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Research Article

Determination of the Daily and Weekly Solar Radiation of September 2015 at Presco Campus Ebonyi State University, Abakiliki-Nigeria

[1]Daniel UgaduOnah, [1]Promise Obasi, [2]Friday Ibeh Gabriel and [1]Edwin Humphrey Uguru
[1]Department of Industrial Physics, Ebonyi State University, Abakaliki, Nigeria
[2]Houdegbe North American University,Cotonou, Republic of Benin

Abstract: This study focused on the measurement of global solar radiation at the Presco Campus of Ebonyi State University, Abakaliki-Nigeria (06°N, 08°E, 43.9 m) in the month of September, 2015. The variability in global solar radiation was measured using a daystar meter on 30 min, hourly, daily, weekly and monthly scales. GPS global positioning instrument No. 13467763 was also used in determining the elevation and position of the area where the experiment was carried out. The results showed that the peak of the hourly average global insolation was 2.25 W/m^2. In a clear partially bright sunny day, the daily average of global solar radiation was 627.44 W/m^2 while the daily average of irradiation on a cloudy day was 384.19 W/m^2. On a weekly scale, the average irradiation was 2.95 W/m^2 whereas on a monthly scale, the average was 11.79 KW/m^2 for the month of September, 2015.

Keywords: Daily and weekly radiation, global, measurement, solar meter, solar radiation

INTRODUCTION

The global solar radiation is of economic importance as renewable energy alternatives and this has made the study of solar radiation and its measurement very paramount in physics and science in general. Radiation is the transmission of energy through space. The radiation transmitted consists of particles or waves. Solar energy flows through the earth's natural system at a rate 10,000 times greater than all energy from the world's fossil and nuclear-powered machines (Gary and Pinkerton, 1982). Solar radiation is the total frequency spectrum of electromagnetic radiation produced by the sun. This radiation can be in form of direct and diffuse radiation. Several fusion reactions have been suggested to supply the energy radiated by the sun of which the most important is the combination of four proteins to form helium nucleus (Tiwari, 2006). We exist because of the sun's energy, since the sun supplies almost all the energy for natural processes on the earth surface and also in the atmosphere. The value of solar radiation falling on collectors in a particular place or location is very important in order to enable engineers design appropriate energy conversion and storage systems (Onah and Osuji, 2007).

Solar radiation is received at the Earth's surface under different atmospheric conditions, which obviously affect the amount and quality of radiation obtained at the ground during the course of the day. The knowledge of the local solar radiation variability is the bases of any climatic study and its application to meteorology, industry, agriculture, engineering, architecture, water resources etc (De Souza*et al*., 2005). Atmospheric conditions such as, turbidity and transparency, air mass, atmospheric water vapor content and layers and distribution of cloud cover have been suggested to exert depleting influence on solar radiation at the Earth's surface, mainly by absorption, scattering and reflection of the incoming solar radiation (Serway and Jewett, 2015).

The clearness index (which is the ratio of the global solar radiation measured at the earth surface to the total solar radiation at the top of the atmosphere) is a veritable tool in the characterization of sky conditions (or classification of sky types) over a particular locality (Ideriahand Suleman, 1989; Kuye and Jagtap, 1992; Okogbue and Adedokun, 2002). Synoptic cloud observations have remained the only source of information on sky conditions for most parts of tropical Africa, but these are very subjective.

Pyranometer is an instrument that can be used to measure global solar radiation. It is a simple whole sky solarimeter. However, the use of pyranometer in the measurement of surface solar radiation is still relatively scarce. A sky clearness index (overcast, partially cloudy and clear) has been used by many scholars to quantify surface global solar irradiance (De Souza*et al*., 2005; Meek, 1997). Other researchers have used one or

Corresponding Author: Daniel UgaduOnah, Department of Industrial Physics, Ebonyi State University, Abakaliki, Nigeria

moremeteorological parameters and modeling to estimateglobal solar radiation on horizontal surface of so many locations (Ibeh*et al*., 2012).

The major interest in this study is the measurement of global solar radiation at the Presco Campus of Ebonyi State University, Abakaliki, Nigeria (06°N, 08°E, 43.9 m) in the month of September, 2015). The data obtained in this regard could be used to determine the monthly average clearness index and other solar energy parameters such as beam and diffuse components of daily radiation.

