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Scientific Journal of Mehmet Akif Ersoy University

Year: 2019 Volume: 2 Issue: 3

Editor
Prof. Dr. Afşin GÜNGÖR

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Indexes and Platforms

Our true mentor in life is science.

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Year: 2019 Volume: 2 Issue: 3

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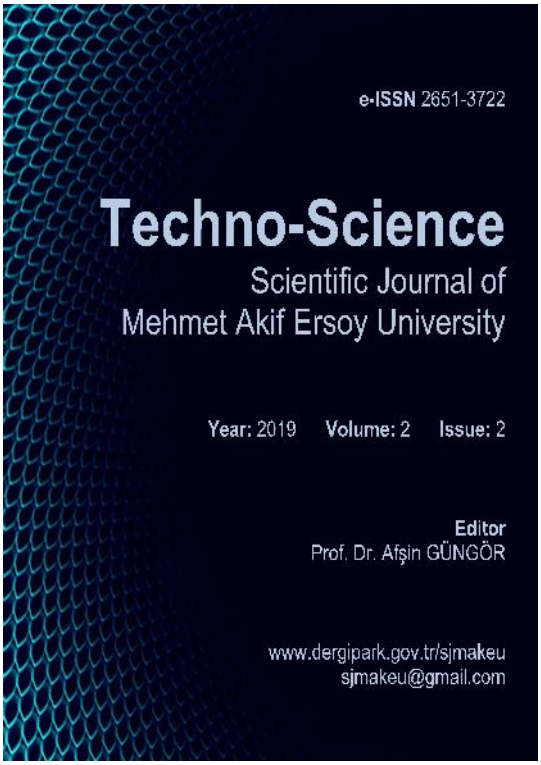
Preface to Second Volume, Third Issue



We are happy to introduce the second issue of the third volume of our journal. I thank everyone who contributed to this issue. See you in the next issue.

September 30, 2019
Prof. Dr. Afşin GÜNGÖR
Executive Manager and Editor
On behalf of the Editorial Board

Techno-Science

Scientific Journal of Mehmet Akif Ersoy University

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[5]. BS EN 14214:2012+A1:2014. *Liquid petroleum products - Fatty acid methyl esters (FAME) for use in diesel engines and heating applications - Requirements and test methods.* The British Standards Institution. London.

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Original Research Article

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Prediction of wind blowing durations of Eastern Turkey with machine learning for integration of renewable energy and organic farming-stock raising

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ABSTRACT

Applications which integrate wind energy and both agriculture and stock raising are increasingly becoming popular especially in Europe. Subject applications enable the land to be utilized in various favorable ways. In this study, by using a 5-year average wind data referring to Erzurum and Ardahan, two eastern cities of Turkey which are characterized by prevailingly an extensive cattle-raising, wind-blowing durations were calculated by Rayleigh distribution. Annual wind blowing durations for Erzurum and Ardahan ranged between 479.6-5825.7 hours and 1643.6-6710.8 hours, respectively. The data obtained was predicted via artificial neural networks and output results indicate an prediction accuracy at 99% level thereupon. The integration of agricultural and stock raising activities with wind energy shall contribute to environmental aspects as well increasing the efficiency and effectiveness in the region.

1. INTRODUCTION

Global energy needs are increasing rapidly in accordance with the increasing population. Due to depletion and their environmental damage, the fossil fuels used today to meet the energy needs are being replaced by renewable energy sources. Wind energy is a renewable energy source that is increasingly used in our country. Wind energy generation in a certain region depends on the performance characteristics and operating conditions of the wind on that specific region. It would not be possible to determine a stable model for the system where and if the wind velocity and the output power data have frequently variable characteristics. Hence, the amount of wind energy to be generated will be closely related to the wind velocity in that region. The energy which can be generated on a wind turbine depends on several parameters such as the wind velocity, the tower height of the wind turbine, the wing diameter, the density of the zone, and the wind-blowing duration.

Organic farming activities gained a worldwide momentum due to the fact that consumers in advanced countries have come to realize the damages caused by industrial processes to human health as well as environment. This type of production activity has spread rapidly all over the world and it has been observed that it was possible to yield a richer aroma in the products grown under organic farming conditions. Organic livestock activities have survived from the 1980s onwards. The main goal in this kind of activity is to restore the natural balance which tended to be lost in the ecosystem and to give weight to animal health, as well as human health [1]. Besides, industrial agriculture and stock raising generally require high energy consumption. This requirement brings about economic and environmental problems. In order to prevent these problems, the issue of agricultural and stock raising applications integrated with renewable energy have become an important research topic in recent years, particularly in European countries.

