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# Effect of Dust Accumulation on Performance of Photovoltaic Solar Modules in Sahara Environment

**Ali Omar Mohamed, Abdulazez Hasan**

Arab Centre for Research and Development of Saharian Communities - Mourzuq , Libya
National Authority for scientific research, Libya

## ABSTRACT

Occasionally exposures the southern area of Libya through the period from (February to May) to seasonal winds, which usually carrying dust and sand. So, tiny particles of sand, trees debris, and birds' droppings are accumulating on surface of PV modules, which yield a shading sunlight on modules, the consequence a significant power loss. The area of study classified as rural desert. In particular region a large amount of solar irradiance is abundance over the year. That reason encouraging to adopted clean energy resource on desert environment. This paper investigated a framework of weekly cleaning on PV modules array throughout the period from February to May. The results indicated a significant gradual decrease of power, so frequent weekly water washing maintaining performance losses between (2 - 2.5%). It is important feature of water washing on the modules surfaces deemed more reliable to recover power loss.
**KEYWORD:** accumulation on PV solar module, power losses, weekly cleaning, performance recovery.

## INTRDUCTION

Solar energy is one of the main promising clean energy sources in future of the world. The technology of Photovoltaic PV is always on continuous developing in many applications, so it is generate electricity without dangerous effect on environment. It can utilize in pipelines catholic protection. Furthermore, Photovoltaic systems are today largely used in rural electrification, and grid connected systems, also in a water pumping irrigation and remote check point etc.

Because of their versatility, low maintenance, and long lifetime, photovoltaic (PV) modules are an alternative for small, off the grid energy projects. In recent years, the use of these devices in the greater Sonoran Desert region has increased considerably [10].

The PV power supply systems for supplying electrical energy to remote and isolated areas are justified based on economical and technical reasons. It is also recommended to install more PV systems to feed all inhabitance those suffer from shortage or lack of electrical supply.

The availability of power supply will give a good chance to involve the populations of such remote areas increasing their knowledge and becoming familiar with the daily life of modern society [1,3,12]. Experimental system of solar energy has been installed in Saharian environment, for scientific research purpose, this system applied for water pumping. Polycrystalline photovoltaic modules type, parameters of each photovoltaic PV module generates 75W on peak of power, open short circuits current of the module is 4.7A and open circuit voltage 18V. The modules have a bypass diode to minimizes the power drop, which might caused by shade. Every four modules are connected in series and represent array. An installation tilted angle is $40^o$ to the north.

The load is electrical submersible pump to produce $50m^3$ of water daily at optimum performance; a motor rated power is 2200W and service voltage160V.

The area of study has great potential of solar intensity, effulgent hours and it is located in land sun-belt. Average of annual solar irradiance is 1700-2800KWh/$m^2$/daily. Also, annual of solar ground energy average 4- 8KWh/$m^2$/daily [3].

### Environment of study area

Mourzuq is oasis located on southern area of Libya, this area classified as desert environment; it is altitude 450m above sea level. The climate of desert is the dry hot in summer and dry cold in winter. It is

**Corresponding Author:** Ali Omar Mohamed, Arab Centre for Research and Development of Saharian Communities - Mourzuq, National Authority for scientific research, Libya. E-mail: Maca_4212@yahoo.co.uk

rarely rainy, but the western wind, and" Gebli" is local wind prevailing on region, usually carrying dust especially in a spring season.

Monthly deposition rates are compared with meteorological data, particle size distribution and comparison of annual dust deposition rates in Libyan Desert. Figure (1) illustrates a relative distribution of particles number, and it is possible to estimate the most significant ranks in sizes. The size of the particles' diameter measured, and it was between (0.5 - 1000) microns, variable from month to other. The fractions distribution of the surface area of the particles presents the distribution of the fraction of particles per volume, hence the maximum percentage volume 8% [8]**.** Dust particles have distinct transmittance indices; some are completely opaque, while others have a specific degree of transparency .The principal components, in order of importance, of the dust collected is clay, sand [10]**.**

