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THE EFFECT OF DUST ON AN EFFICIENCY OF CURRENT FLOW IN SOLAR CELL

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ABSTRACT

The dust deposited on the surface of photovoltaic module influence the transmittance of solar radiations from the photovoltaic module's glazing surface. The work aimed to investigate the effect of dust deposited on the surface of polycrystalline silicon. Modules of each type were used and one module from each pair was left exposed to natural atmosphere for months in Shendi city, Sudan. Systematic series of measurements were conducted for the time period of months corresponding to the different dust densities. The difference between the output parameters of clean and dirty modules percentage loss at different dust densities were obtained. The dust materials used are Black clay, Sand dunes, alteration and Cement powder. The results showed that dust deposition has strong impact on the performance of photovoltaic modules. The modules showed about 20% decrease of average output power respectively compared to the clean modules of same type.

Keywords: *solar cells, photovoltaic, dust, Black clay, Sand dunes*.

I. INTRODUCTION

Solar cells is one of the important renewable energy that to solve the energy problem in the world. Silicon solar cells which are now a day widely used suffer from noticeable problems, like high cost and complex fabrication. There is a need for new solar cells types which are cheap and easy to fabricate. The most promising type is the nano dye sensitized solar cells [1]. Energy is very important for civilizations. It is important for industry telecommunication, and transportation. Among these energy sources, solar energy looks a more convenient for human needs [2]. This is since it is renewable, neat & pollution frees [3]. Also solar energy can be converted into useful energy forms. The most popular conversion is to convert solar light energy into electrical one. This is because electricity is widely used and can be converted to other energy forms. The commercially available solar cells now are silicon solar cells. Silicon solar cells are compact, portable, and does not cause contamination. Unfortunately they are expensive and have low efficiency. These defects motivate scientists to search for an alternative types of cells [4].

Dust is defined as the minute solid particles with less than 500 μm in diameter [5]. Minute pollens such as bacteria and fungi, and microfibers separated from clothes, carpets and fabrics are also known as dust when settled on surfaces. Dust deposition is a function of various environmental and weather conditions. Pedestrian and vehicular activities, volcanic eruptions, pollution and wind can lift up dust and scatter it into the atmosphere [6]. Dust settlement mainly relies on the dust properties (chemical properties, size, shape, weight, etc.) as well as on the environmental conditions (site-specific factors, environmental features and weather conditions). The surface finish, tilt angle, humidity and wind speed also affect the dust settlement. There have been different studies conducted to investigate the effect of dust on solar cells [7].

II. BASIC CONCEPTS

Minute pollens such as bacteria and fungi, and microfibers separated from clothes, carpets and fabrics are also known as dust when settled on surfaces. Dust deposition is a function of various environmental and weather conditions. Pedestrian and vehicular activities, volcanic eruptions, pollution and wind can lift up dust and scatter it into the

atmosphere [8]. The direct beam solar radiation on tilted panels covered with dust is formulated for design purpose calculations[9].Thus, it can be concluded from the results that modules tilted with larger angles let less dust get accumulated on surfaces, leading to less transmittance drop. It can also be concluded that finer particles affect the PV efficiency more considerably than coarser particles. Dust promotes dust, so that the performance of PV modules declines exponentially with more dust piles up [10].

Type of dust:
For dust effects, the type of dust is an important factor. Some researchers reported the effect of natural pollutants like wind induced soiling while other used artificial dust for laboratory experiments. In this research used four kinds of dust having different properties:
Sand dunes: In physical geography a dunes is a hill of loose sand built by wind or the flow of water. Dunes occurring different shapes formed by interaction with the Flow of air and water.

Alteration (laurite): A reddish clayey material, hard when dry a forming. Atop soil in some tropical of subtropical regions and some time use for building. Geology a clayey soil horizon rich in iron and aluminum oxides formed by weathering of igneous rocks in moist warm climate.

Black clay: Is a soil in which there is a high content of expensive clay known as montmorillonite that from deep cracks in drier season or year

Cement powder: Due to the fact that Atbara city is surrounded by the cement industries the effect of dust on PV modules cannot be ignored.

Effect of dust on solar irradiance:
Solar intensity gets absorbed and reflected by accumulation of natural dust to the photovoltaic p-n junction module reduces strongly the energy received. The influence of wind speed or its direction is not considered for probably loss, because high relative humidity contributes to the adherence of dust particles on the module surface.