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Likewise its utilization in many other areas, artificial neural networks (ANN) have been used also for the determination of wind data such as wind velocity data and blowing duration of wind. By using statistical methods plus ANN, Kırbaş predicted the short-term multi-step wind velocity [2]. Using the wind velocity data for Akhisar region, Ata predicted the wind-blowing duration of that region with ANN [3]. Gnatowska and Moryn-Kucharczyk evaluated the wind energy perspective in Poland particularly in terms of wind power. He emphasizes the significance of state support in the production of wind energy in his study [4]. In an attempt to increase the estimation quality in wind energy studies, Yan and Ouyang suggested a new approach and verified their study in a real-world wind production facility [5]. In their study, which well summarized the characteristics of wind energy, Güngör and Eskin examined the deficiencies in previous studies, while also pointing out the possible future development areas in energy envisionings. [6]. In his study, Güngör investigated the effect of global warming on the potential of wind energy [7].

In this study, by using the wind velocity data at an altitude of 10 meters in Ardahan and Erzurum which was obtained from Turkish General Directorate of Meterological Affairs (GDMA) [8], wind blowing durations were calculated. Wind blowing durations obtained were predicted with ANN. The present study aims at integrating the renewable energy sources with agriculture and stock raising, and is intended to be served as an example for respective engineers, designers and planners in this regard.

2. AGRICULTURAL AND LIVESTOCK CHARACTERISTICS IN THE STUDIED REGION

The urbanization rate in Erzurum is below Turkey's average and rural employment in the city constitutes 62.3% of total employment. These socio-economic indicators suggest that stock raising is important for the provincial economy and will preserve this importance in the near future. Number of milked cattle in Erzurum constitutes 4.5% of the total milked cattle in Turkey, while its contribution to Turkey's total milk production amounts to 4.3% of the overall milk production in the country. The presence of sheep and goat in the province has demonstared a significant decline in recent years. As for 2017 data, there are 730.000 cattle and 714.000 sheep and goat in Erzurum [9,10].

Due to elevation features and air masses effective throughout the year, a harsh continental climate is dominating in Ardahan. Based on these parameters, the average temperature is below -10 °C in winter and is about 16-17 °C in summer period. According to the official data of the GDMA, the average annual temperature is 3.7 °C. The highest temperature in Ardahan is measured as 16.3 °C in July, whereas lowest temperature values are measured in January. In addition, due to its geographical location, the large mountain ranges in southwest-northeast direction are found to have an altitude about 2000-2200 meters whereas in volcanic masses it even reaches to 3000 meters and over. Due to the fact that the climatic conditions are convenient for agriculture, the proportion of land allocated to agriculture in the province is around 17%, 80% of which is assigned to grain products. In the remaining areas, the mostly cultivated product group is forage crops. Through some narrow areas in the vicinity of Posof and in Kurtkale basin which enable pomiculture, a variety of fruits are grown such as apples and walnuts [11].

Cattle raising is of particular importance in Ardahan and is mainly represented by beef raising. While there is more cattle in the central district and Göle with their larger grassland areas, in the villages of Posof basin the number is much fewer due to lack of pasture areas. Small livestock in the province is basically represented by sheep raising. It is mostly raised in the central district and Çıldır. Poultry farming, which is mainly forefronted by goose breeding, is a city-wide common activity. Other poultry includes chicken, turkey and duck [11].

Considering the agricultural and livestock activities and the potential in the region, it can be suggested that these activities can be increased through several governmental promotions and support. Rough and high mountainous areas in the region is one of the main factors restricting the effective use of region's available lands. Besides, agricultural and stock raising activities when supported by future wind power plants in the region shall contribute to the efficient use of the area.

3. DESIGN

There are varios methods available in the literature to determine the wind energy potential of a region, yet, the most commonly used ones are the Weibull and the Rayleigh distributions. In order to determine the duration and distribution of the wind in a region during a given period, in addition to the Weibull distribution, Rayleigh distribution is used by taking the shape parameter in the probability density function as two. Generally, the Rayleigh distribution is used when only the average velocity value is known for the region.

Rayleigh density function is shown as below;

$$f_R(v) = \frac{\pi}{2} * \frac{v}{v_{ort}^2} \exp(-\left(\frac{\pi}{4}\right) * \left(\frac{v}{v_{ort}}\right)^2 \quad (1)$$

Rayleigh cumulative distribution function is shown as below;

$$F_R(v) = 1 - \exp(-\frac{\pi}{4}(\frac{v}{c})^2) \quad (2)$$

where; c is parameter of scale (m/s). The biggest advantage of the Rayleigh distribution function is that it can determine the wind distribution of a given region depending only on the average velocity. The blowing velocity/hour can be calculated according to the Rayleigh distribution function with the help of Equation 3 [12].

$$h_r = f_R(v) * 8760 \quad (3)$$

The average annual wind velocity data for Ardahan and Erzurum at altitude of 10 m for the years 2014-2018 are given in Table 1 and 2, respectively [8]. Out of five-year histrorical data regarding Ardahan, the highest average wind velocity is featured in station no.3 (Çıldır) with 3.515 m/sec. The lowest average wind velocity featured in the same city belonged to station no.2 (Posof) with 0.951667 m/s. In Erzurum, while the station no.25 (Karaçoban) is observed as having the lowest wind velocity with 1.41 m/s, the highest value appeared in station no.12 (Yakutiye) with 4.180 m/s.