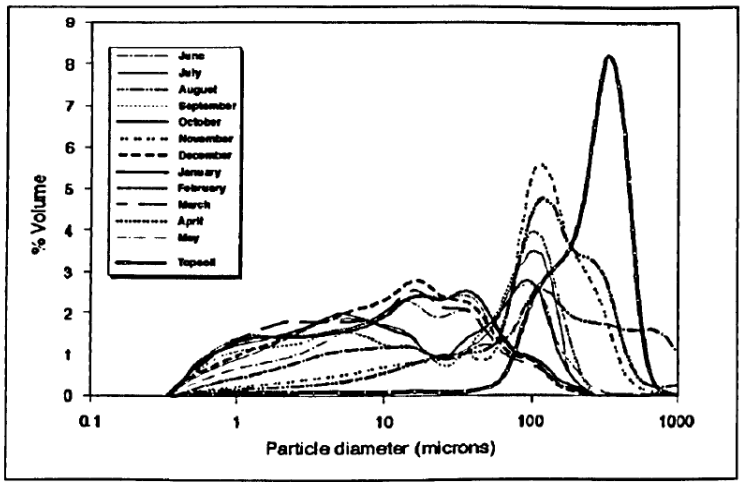


Figure (1) measurement of dust deposition in Libyan Sahara [8].

Numerous research studies demonstrated the ambient temperature had affecting on module performance. Although, an increase of ambient temperature is cause slight increase of short circuits current and significant decrease in open circuit voltages to (2.3-2.2) C/Vm. These changes factor in voltage caused a temperature increase, that yield a change in the diode conduction characteristics [1,3]. Figure (2) illustrate variation of ambient temperature.

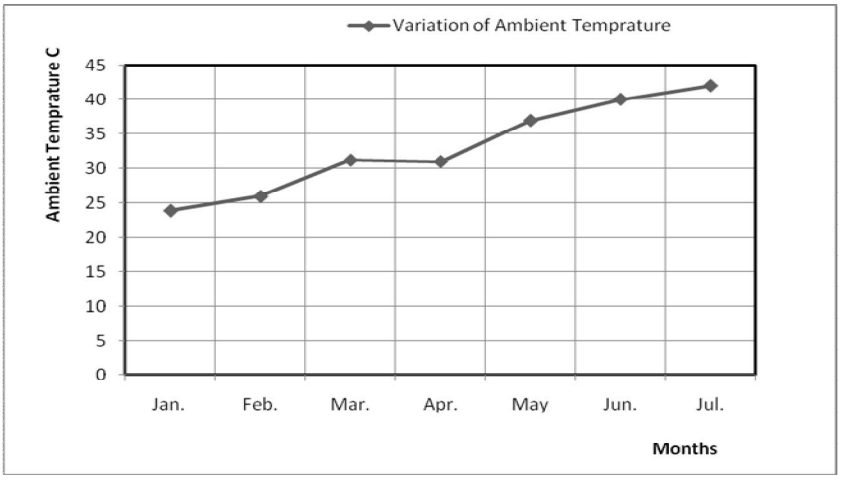


Figure (2) shows region variation of ambient temperature from January to July in Mourzuq area.

**Performance Losses in PV modules**

The performance of PV module is influenced by several parameters such as ambient temperature, humidity, rain, cloud and dust. In a desert environment the operational performance is impeded via sand particles accumulation on surface and higher ambient temperature. An appropriate tilted angle might reduce

dust accumulation over PV modules. Furthermore, during installation of solar array to be taken into account the bulk of sunlight through diurnal hours, hence consideration before/after mid day.

The result of earth rotating around the sun, therefore sun passes over the tropic of cancer in the summer, the sun deviates to the north. In winter season the sun lying directly on the tropic of Capricorn the sun deviates to the south, which might need change the tilt angle from season to other.

**Experimental Set Up**

A simultaneous measuring is implemented in maximum operating Voltage, and Current on each module for both before/after washing modules. Weekly water washing is preformed through these months (February – may) in order to evaluate PV performance. So the maximum current and voltage is measured at terminal via digital Multi-meter device, before/after washing in order to gain the maximum power at operating point generated by module.

## RESULTS AND DISCUSSIONS

The heavy layer of dust accumulation on module array might cause reduction in output power, so that can recovered by washing process [1,2]. Figure (3) show solar module have heavy dust layer. A major problem facing scientist is sand accumulation, hence numerous researches proved that, more than 50% of solar module performance reduction caused by unclean throughout period of one month [4,5]. The Polycrystalline photovoltaic modules maximum efficiency averages about 10 to 14%, but it is less cost compared to Monocrystalline photovoltaic modules [3].

The scheduling of cleaning period is required knowledge about environment of the area, which various from country to other. Therefore, before an installation of solar system to be consider the environment and weather of targeted location.

In this study a digital multi-meter device is used to measuring voltage and current in four modules regularly each week. Water wash is applied once a week on module, manually by mixed detergent with water and use of hand cleaning materials. Moreover, automatically by retrofits a spry nozzle at the top, to wash surface module. Some manufacturer companies invented robot to wash surface of PV module. There is no cost effectiveness when perform water washing, approximately each module consumes around 5 liters of water, figure (4) shows a brightness module after cleanness.

