stations [18-22], or by generating them directly using photovoltaic cells [23, 24].

Photovoltaic cells convert sunlight directly into electricity by using properties in certain materials known as the photoelectric effect, which absorbs photons of light and emits electrons. When these free electrons are captured, an electric current is produced that can be used as electricity [25-27]. Solar cells consist of the same types of semiconductor materials, such as silicon, used in the microelectronics industry. For solar cells, the thin semiconductor chip is specifically treated to form an electric field, positive and negative side on the other side. When photovoltaic energy collides with solar cells, electrons are lost from semiconductor atoms. If electrical conductors are connected to the positive and negative sides, to form an electric circuit, electrons can be captured in the form of an electric current - ie electricity [28-30]. This energy can then be used to run a load, such as a light or tool. Photovoltaic cells are used in road lighting [31], processing of communication stations [32], operation of water pumps in remote areas for irrigation and grazing [33], in addition to several important applications [34-37].

The most important hurdles to the rapid proliferation of photovoltaic cells worldwide is the process of storage of electricity produced, which can be stored in addition to batteries using fuel cells [38], or in heat storage methods for the use of phase change materials [39]. These cells are also affected by weather conditions such as temperature and the intensity of solar radiation [40-42]. Of the dangerous effects that reduce the productivity of photovoltaic cells shade that can be a natural source such as clouds and dust or a topographical source such as mountains or a human source as buildings [43, 44].

Dust is a natural element available in the environment. The variation in the size and composition of the dust particles depends on the location [45]. In some areas, dusty weather conditions tend to be more severe than others, causing deterioration of vision during dusty days. Also, dust tends to settle, creating a thin layer of dust accumulated on any open surface. Various parameters have been reported to support dust accumulation such as

gravitational forces, wind speed, wind direction, electrostatic charges and surface wetness [46-49]. Among these criteria, the most dominant influences are gravity, particle size, and wind direction [50]. Slow winds will increase dust deposition, while rapid wind speeds will help remove dust if wind winds in an appropriate direction. The random accumulation of dust on the surface area of the PV module can produce patches with a varying concentration of dust particles. These spots vary in shape, location and concentration intensity. The difference in accumulation of dust anywhere can lead to a different permeability of light in the unit, leading to small random areas on the PV unit with partial shading of solar radiation [51-53]. The accumulation of dust and dirt on the surface of solar panels is one of the most important factors in the loss of the performance rate of the system. This fact means that photovoltaic cells are receiving less radiation. The accumulation of dirt is not regularly distributed due to bird droppings; these dirt result in a partial shading effect on the cells. Obviously, if the maintenance tasks include periodic cleaning of the units, a large part of these losses can be avoided [54, 55].
The current study aims to find differences in the characteristics of accumulated dust on the performance of photovoltaic cells depending on its source. The accumulated dust was selected for three Iraqi cities, Basra, Baghdad and Mosul. The specifications of the human activities of each city are different from each other, so the effect of these activities on the components of dust will also have a different effect on the performance of photovoltaic cells.

2. Experimental Setup

Three important Iraqi cities were chosen, namely Basra, which is located in southern Iraq and is known as the economic capital of Iraq, as 90% of the oil of this country is produced from the territory of this province. Baghdad, the historic capital of Iraq and extends to large areas and a large number of cars and trucks in addition to hundreds of thousands of generators used to produce electricity and use diesel and gasoline as fuel. Mosul is the second largest city in Iraq with a population of three million and is famous for its green cultivated land as well as its proximity to the sulfur mines in Mashraq.

The dust was collected in all the above mentioned cities and accumulated on a glass plate of 1 m x 0.8 m for three months, March, April and May 2019. This dust was used in quantities of 100 and 200 g as it was scattered on the photovoltaic cell and was manually shaken for five minutes to ensure homogeneously. A laboratory solar cell whose characteristics are listed in Table 1 has been used with the use of a projector rather than a sun. The data and outputs of the cell were taken and the effect of changing the type and source of dust on the photovoltaic cell outputs was compared.

Figure 1: The system used in the study

TABLE 1: THE USED PV MODULES SPECIFICATIONS

Solar module type	APM-P 110-12
Peak power	110 W
Max. Power voltage	17.2 V
Max. Power current	6.40 A
Open-circuit voltage	21.6 V
Short-circuit current	7.0 A
Weight	11.4 kg
Dimensions	1450x 720x35
Operating temperature	-40^{o}C to 90^{o}C
Wind resistance	2400 Pa

3. Results and Discussions

Table 2 shows the effect of dust accumulation (100 g) on the produced capacity. The results showed that the greatest impact was from Basra dust, being contaminated with volatile hydrocarbons from oil exploration. The least impact dust was Mosul dust. Note that all species caused a decrease in production capacity of 25.7%, 40% and 22% for Baghdad, Basra, and Mosul, respectively.

Table 2: the impact of 100 gram of accumulated dust on the resulted power

City	Quantity (gram)	PV power (W)	Reduction rate
Clean panel	0	105	-
Baghdad	100	78	25.7
Basra	100	63	40
Mosel	100	82	22

Table 3 shows the effect of dust accumulation (200 g) on the produced power. As in the results of Table 2, the table results showed that the greatest effect was for Basra dust and for the same reason above. Hydrocarbons are of nano-scale size and are dangerous in their difficult cleaning and their high ability to adhere to the surface of the photovoltaic cell or penetrate into the cracks. The lowest impact was for Mosul dust, although this did not mean that it was less dangerous than the dust of the city of Basra, where it found traces of sulfur can dissolve the water coming from the dew and the sulfuric acid causes erosion of the surface of the cell or its conductors. Al-Baghdadi dust contains hydrocarbons as well as cement materials that can stick to the surface of the cell and make it difficult to clean. The amount of accumulated dust has resulted in a decrease in produced power of 37%, 45.7% and 32% for Baghdad, Basra, Mosul, respectively.

Table 3: the impact of 200 gram of accumulated dust on the resulted power

City	Quantity (gram)	PV power (W)	Reduction rate
Clean panel	0	105	-
Baghdad	200	66	37
Basra	200	57	45.7
Mosel	200	71	32

Table 4 compares the ratio of the decrease in solar cell generated power of the three accumulated dust types. Increasing the amount of low power generated by increasing the amount of dust accumulated, which means the need for periodic cleaning with a regular emphasis on the quality of dust and its components, for example, dust and sand from Basra city because of the presence of relatively high hydrocarbons needs to be cleaned with solvents able to interact with such materials and cleaning. Mosul dust requires alkaline solvents that can reduce the impact of sulfur in this dust.

Table 4: Comparison between the reduction rates of power

Quantity City	100g % of Reduction	200g % of Reduction
Clean panel	-	-
Baghdad	25.7	37
Basra	40	45.7
Mosel	22	32

4. Conclusions

The effect of the accumulated dust from three Iraqi cities (Basra, Baghdad and Mosul) on the power generated of the photovoltaic cell has been studied. The results showed that the produced power decreases with the increase of dust particles accumulation and the decrease in this power increases in the case of accumulating more dust. The results showed that Basra dust, due to the high percentage of hydrocarbons, has a significant impact on the productivity of the photoelectric panel. The decrease in the generated capacity was 40% and 45.7% for the accumulation of 100 and 200 g, respectively. The study also showed that the Mosul dust has the lowest effect between the types of dust studied by 22% and 32% for the case of accumulation of 100 and 200 g, respectively. Periodic cleaning is important to minimize the negative impact of dust accumulation. A number of methods and cleaning materials have been suggested in the study.

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