Table 1. *The average annual wind velocity data for Ardahan [m/s] [8]*

Measurement station	Province/region	2014	2015	2016	2017	2018
1	Ardahan	1.25	1.283333	1.025	1	0.991667
2	Posof	0.866667	0.883333	1.1	0.991667	0.916667
3	Çıldır	3.683333	3.383333	3.65	3.425	3.433333
4	Damal	2.466667	2.575	2.7	2.608333	2.516667
5	Göle	2.108333	2.141667	2.216667	2.083333	2.091667
6	Hanak	2.025	2.091667	2.116667	2.208333	2.05

Table 2. T*he average annual wind velocity data for Erzurum [m/s] [8]*

Measurement station	Province/region	2014	2015	2016	2017	2018
7	Erzurum	1.458333	1.391667	1.466667	1.341667	1.391667
8	Erzurum Airport	3.083333	2.783333	3.4	3.025	2.575
9	Uzundere	1.666667	1.791667	1.783333	1.8	1.883333
10	İspir	1.666667	1.716667	1.741667	1.641667	1.783333
11	Oltu	2.175	2.133333	2.058333	2.125	1.975
12	Yakutiye	4.857143	4.75	4.714286	3.166667	3.414286
13	Palandöken	4.033333	3.4125	3.366667	3.641667	3.77
14	Aziziye	4.011111	9.74	3.022222	2.755556	2.366667
15	Tortum	1.441667	1.491667	1.483333	1.541667	1.425
16	Horasan	1.141667	1.2	1.15	1.166667	1.233333
17	Aşkale (Kop Mountain)	3.375	3.7	4.036364	3.2	3.025
18	Hınıs	1.258333	1.35	1.4	1.308333	1.416667
19	Palandöken Ski Center	4.866667	3.4	3.95	3.85	4.033333
20	Pasinler	4.008333	3.916667	2.833333	2.375	2.266667
21	Narman	1.908333	1.85	1.925	1.958333	1.808333
22	Çat	3.358333	3.916667	2.683333	2.308333	2.291667
23	Karayazı	3.125	3.25	3.391667	3.175	3.175
24	Aşkale	1.35	1.525	2.275	2.183333	2.083333
25	Karaçoban	1.233333	1.183333	1.083333	1.025	1.358333
26	Köprüköy	2.375	2.291667	2.45	2.2	2.216667
27	Olur	2.008333	2	2.066667	2.1	2
28	Pazaryolu	2.641667	2.55	2.6	2.35	2.583333
29	Şenkaya	2.525	2.55	2.558333	2.633333	2.5
30	Tekman	2.633333	2.391667	2.641667	2.35	2.375
31	Çayırözü	2.428571	2.533333	2.166667	2.2	2.391667