Figure (3) shows solar module covered by heavy layer due to dust accumulation before cleaning.

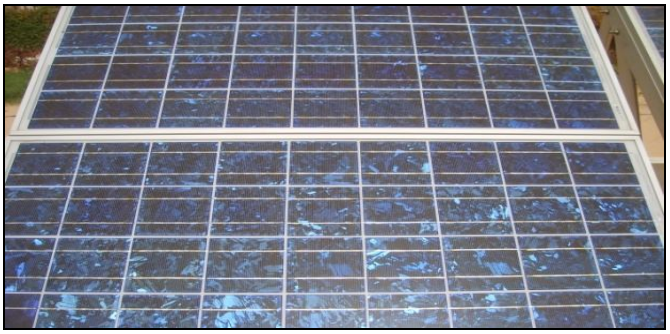

Figure (4) shows solar module after cleaning.

The maximum power at operating point generated by module, hence the maximum current and voltage is measured at terminal via digital Multi-meter device, before/after washing. In order to determine the amount of maximum operating power by applying in equation (1) as follows:

$$P_{max} = V_{max.} * I_{max} \quad (1)$$

Where,

$P_{max.}$ maximum operating Power [W]

$I_{max.}$ maximum operating Current [A]

$V_{max.}$ maximum operating Voltage [V]

Data acquisition over period from February to May, while no excessive increase on ambient temperature during those months. An assessment of water pumps PV module system is taken place when it is operating at peak of power. Performance characteristic of module efficiency given by follows equation (2).

$$\eta_m = \frac{p_{max}}{p_r} \quad (2)$$

Where:

$P_{max} = I_{max} * V_{max}$.

$P_r$ Solar Power Radiation in system = irradiance * area of solar module.

An assessment result of the four modules respectively. Accordingly, via utilized a frequent weekly water washing maintaining performance losses between (2 - 2.5%). In contrast unclean module with clean, there is a gradual reduction of power, although by water flashing led to rapidly power recovery. It is recommended ought to clean either at evening or early on the morning before exposure the module to intense solar radiation.

Explicitly, that unclean module had slight increase in current and voltage, which yield a significant power loss. While the clean module explicit that all parameters increase, the power of course will improve. So, fluctuation in power of clean and unclean module is variable between (69W - 74.2W). Despite the maximum design power of PV modules (75W). Figures (5, 6, 7 and 8) illustrated power status versus periods from February to May.

However, Performance of the PV module is proportional to dirt accumulation. Actually as little of 10% shade on PV module array can result in of 50% lost energy [5]. Even though with an appropriate tilt angle installation still sand particles accumulate on module surface. By performing water washing has no extra operation and maintenance cost, particularly in water pumping application.

Through the measurement of the array "four modules in series link" before washing found the voltage is (50V) after washed voltage enhanced to (68V), hence rated current of the array is (14A). The aggregated voltage from four modules appeared a significant loss in power losses. Although, an increase in open short circuit current jeopardized modules integrity to failure risk.

In the meantime system reliability will increase, while module cleaned, in terms of reliability is desired on all PV applications. In addition lifespan of PV module will reduce, whilst performance decrease. It is quite important to develop technology to be mounted on the top of PV module, in order to mitigate performance losses particularly in desert environment.

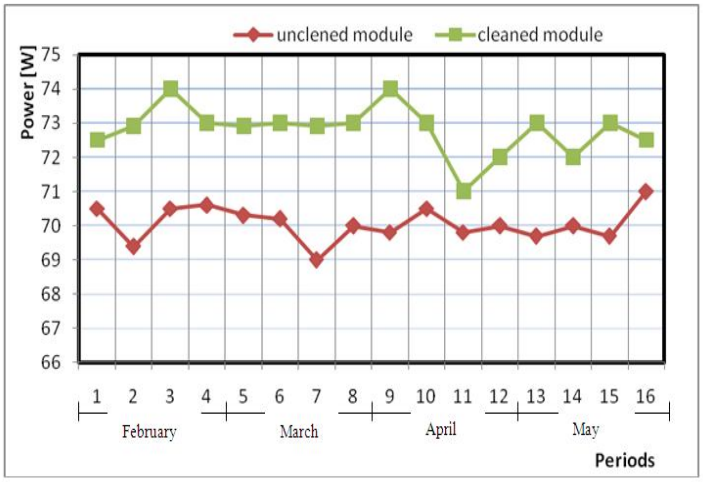


Figure (5) power measurement of first module while, cleaned/uncleaned.