MATERIALS AND METHODS

This study used a daystar solar meter to measure global solar radiation at Presco campus of Ebonyi State University, Abakaliki. This instrument was used to measure and determine the amount of insolation that was received on a horizontal surface for one month. Subsequently, the daily and weekly average of global solar radiation on a horizontal surface in Ebonyi State University, Presco campus were determined from the

Table 1: The first week of September 2015 (31stAugust to 6th September) solar radiation data (W/m^2) at Prescocampus of Ebonyi State University, Abakaliki

Time (mins)	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Total	Average
6:00 am	0	0	0	0	0	0	0	0	0
6:30 am	5	6	11	7	3	34	7	73	10.4286
7:00 am	36	38	26	55	63	120	45	383	54.7143
7:30 am	122	103	67	165	75	200	226	958	136.8571
8:00 am	153	268	77	278	54	215	234	1279	182.7143
8:30 am	180	187	56	290	74	224	320	1331	190.1429
9:00 am	221	567	149	460	210	234	422	2263	323.2857
9:30 am	280	467	472	934	260	346	583	3342	477.4286
10:00 am	325	373	315	1025	348	576	1014	3976	568.0000
10:30 am	570	338	590	390	1053	364	512	3817	545.2857
11:00 am	554	223	1014	413	1130	258	481	4073	581.8571
11:30 am	500	1002	319	296	432	448	432	3429	489.8571
12:00 pm	620	356	292	460	1199	105	537	3569	509.8571
12:30 pm	810	875	437	646	372	230	786	4156	593.7143
1:00 pm	422	807	777	440	870	1039	552	4907	701.0000
1:30 pm	450	736	705	354	1004	958	456	4663	666.1429
2:00 pm	575	748	305	791	1148	793	451	4811	687.2857
2:30 pm	807	647	357	147	432	143	253	2786	398.0000
3:00 pm	648	311	657	558	373	612	647	3806	543.7143
3:30 pm	310	252	586	426	530	378	4299	6781	968.7143
4:00 pm	288	122	412	329	373	1167	530	3221	460.1429
4:30 pm	154	106	288	185	160	206	218	1317	188.1429
5:00 pm	174	34	132	132	209	136	213	1030	147.1429
5:30 pm	102	68	98	102	152	68	152	742	106.0000
6:00 pm	26	42	53	54	42	35	41	293	41.8571

Table 2: The second week of September 2015 (7th to 13th) solar radiation data (W/m^2) at Prescocampus of Ebonyi State University, Abakaliki

Time (mins)	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Total	Average
6:00 am	0	0	0	0	0	0	0	0	0
6:30 am	5	5	8	4	5	2	5	34	4.8571
7:00 am	39	64	49	24	32	54	49	311	44.4286
7:30 am	224	74	243	78	101	68	79	867	123.8571
8:00 am	233	53	233	190	224	73	96	1102	157.4286
8:30 am	321	78	310	886	127	310	149	2181	311.5714
9:00 am	423	220	432	456	556	432	194	2713	387.5714
9:30 am	580	310	910	543	454	321	199	3317	473.8571
10:00 am	1015	240	1034	670	543	996	358	4856	693.7143
10:30 am	513	1029	432	876	445	1123	425	4843	691.8571
11:00 am	482	1140	413	943	322	453	466	4219	602.7143
11:30 am	431	423	342	1187	1009	1009	429	4830	690.0000
12:00 pm	530	1098	564	565	543	543	1027	4870	695.7143
12:30 pm	781	657	745	723	765	765	387	4823	689.0000
1:00 pm	550	780	540	610	987	987	466	4920	702.8571
1:30 pm	450	1007	354	254	578	578	1196	4417	631.0000
2:00 pm	453	1117	835	951	5578	6543	306	15783	2254.7143
2:30 pm	254	442	231	543	654	567	557	3248	464.0000
3:00 pm	649	390	543	632	321	321	585	3441	491.5714
3:30 pm	4239	158	4326	4321	346	107	159	13656	1950.8571
4:00 pm	530	310	442	542	453	654	267	3198	456.8571
4:30 pm	218	208	234	334	108	543	366	2011	287.2857
5:00 pm	213	152	213	213	42	180	144	1157	165.2857
5:30 pm	150	58	143	78	54	175	88	746	106.5714
6:00 pm	47	34	64	15	12	24	72	268	38.2857

measured values of global solar radiation. This willhelp to know the daily and weekly average values of solar radiation in the environment within the month of September, 2015 and also provide good and accurate information of expected data of the City (Abakaliki) for designing and fabrication of any solar energy devices (photovoltaics) for practical or solar energy applications. Also GPS global positioning instrument No 13467763 was used in determining the elevation and position of the area where the measurement of global solar irradiation was taken.