III. MATERIALS AND METHODS

Dust is major environmental factor which effect the module performance. Investigated the impact of dust deposition on the performance of the PV module in side the laboratory under the controlled condition. The measurements have been made with four types of materials sand dunes ,alteration, black clay ,and cement powder. To have the best coating, all materials must adapt to a specific size. This made with a sieve. The next thing the had to be solved was the method of spreading, collecting and weighting the dust. We need the weighting in order to be able to calculate the thickness of the coating. Spreading decided to be with the sieve collecting made with a rubber glass cleaner and then we set the powder in a pre weighted piece of nylon. All weightings were made on a weighting scale with accuracy of 0.1 grams.

IV. RESULT AND DISCUSSION

The effect of dust can found by depositing dust of different weights and thickness. Then series of reading for V and I were taken to fine I_{SC} ,V_{OC} ,V_m , I_m ,FF, P_m and η.

Table 1 : I-V characteristics of solar cell without dust

R× $10^3\Omega$	o	1	2	3	4	5	6	7	8	9	10
V_{oc}(volt)	0.027	6.5	7.23	7.63	7.95	8.01	8.21	8.29	8.35	8.4	8.43
Is(m A)	10.2	8.9	7.22	3.7	2.6	2.3	1.6	1.37	1.18	1.04	0.93

Table 2: I-V characteristic of solar cell-type of dust sand dunes 1gram

R× $10^3\Omega$	o	1	2	3	4	5	6	7	8	9	10
Voc(volt)	0.022	6.2	6.75	7.34	7.73	7.94	8.06	8.15	8.21	8.26	8.3

Is(m A)	9.81	8.7	6.85	3.64	2.55	1.97	1.6	1.34	1.16	1.02	0.91

Table 3: I-V characteristic of solar cell-type of dust sand dunes 2grams

R× $10^3\Omega$	o	1	2	3	4	5	6	7	8	9	10
Voc(volt)	0.02	5.5	6.52	7.14	7.56	7.77	7.9	7.99	8.05	8.1	8.15
Is(m A)	9.57	8.7	6.5	3.55	2.49	1.92	1.56	1.32	1.14	1	0.89

Table 4: I-V characteristic of solar cell-type of dust sand dunes 3grams

R× $10^3\Omega$	o	1	2	3	4	5	6	7	8	9	10
Voc(volt)	0.006	5.7	5	6.81	7.27	7.5	7.65	7.74	7.81	7.86	7.9
Is(m A)	7.96	7	6.2	3.38	2.4	1.86	1.51	1.28	1.1	0.97	0.87

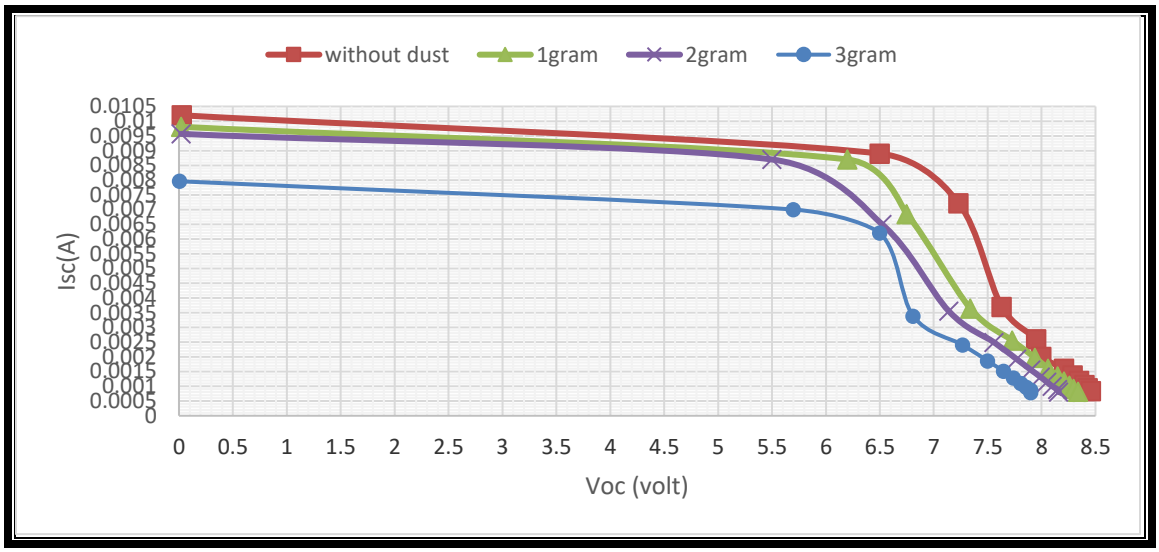

Figure 1: Show different I-V Curve of PV at different mass of sand dunes

Table 5: I-V characteristic of solar cell-type of dust alteration 1gram

R× $10^3\Omega$	o	1	2	3	4	5	6	7	8	9	10
Voc(volt)	0.008	5.7	6.53	7.05	7.47	7.68	7.81	7.9	7.97	8.01	8.05
Is(m A)	8.75	8.2	6.5	3.5	2.46	1.9	1.55	1.3	1.13	0.99	0.89