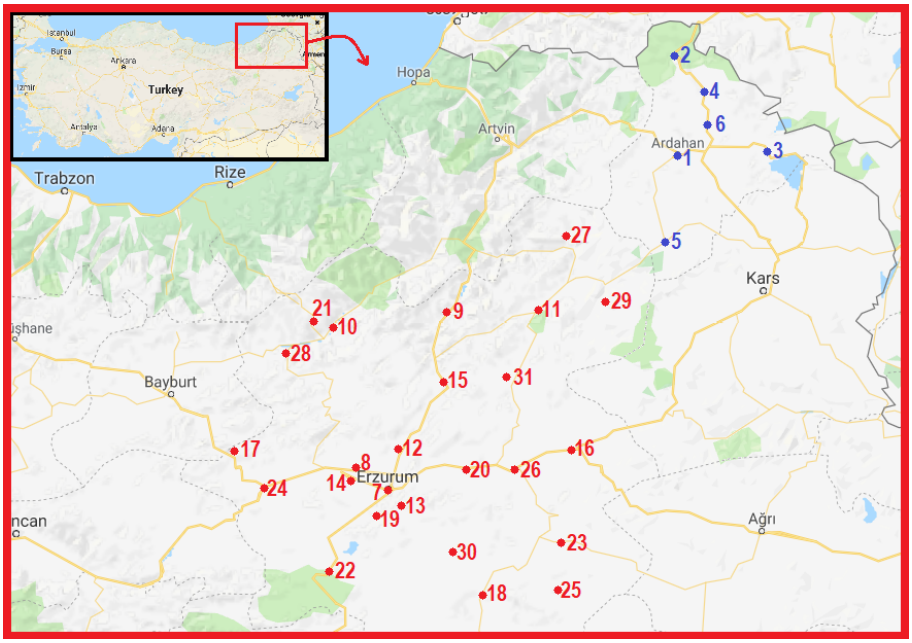

Fig. 1. *Locations of the measurement stations*

Fig.1 shows the locations of the measurement stations from which the data is collected. Blue and red colors demonstrate the stations in Ardahan and Erzurum, respectively. As can be followed clearly from the figure, the measurement stations cover a satisfactorily large area and can well generate comprehensive results about the regions under study.

4. SOLUTION METHOD

In this study, feedback propagation learning algorithm was used to determine the wind blowing duration. The study benefited from the artificial neural network toolbox which is available in MATLAB/Simulink software package. Normalization techniques were applied to input values in order to improve the performance results. The input and output data of the ANN which was obtained from the GDMA consist of 70% training cluster, 15% validation cluster and 15% test cluster, which amounted as 1249, 268 and 268 data figures, respectively. The performance analysis of the neural network was evaluated by the Mean Square Error (MSE) and the Regression curve. According to the test results, the best results for wind blowing duration prediction were obtained via 9 hidden layer architecture. Network was trained using the Levenberg-Marquardt optimization technique. Using input/output values, different network configurations are trained in order to produce minimum Mean Square Error (MSE) and maximum regression values. The ANN architecture designed for the study is given in Fig. 2.

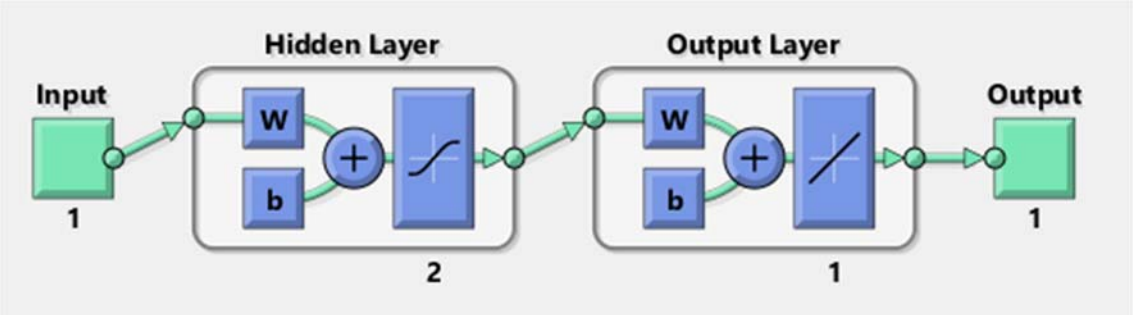

Fig. 2. *Developed ANN structure*

5. RESULTS AND DISCUSSION

The results indicate that, the station with the maximum wind duration in Ardahan is Posof, while the station with the least blowing duration is station no.3. Similarly, the maximum and minimum wind blowing duration in Erzurum belong to station no.25 and no.12, respectively. Maximum wind blowing durations occured in the areas which had minimum wind velocity; and, just in contrast, minimum wind blowing durations occured in the areas with maximum wind velocity. Table 3 and Table 4 depict the annual average values (in hours) of wind blowing durations produced via Equation 3. It can be observed that wind-blowing durations for the areas under study vary between 479.6-5825.7 hours and 1643.6-6710.8 hours per year for Erzurum and Ardahan, respectively.

Table 3. *Annual average values (in hours) of wind blowing durations of Ardahan (hrs/year)*

Measurement station	Province/region	2014	2015	2016	2017	2018
1	Ardahan	4733.203	4370.249	5756.821	5658.453	6041.088
2	Posof	6495.56	6710.821	5324.31	5846.948	6345.464
3	Çıldır	1646.835	1805.675	1643.636	1765.14	1755.765
4	Damal	2337.085	2343.559	2213.281	2297.478	2413.2
5	Göle	2763.522	2747.942	2693.202	2814.068	2909.252
6	Hanak	2840.275	2869.319	2810.844	2667.931	2917.438

Table 4. *Annual average values (in hours) of wind blowing durations of Erzurum (hrs/year)*