PRESENTATIONS AND DISCUSSION OF RESULTS

Solar radiation was measured using a daystar solar meter. The results of the daily and weekly measurement of global solar radiation at Presco Campus of the Ebonyi state University Abakiliki, were recorded. The measurement was taken in 30 min interval from 6.00 am to 6.00 pm for the duration of four weeks in September 2015, starting from Monday to Sunday respectively in each week. The results are presented in Table 1 to 4 and the graphs of the results are also

Table 3: The third week of September 2015 (14th to 20th), solar radiation data (W/m^2) at Prescocampus of Ebonyi State University, Abakaliki

Time (mins)	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Total	Average
6:00 am	0	0	0	0	0	0	0	0	0
6:30 am	5	6	8	5	5	2	9	40	5.7143
7:00 am	46	52	27	52	78	13	82	350	50.0000
7:30 am	78	78	100	87	108	73	256	780	111.4286
8:00 am	98	63	95	177	258	94	240	1025	146.4286
8:30 am	146	75	102	215	386	211	214	1349	192.7143
9:00 am	194	310	185	532	586	462	447	2716	388.0000
9:30 am	198	298	142	207	667	546	396	2454	350.5714
10:00 am	348	486	141	280	839	684	241	3019	431.2857
10:30 am	415	1067	514	285	243	720	808	4052	578.8571
11:00 am	463	1070	395	441	744	957	903	4973	710.4286
11:30 am	428	442	184	919	241	303	330	2847	406.7143
12:00 pm	1021	1120	265	240	994	407	1097	5144	734.8571
12:30 pm	388	214	233	460	1025	344	231	2895	413.5714
1:00 pm	462	871	873	552	995	306	962	5021	717.2857
1:30 pm	1197	1008	904	925	942	960	857	6793	970.4286
2:00 pm	309	1152	907	287	849	955	961	5420	774.2857
2:30 pm	554	558	793	215	713	590	709	4132	590.2857
3:00 pm	583	530	755	219	716	572	598	3973	567.5714
3:30 pm	149	363	152	107	386	559	434	2150	307.1429
4:00 pm	263	162	643	335	278	412	358	2451	350.1429
4:30 pm	326	314	174	257	277	223	114	1685	240.7143
5:00 pm	141	121	57	147	188	125	116	895	127.8571
5.30 PM	87	72	40	132	156	112	99	698	99.7143
6.00 PM	70	63	34	117	139	98	87	608	86.8571

Table 4: The fourth week of September 2015 (21st to 27th), solar radiation data (W/m^2) at Prescocampus of Ebonyi State University, Abakaliki

Time (mins)	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Total	Average
6:00am	0	0	0	0	0	0	0	0	0
6:30am	8	7	9	5	6	9	11	55	7.8571
7:00am	83	38	63	13	68	83	71	419	59.8571
7:30am	257	128	75	64	127	215	129	995	142.1429
8:00am	240	268	52	30	262	185	263	1300	185.7143
8:30am	212	187	74	104	216	224	217	1234	176.2857
9:00am	445	567	216	255	201	260	202	2146	306.5714
9:30am	395	467	260	541	207	159	209	2238	319.7143
10:00am	241	373	346	821	256	345	257	2639	377.0000
10:30am	809	413	578	390	272	507	274	3243	463.2857
11:00am	902	463	367	317	362	630	361	3402	486.0000
11:30am	330	428	256	548	540	484	540	3126	446.5714
12:00pm	1097	1021	448	881	354	864	357	5022	717.4286
12:30pm	230	388	105	512	486	977	489	3187	455.2857
1:00pm	960	460	462	624	666	865	668	4705	672.1429
1:30pm	856	1197	1197	431	807	1025	808	6321	903.0000
2:00pm	960	306	309	270	800	985	801	4431	633.0000
2:30pm	708	554	554	225	782	843	784	4450	635.7143
3:00pm	595	584	583	197	634	328	632	3553	507.5714
3:30pm	432	342	149	132	542	292	544	2433	347.5714
4:00pm	348	265	263	120	314	193	354	1857	265.2857
4:30pm	114	324	321	152	105	213	115	1344	192.0000
5:00pm	106	141	141	96	67	125	68	744	106.2857
5.30pm	99	135	130	87	59	115	59	684	97.7143
6.00pm	86	124	127	73	45	98	45	598	85.4286

presented in Fig. 1 to 4. In addition, Fig. 5 is the bar graph of the weekly average of the solar radiation data for September 2015.