Table 6: I-V characteristic of solar cell-type of dust alteration 2grams

R× $10^3\Omega$	o	1	2	3	4	5	6	7	8	9	10
Voc(volt)	0.006	5.1	6	6.8	6.87	7.15	7.3	7.41	7.49	7.55	7.6
Is(m A)	7.9	7	4.47	3.12	2.27	1.77	1.45	1.22	1.06	0.93	0.84

Table 7: I-V characteristic of solar cell-type of dust alteration 3 grams

R× $10^3\Omega$	o	1	2	3	4	5	6	7	8	9	10
Voc(volt)	0.003	5	5.6	6.2	6.45	6.66	6.68	7.02	7.12	7.19	7.32
Is(m A)	7.3	6.7	4.43	2.66	2.06	1.65	1.38	1.16	1.05	0.89	0.8

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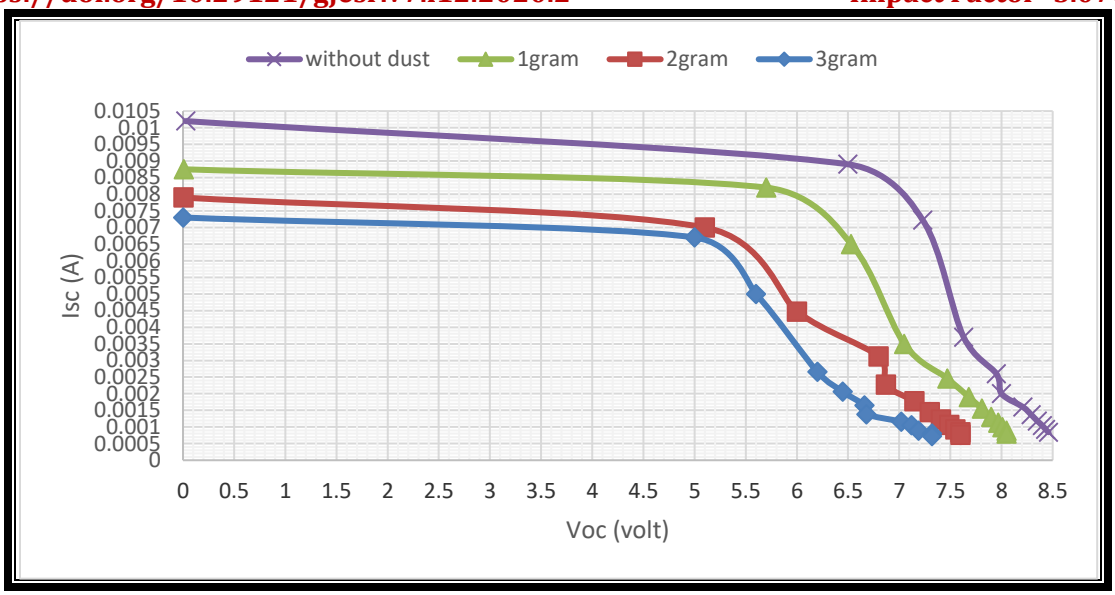

Figure 2: Show different I-V Curve of PV at different mass of alteration

Table 8: I-V characteristic of solar cell-type of dust black clay 1gram

R× $10^3\Omega$	o	1	2	3	4	5	6	7	8	9	10
Voc(volt)	0.005	5.6	6.3	6.89	7.34	7.57	7.71	7.8	7.86	7.9	8.04
Is(m A)	8.6	8	6.27	3.42	2.42	1.87	1.53	1.29	1.3	1.2	1

Table 9: I-V characteristic of solar cell-type of dust black clay 2grams

R× $10^3\Omega$	o	1	2	3	4	5	6	7	8	9	10
Voc(volt)	0.003	5	5.73	6.02	6.42	6.63	6.8	6.91	6.99	7.05	7.02
Is(m A)	7.2	6.7	5.8	3.4	2.7	1.8	1.6	1.4	1.2	1.1	1

Table 10: I-V characteristic of solar cell-type of dust black clay 3grams

R× $10^3\Omega$	o	1	2	3	4	5	6	7	8	9	10
Voc(volt)	0.001	4.7	5.2	5.7	5.79	5.86	5.92	5.96	6.09	6.19	6.25
Is(m A)	6.95	6.3	5.4	3.2	2.6	1.5	1.3	1.2	1.1	0.8	0.6