Measurement station	Province/region	2014	2015	2016	2017	2018
7	Erzurum	4145.23056	4165.447	4000.046	4268.346	4250.11
8	Erzurum Airport	1955.67937	2087.265	1765.158	1871.672	1260.116
9	Uzundere	3143.11204	2989.538	3070.985	2997.615	2973.711
10	İspir	3582.86985	3414.167	3440.17	3636.309	3379.16
11	Oltu	2811.79328	2887.914	2995.521	2871.655	3129.309
12	Yakutiye	743.355147	479.62	1181.252	1387.385	1200.451
13	Palandöken	1450.10758	1214.802	1841.948	1699.523	1338.103
14	Aziziye	1034.91279	120.0423	1604.926	2285.331	2373.665
15	Tortum	4244.62423	3961.477	4089.219	4035.151	4257.486
16	Horasan	5114.41945	4791.188	5119.905	4967.086	4946.985
17	Aşkale	1628.93456	1393.711	1407.308	1450.408	1999.496
18	Hınıs	4671.12966	4472.484	4294.659	4632.293	4299.778
19	Palandöken	1225.52058	154.1213	1562.849	1615.985	1523.813
20	Pasinler	1497.82276	1530.157	2064.185	2508.328	2658.609
21	Narman	3066.36423	3144.852	3124.87	3021.858	3351.015
22	Çat	1807.19975	1507.764	2172.554	2555.485	2652.498
23	Karayazı	1941.27699	1906.42	1804.562	1918.092	1918.092
24	Aşkale	4340.22092	3854.256	2625.005	2747.386	2900.057
25	Karaçoban	4716.85948	4982.754	5567.42	5825.745	4377.563
26	Köprüköy	2458.29597	2518.716	2428.775	2592.623	2717.93
27	Olur	2885.8709	3016.304	2879.499	2834.338	2985.84
28	Pazaryolu	2191.1886	2251.299	2221.07	2411.023	2326.168
29	Şenkaya	2313.407	2319.602	2362.507	2279.923	2444.502
30	Tekman	2228.62933	2451.254	2240.628	2441.056	2539.75
31	Çayırözü	1426.98881	1179.395	665.2048	2706.959	2514.132

Table 5. *Regression and MSE for different architecture.*

Hidden Layer	Regression			Validation MSE	Epoch
	Training	Validation	Test		
2	0.9894	0.9851	0.9820	0.011	800
3	0.8918	0.9315	0.8800	0.017	800
4	0.8874	0.9232	0.9366	0.016	800
5	0.9001	0.8879	0.9239	0.024	800
6	0.8943	0.9247	0.9097	0.018	800
7	0.8951	0.8869	0.9360	0.026	800
8	0.9001	0.8970	0.9156	0.025	800
9	0.9048	0.8721	0.9112	0.026	800
10	0.8951	0.8932	0.9042	0.028	800

A given regression result converging to 1 represents a close relationship between variables, while they are meant to have a weaker relationship when the regression result converges to 0. As shown in Fig. 3, the results of the network with 2 hidden layer have a regression value of approximately 1, which means that ANN successfully predicts the unknown data.

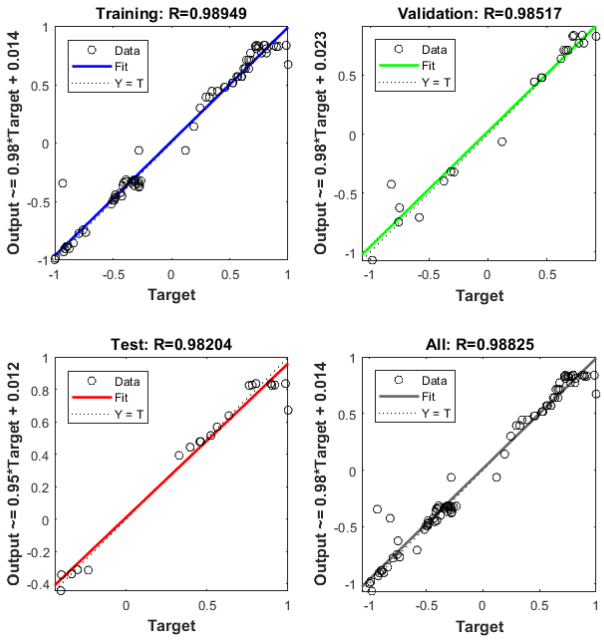

Fig. 3. *Regression results of ANN*

The output function obtained as a result of ANN modeling and prediction of the data is provided in Fig. 4, and error histogram and validation MSE obtained from the study are given in Fig. 5. As expected, maxiumum error values shown in Fig. 5 are noted to occur during the training of the network.