Hourly global irradiance: The variation of global irradiance in the study is influenced by atmospheric constituents such as aerosols and water vapour among other constituents (Iqbal, 1983). Also, cloud cover and rainfalls influenced the measured values of global solar radiation significantly. The peak value of the hourly average global insolation is 2.25 KW/m^2.

Daily global irradiance: On a clear partially sunny day, the daily average of global solar radiation is 627.44 W/m^2 while the daily average of irradiation on a cloudy day is 384.19 W/m^2.

Weekly global irradiance: On a weekly scale, the average irradiation obtained is 2.95 KW/m^2.

Monthly global irradiance: On a monthly scale, the global solar radiation obtained for the month of September, 2015 is 11.79 KW/m^2.

These results are simply added data because there were no availably data on measured values of global solar radiation which could be compared with the results obtained in this experiment. For example, Sanusi *et al*. (2005) evaluated some models for the prediction of global solar radiation in Sokoto environment, Nigeria. In addition, the prediction of global solar radiation with some climatological parameters has been reported (Aidan *et al*., 2005). In these developed models, there were no recorded values of global solar radiation.

These observations and records were taken in order to have accurate data of solar radiation information in the month of September 2015 and make the same information available for agriculturalists and any interested scholar for economic development. It was

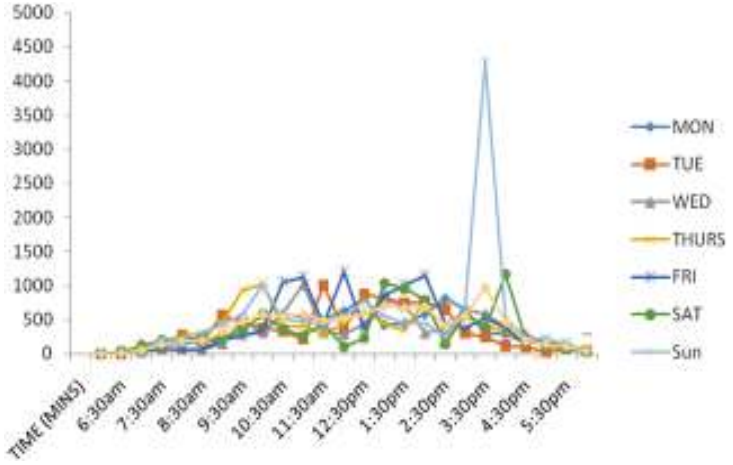

Fig. 1: Graph of the solar radiation (W/m^2) verses time (Min.) for the first week of September, 2015 (31st August to 6th September) at Prescocampus of Ebonyi State University, Abakaliki

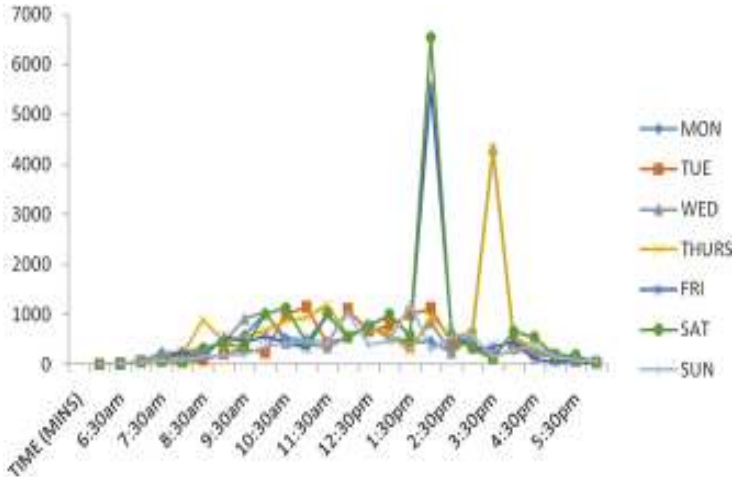

Fig. 2: Graph of the solar radiation (W/m^2) verses time (Min.) for the second week of September, 2015 (7th September to 13th September) at Prescocampus of Ebonyi State University, Abakaliki