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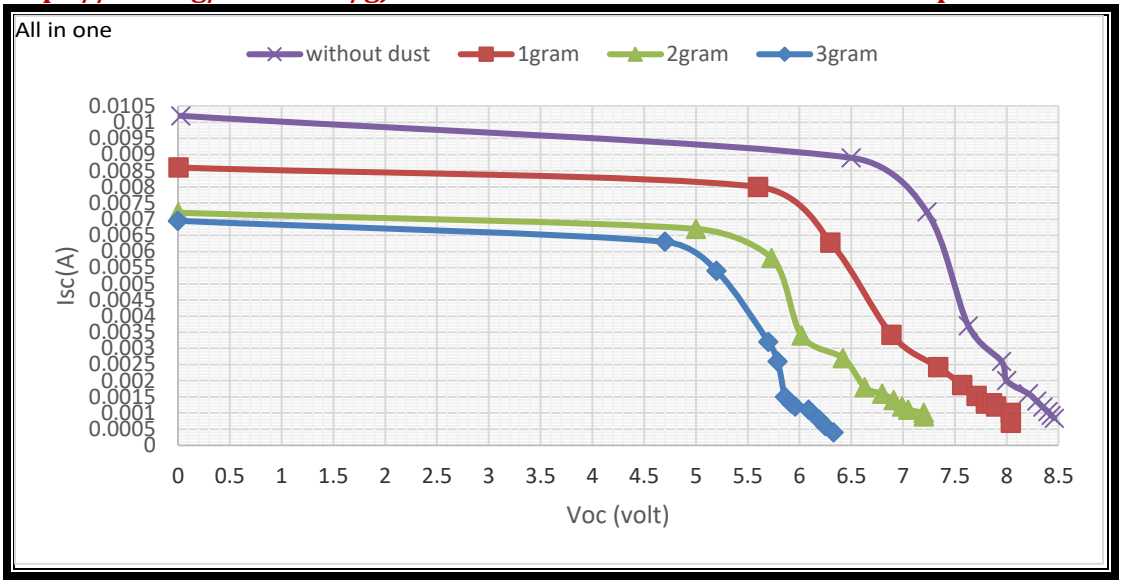

Figure 3: Show different I-V Curve of PV at different mass of black clay

Table 11: I-V characteristic of solar cell-type of dust cement powder

R× $10^3\Omega$	o	1	2	3	4	5	6	7	8	9	10
Voc(volt)	0.006	6	6.26	7.44	7.68	7.79	7.86	7.9	7.93	7.95	7.96
Is(m A)	9.7	8.5	6.8	5.2	3.6	2.7	2.2	1.8	1.6	1.4	1.2

Table 12: I-V characteristic of solar cell-type of dust cement powder 2grams

R× $10^3\Omega$	o	1	2	3	4	5	6	7	8	9	10
Voc(volt)	0.005	5.3	6.62	6.72	7.18	7.36	7.45	7.51	7.55	7.59	7.64
Is(m A)	9.35	8.5	6.3	4.6	3.2	2.5	2	1.7	1.5	1.3	1.2

Table 13: I-V characteristic of solar cell-type of dust cement powder 3grams

R× $10^3\Omega$	o	1	2	3	4	5	6	7	8	9	10
Voc(volt)	0.003	5.3	5.8	6.27	6.89	7.11	7.23	7.29	7.35	7.39	7.43
Is(m A)	7.94	6.8	5.4	4.3	3.1	2.4	2	1.6	1.4	1.2	1.1

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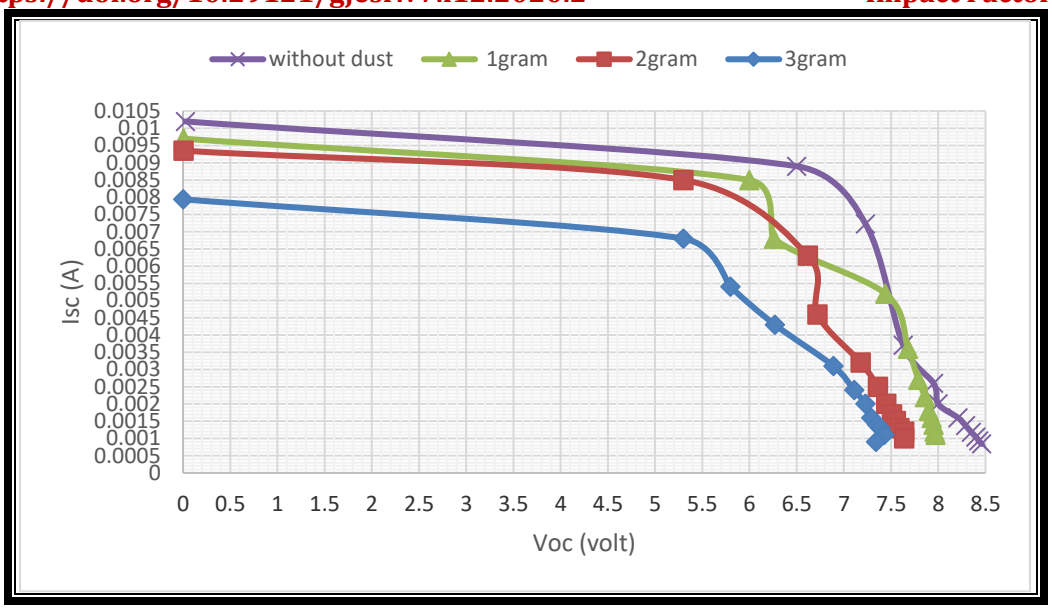