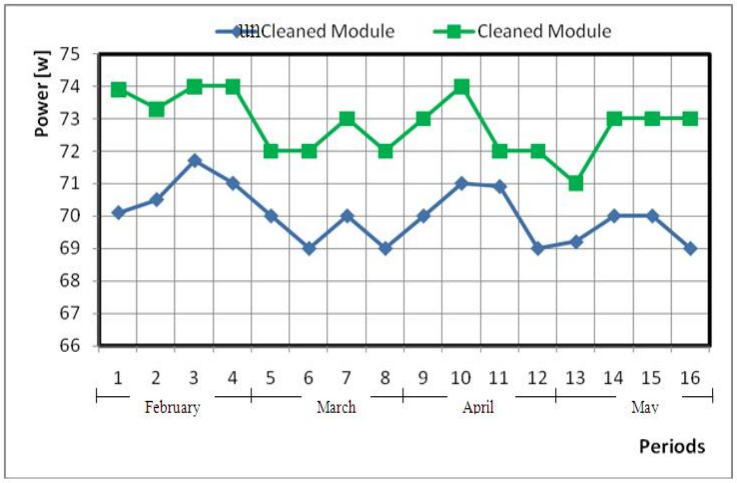


Figure (6) power measurement of second module while, cleaned/uncleaned.

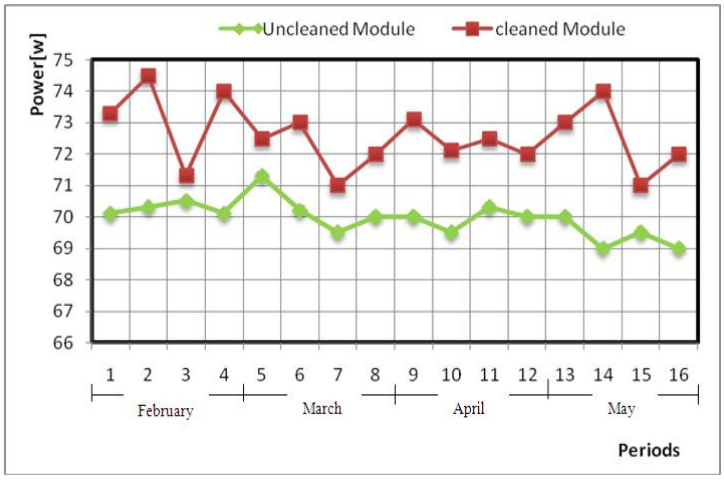


Figure (7) power measurement of third module while, cleaned/uncleaned.

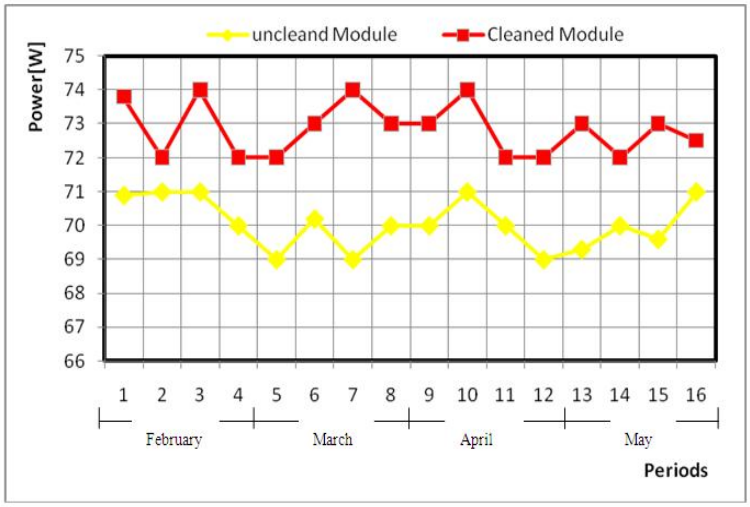


Figure (8) power measurement of fourth module while, cleaned/uncleaned.

## Conclusions

In fact PV installation in desert region necessitates a regular cleanings to maintain an optimum performance. However, the accumulations of dirt objects on solar module have a significant, impact on output power and over all system efficiency.

Periodically weekly cleaning maintained performance losses between 2 – 2.5%. In framework once a week cleaning intervals and rinse every three days from (February to May), then follows by once a month cleaning in other months, that help to reduce the dirt's and debris build up. The cleaning intervals is different from site to another, it is important before schedule such agenda to have a fully knowledge of region environment pollution type and it is occur period.

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