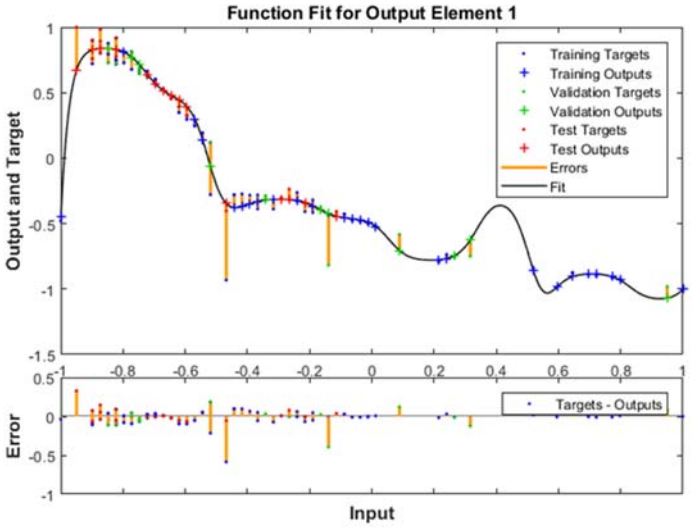

Fig. 4. *Simulation and Real Values of Data*

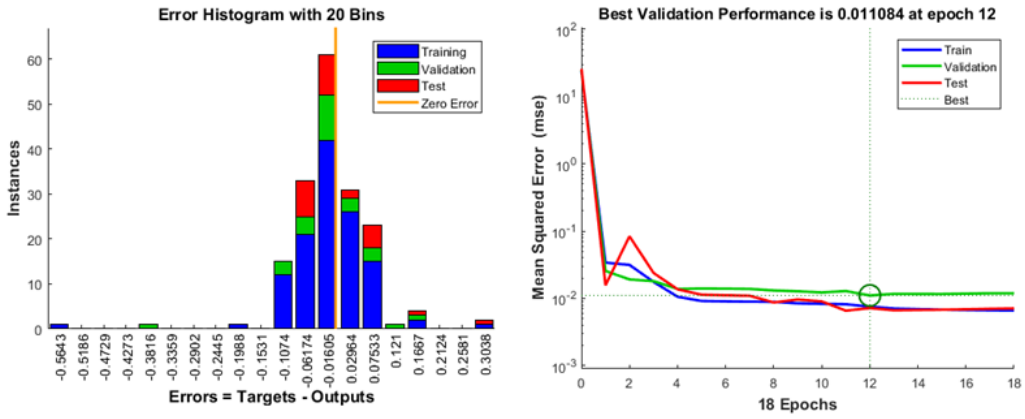

Fig. 5. *Error histogram of ANN modeling (left), Validation MSE values (right)*

6. CONCLUSIONS

As a renewable energy source, durableness of wind energy and pre-measurements for turbine installation are of great importance. The installation of the wind turbine at an optimal location is a parameter that directly affects the amount of electrical energy to be obtained. In this study, wind blowing durations in Erzurum and Ardahan, two eastern cities in Turkey, where cattle raising and agriculture activities are carried out, were determined with Rayleigh distribution and the results were predicted by artificial neural networks which is one of the techniques of machine learning. Prediction results performed a 99% accuracy. The current study showed that agriculture and stock raising activities would be carried out in integration with wind energy, especially for the locations with long wind blowing durations. Considering the high performance rates as for the prediction of artificial neural networks, this method is promising in predicting several other parameters regarding wind energy.

As far as the regions under study is concerned, it is possible to assert that these regions can be improved in terms of energy as well as agriculture and stock raising. Integrating agriculture and stock raising activities with wind energy, which is a sort of renewable energy, would yield to increase the efficiency and effectiveness and make favorable contributions to environment.