Figure 4: Show different I-V Curve of PV at different mass of cement powder

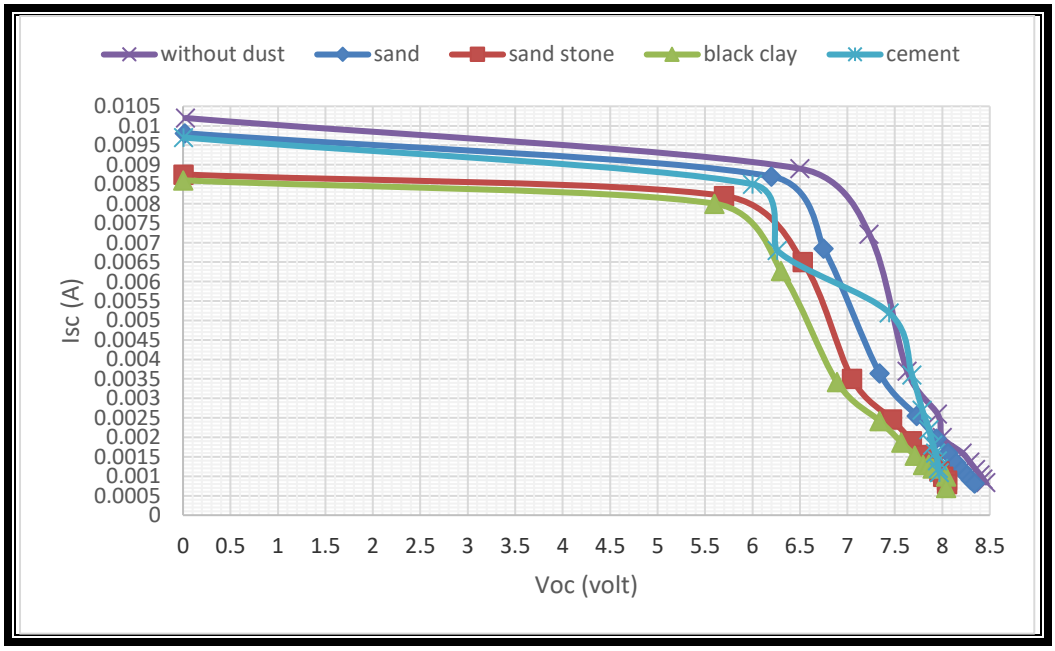

Figure 5: Show different I-V Curve at different type of dust the mass 1gram

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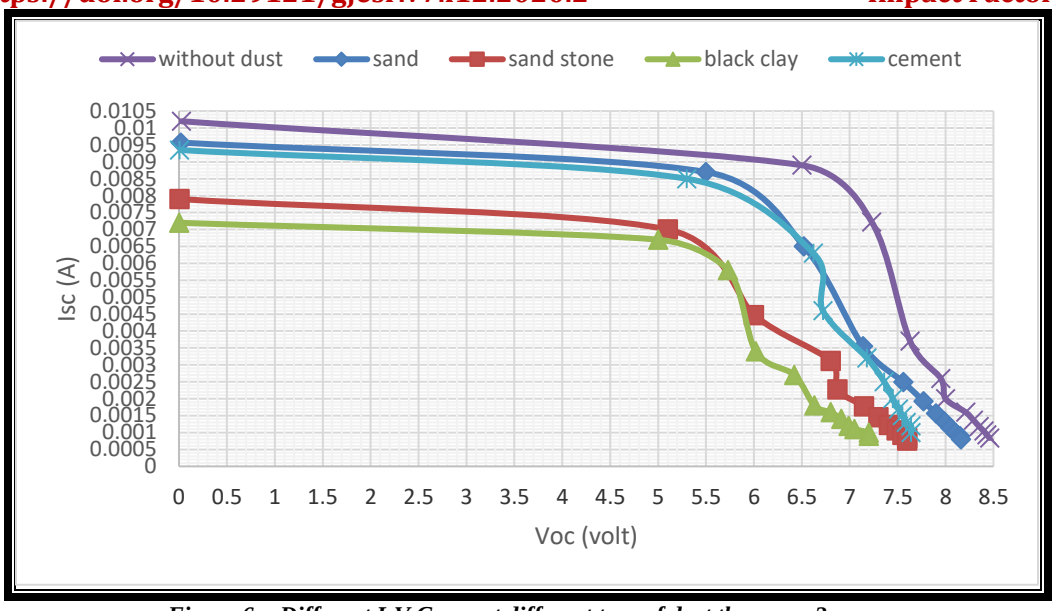