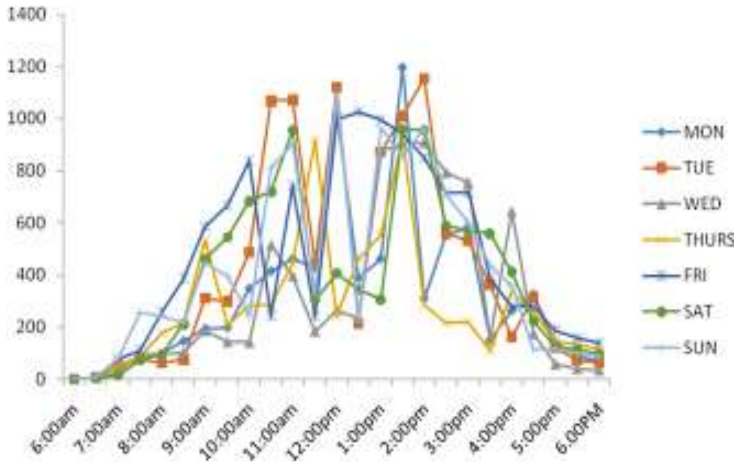

Fig. 3: Graph of the solar radiation (W/m^2) verses time (Min.) for the third week of September, 2015 (14^{th} Septemberto 20^{th} September) at Prescocampus of Ebonyi State University, Abakaliki

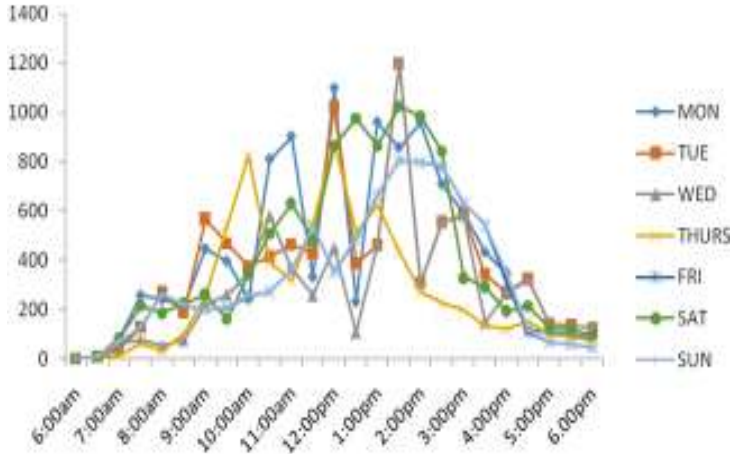

Fig. 4: Graph of the solar radiation (W/m^2) verses time (Min.) for the fourth week of September, 2015 (21^{st} September to 27^{th} September) at Prescocampus of Ebonyi State University, Abakaliki

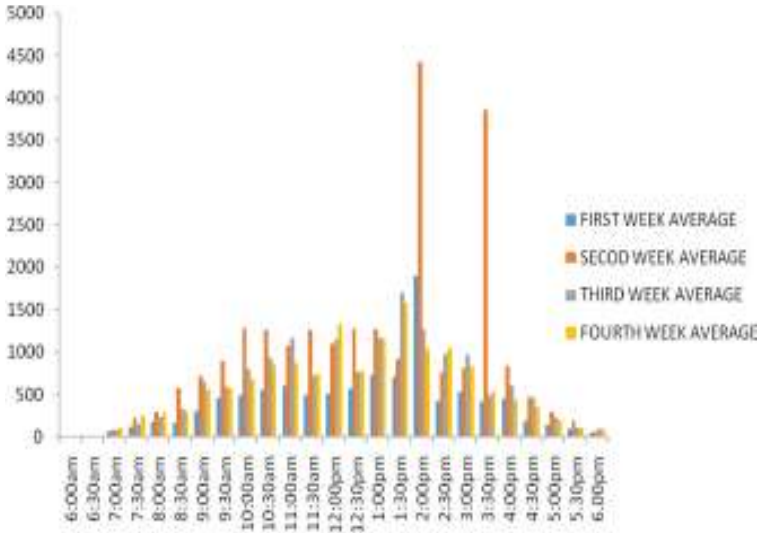

Fig. 5: Bar graph of the weekly average of solar radiation (W/m^2) verses time (Min.) for September, 2015 at Prescocampus of Ebonyi State University, Abakaliki

also carried out in order to assist any scholar estimate other meteorological parameters such as temperature, relative humidity etc. for Abakaliki town.

CONCLUSION

Global solar radiation for the Month of September 2015 has been successfully measured using daystarsolarmeter at Presco Campus of Ebonyi State University, Abakaliki-Nigeria. The highest total daily insolation for the month of September, 2015, was obtained in the second week of the Month, having a value of 15.78 KW/m^2. The average solar radiation for the month of September, 2015 is 11.79 KW/m^2.

This study was done in order to make the information available for agriculturalists and any interested scholar for economic development. It was also carried out in order to assist any scholar estimate other meteorological parameters such as temperature, relative humidity etc. for Abakaliki town and its environment.

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