REFERENCES

[1]. Yussefi, M., Willer, H. (2003). The World of Organic Agriculture Statistics and Future Prospects Annual Report, p. 3-16.
[2]. Kırbaş İ. (2018). Short-term multi-step wind speed prediction using statistical methods and artificial neural networks. Sakarya University Journal Of Science, vol. 22, no. 1, p. 24-38, DOI: 10.16984/saufenbilder.305224. (in Turkish)
[3]. Ata R. (2014). Neural Predictıon of Wind Blowing Durations Based on Average Wind Speeds for Akhisar Location, Pamukkale University Journal of Engineering Sciences, vol. 20, no. 5, p. 162-165, DOI: 10.5505/pajes.2014.85047. (in Turkish)
[4]. Gnatowska, R., Moryn-Kucharczyk, E. (2019), Current status of wind energy policy in Poland. Renewable Energy, vol. 135, p. 232-237, DOI: https://doi.org/10.1016/j.renene.2018.12.015.
[5]. Yan, J., Ouyang, T. (2019). Advanced wind power prediction based on data-driven error correction. Energy Conversion and Management, vol. 180, p. 302–311, DOI: https://doi.org/10.1016/j.enconman.2018.10.108.
[6]. Güngör A., Eskin N. (2008). The Characteristics That Define Wind as an Energy Source. Energy Sources, Part A: Recovery, Utilization, vol. 30, p. 842-855, DOI: https://doi.org/10.1080/15567030601082415.
[7]. Güngör A. (2015). Effects of global warming on wind energy potential, World Journal of Engineering, vol. 12, p. 369-374, DOI: https://doi.org/10.1260/1708-5284.12.4.369.
[8]. Turkish General Directorate of Meterological Affairs, Official letter no. 8059, 17.07.2019.
[9]. Koçyiğit, R., Aydın, R., Diler, A. (2015). Situation of the Cattle Production in Erzurum Province and Some Suggestions for Its Improvement. Alınteri Journal of Agriculture Science, vol. 29, no. 2, p. 34-46. (in Turkish)
[10]. Uçum, İ., Gülçubuk, B. (2018). Local Industrial Enterprises Based on Livestock Production and Problems in the Process of Contribution to the Local Economy. KSU J. Agric Nat, vol. 21(Special Issue), p. 44-54, DOI: 10.18016/ ksutarimdoga.v21i41625.472849. (in Turkish)
[11]. Aygün, G., Akbulak, C. (2017). Evaluation of the Organic Livestock Potential of Ardahan Province. Dumlupınar University Journal of Social Sciences, vol. 53, p. 144-161. (in Turkish)
[12]. Akpınar K.E., Balpetek N., (2018). Statistical analysis of wind energy potential of Elazığ province according to Weibull and Rayleigh distributions, Journal of the Faculty of Engineering and Architecture of Gazi University, vol. 18, no. 1, https://doi.or./10.17341/gazimmfd.416517. (in Turkish)

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Design and analysis of solar air heating system for room

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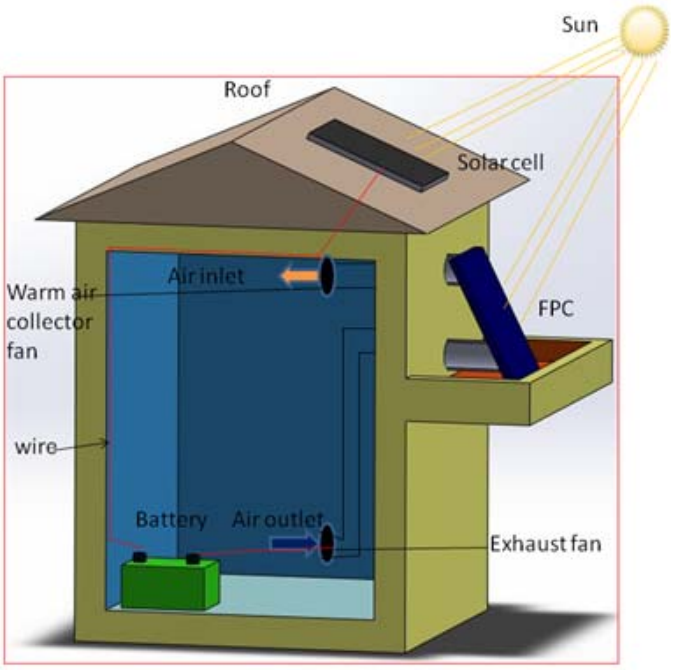
HIGHLIGHTS

- Solar air heating system is designed to warm the room especially for cold climatic regions.
- Design low cost solar air heating system which would be easy to run.
- Maintenance free solar air heating system will be installed in the room which may run for many years.
- Solar air heating system takes energy from sun, which can reduce monthly home energy bills.
- Use of double glazing and insulation materials increases the efficiency of FPC.

GRAPHICAL ABSTRACT



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ABSTRACT

Humankind faces enormous challenges relating to energy supply and ecological safety. Heating system is an essential part of homes in colder area, which needs a lot of energy. In this work a solar air heating system is designed by using easily accessible materials to heat the room. The adoption of low cost materials and easy design represents the novelties of the proposed system as compare to the other commercial collectors. This eco-friendly solar air heating system consists of flat plate collector (FPC), battery, solar cell and fans. FPC consists of transparent glass, absorbing plate, insulating material and fluid (air). In this experiment flat plate collectors are used inclined vertically at the angle of 45 near to the wall of the room which gives attractive results. The results were obtained from south face located room. The time of solar heating is about 7-8 hours on the daily bases and an average temperature difference obtained was about 12 as compared with the same dimension reference room. Experimental results conclude that this solar air heating system is able to heat the room in cold seasons. Hence the system making very important contribution for the saving of fossil fuels and diminution of carbon release on worldwide scale.