Figure 6: Different I-V Curve at different type of dust the mass 2grams

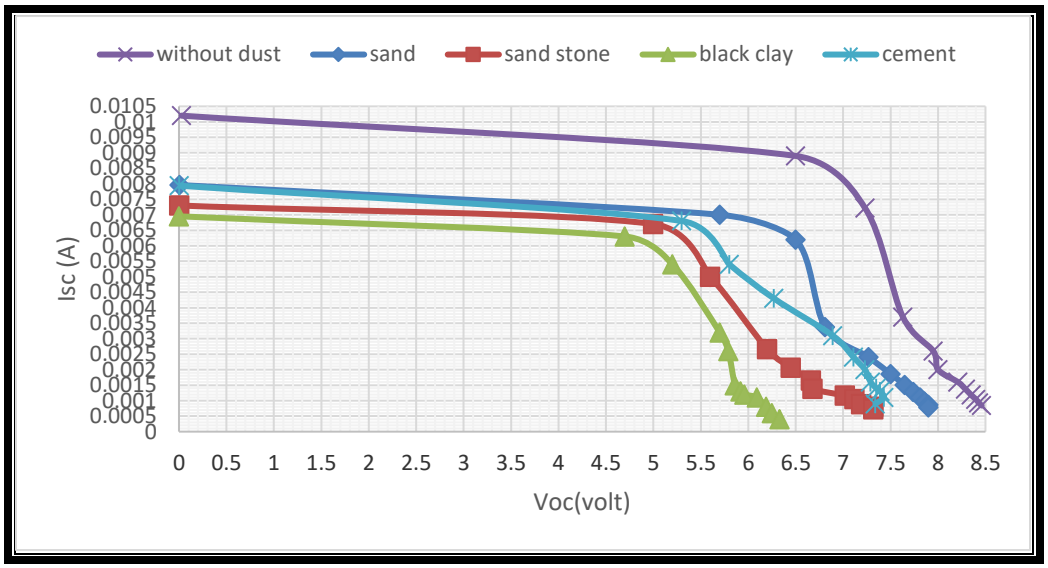

Figure 7: Different I-V Curve at different type of dust the mass 3grams

Table 5.25 Converted measurements at different type of dust and different mass

Type of dust	Pm(watt)	Voc(V)	Vm(V)	Isc(A)	Im(A)	m (gm)	FF	efficiency
Clean	0.0585	8.48	6.5	0.0102	0.009	0	0.676	0.0264
Sand dunes	0.0544	8.39	6.4	0.00981	0.0085	1	0.666	0.0246
	0.0489	8.19	5.75	0.00957	0.0085	2	0.628	0.0221

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	0.0403	7.95	5.75	0.00796	0.007	3	0.636	0.0182
Alteration	0.048	8.11	6	0.0087	0.008	1	0.676	0.0216
	0.0357	7.6	5.25	0.0079	0.068	2	0.595	0.0161
	0.0339	7.32	5.23	0.0073	0.0065	3	0.634	0.0153
Black clay	0.0448	8.04	5.75	0.0086	0.0078	1	0.649	0.0202
	0.0346	7.2	5.25	0.0072	0.0066	2	0.668	0.0156
	0.0304	6.33	4.75	0.0069	0.0064	3	0.691	0.0137
Cement powder	0.0531	7.7	6.25	0.0097	0.0085	1	0.707	0.0224
	0.0462	7.64	5.5	0.0935	0.0084	2	0.646	0.0208
	0.0356	7.44	5.4	0.00794	0.0066	3	0.603	0.0160

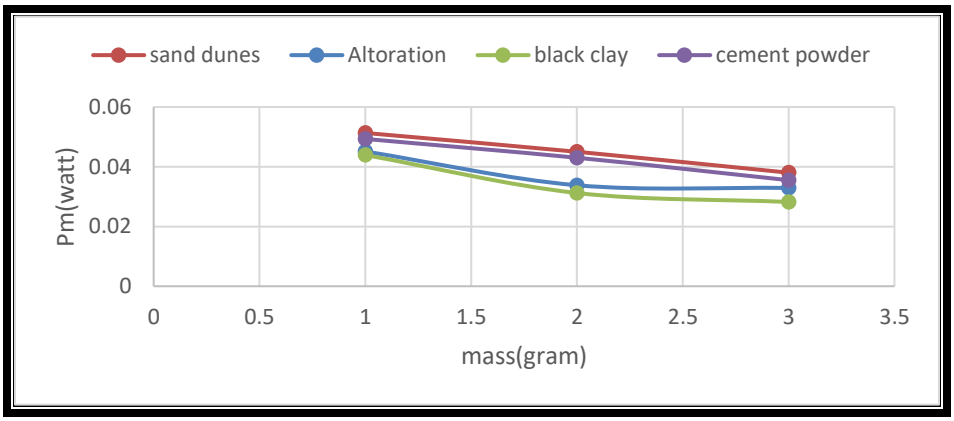

Figure 8: The relation between the Pmax and mass at different type of dust

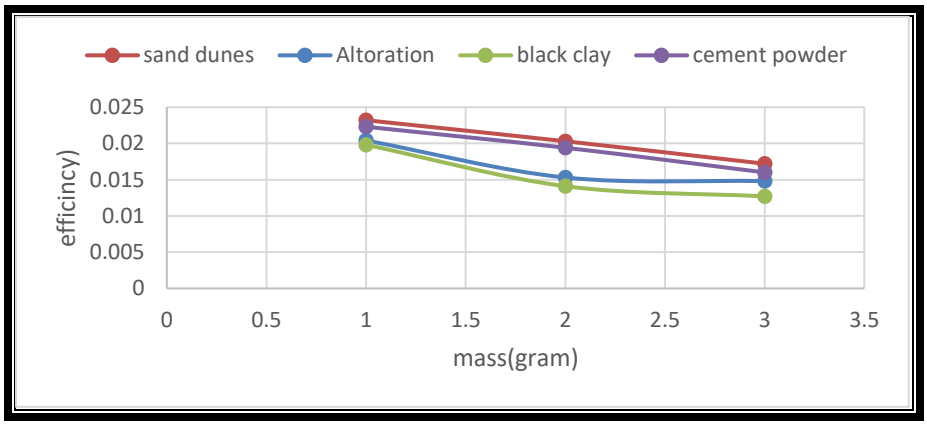

Figure 9: The relation between the efficiency and mass at different type of dust

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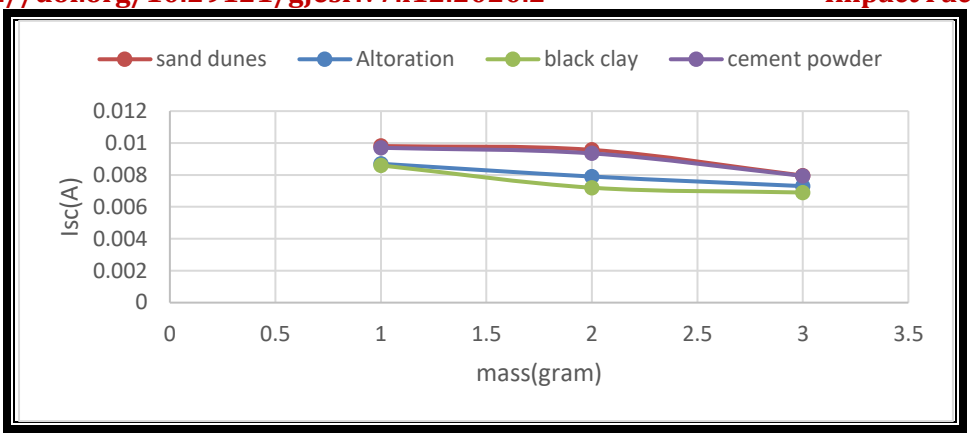

Figure 10: The relation between Isc and mass at different type of dust

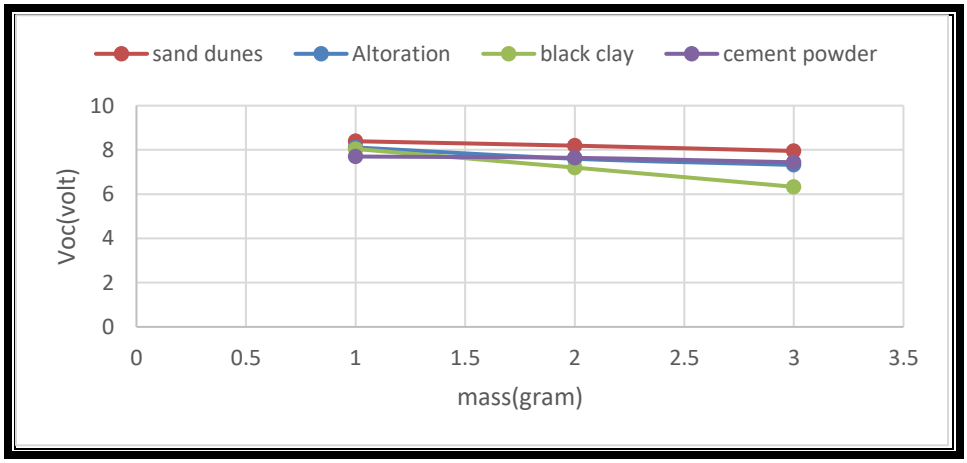

Figure: 11 The relation between Voc(volt) and mass at different type of dust

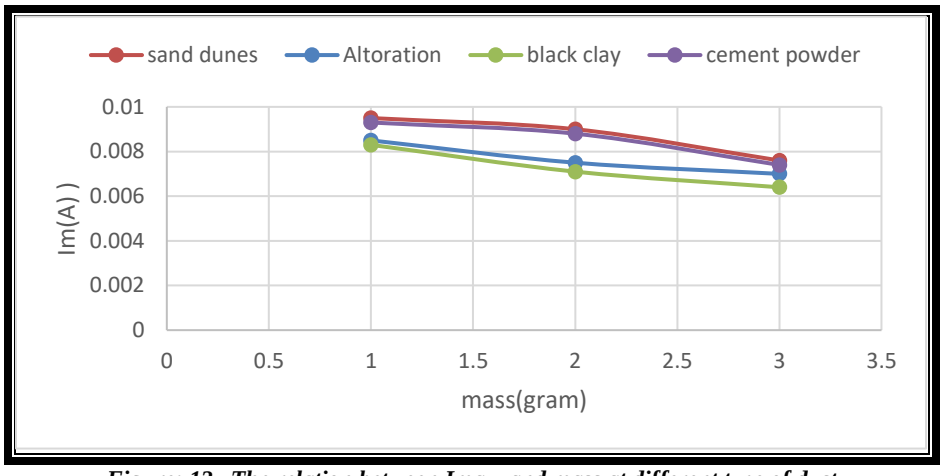

Figure: 12 The relation between Imax and mass at different type of dust

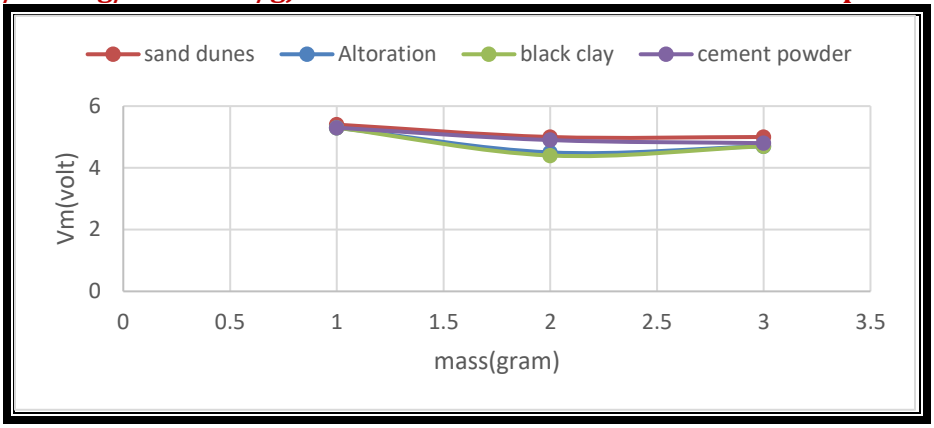

Figure: 13 The relation between Vmax and mass at different type of dust

V. CONCLUSION

Experimental results shows that all electrical parameters of solar cell such as maximum output power, open circuit voltage, short circuit current, fill factor and efficiency have changed with different type of dust. Accurate knowledge of solar module performance parameters from the measured I-V characteristics is very important for the quality control and the performance assessment of the solar system. In this research dust dependency of out put performance parameters of poly crystalline silicon, solar modules has been experimentally investigated. The result show the effect of dust on the photovoltaic module to decrease the electrical energy out put from PV module by obstructing the solar radiation which is absorbed by PV module and reduces the power production and efficiency. The result also shown that the differences between results obtained by using sand dunes, alteration, black clay and cement powder. Also the color of the dust can change as we saw.

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