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1. INTRODUCTION

Nowadays, heating is the most important issue facing by the population in cold areas. Due to increase in scientific advances, in population, in the sustainability of the built environment, and also due to the improved standard of living, demand of energy is increasing day by day and energy saving is becoming a major issue [1].To face the current threads in the world e.g. change in atmosphere, declining of fossil fuel sources, high cost of electricity and the incessant acceleration in the energy demand use of renewable energy and other energy sources are most sustainable ways. The renewable energy is most advantageous in hot and moderate parts of the world where the sun impose enormous quantities of energy on the surrounding which warms our homes and also reduce the use of fossil fuels [2]. Most inexpensive form of energy is solar energy which is accessible in developing countries located on both sides of equator and been looked as a source of infinite energy [3]. Solar radiations of little function will receive on the surface of earth due to reflection, absorption and scattering of the environment. For energy demand solar power is adequate in human society. The power that is intercepted by the earth is approximately 1.8×10^{11} MW, which is several times larger than the energy expenditure of current rate [4]. In many countries house zone utilization of energy is almost 30 -40% of the total energy expenditure. One fifth of the universe total vestige energy generation consumed by household cooling and heating individually, which means that our residence faces many ecological troubles like greenhouse emission. As a result we give a high ecological rate for our future. By examining more deeply building heating demand is about 60% of the total energy. Water heating or room heating is clarified for over 75 percent of energy use in individual or multifamily houses. More exclusively, in Europe the expenditure of energy in buildings is about 37%, and in United States energy expenditure of buildings is about 41% and for China 28% [5]. A large proportion of house zone is dependable on energy expenditure and greenhouse gas emissions. Therefore, an escalating number of managements have taken political actions to get better energy competence and to moderate carbon dioxide in houses. These trials mostly taken to encourage the innovative new energy devices to meet the hose zone energy demands more sustainably and also low in cost. Ventilating, air conditioning and heating systems are some major parts of energy expenditure and energy consumers in buildings. In effect, buildings total heat expenditure differs between 16% and 50% depending on buildings volume and environmental circumstances. These three systems are climate controls of the interior of house which adjust and control the temperature and humidity to provide thermal comfort and air quality inside the house. Solar air heating systems stores and collects the heat from sun, and maintains the heat within the house [6].

Solar collector is a device used to exchange the heat between the outlying sources. Radiations coming from the sun strike the collector absorber plate and then absorber plate collects the heat and transferred this collected heat towards the fluid [7]. There are two types of solar collectors. First one is concentrating and second one is non-concentrating solar collectors. There are further two types of non- concentrating solar collector, evacuated tube solar collector and FPC. The most common and most ancient type of collector is FPC. Hottel and his co-workers first time worked on FPC in 1942 and in 1958, respectively. They manufactured a FPC which consists of absorber plate, glazing, fluid (air or water), and insulating material. To enhance the efficiency of FPC, Tabor prepared choosy black surfaces in 1955 and after that many researches have been done to improve the thermal performance of the FPCs. FPCs catch the heat from the sun and this trapping heat can be used for many applications e.g. to heat the water, for house heating and also for many other industrialized applications. FPC performance can be drastically resolute by a resourceful photo thermal alteration of sun radiations into the thermal heat of the absorber plate of the collector. Due to this reason sun rays of wavelengths three hundred nanometer to twenty five hundred nanometers should be engrossed as far as feasible. For standard and low down applications of heating FPCs are very well-liked [8].

Many devices can be used to convert solar energy into thermal energy like solar thermal collectors, solar plates, solar photovoltaic/thermal (PV/T) collectors, Peltier modules, etc. These devices can be fitted near to the buildings or on to the buildings or sometimes can be incorporated into the building rudiments for example on roofs or on front walls of the buildings [9]. In summer months of the year, extra solar thermal energy can create heating stacks in residences and in other buildings and it is necessary to be eliminated by air conditioning but in winter seasons buildings required heating devices to maintain the thermal comfort inside the buildings [10]. In 2010, FPC was manufactured by Wazed and his co-workers and analyzed its working. They examined that flat plate solar air heater was working very well. They experimentally proved that flat plate solar air heater increased the room temperature about 45.5°C and the difference between this and ambient temperature was 12.25°C [11]. Another flat plate solar air heater was introduced by Chaichan and his co-workers they examined its performance in cold time of the year. They experimentally found that aluminum plate hotness raised about 142.45% as compared to the temperature of air stream. With the absorption of solar radiations the temperature of aluminum plate was 51°C and the ambient temperature was about 40°C [12]. A new installation of solar collectors has been installed by Motte et al., in 2013 which was unseen from the ground. It could be set up on new and old buildings. They calculated on the spot efficiency of collector according to the reduced high temperature and showed that the performance of these types of collectors were similar to the old type [13]. Vestlund and his co- workers commence a fascinating study concerning to the enhancement of the performance of FPC. They replace air with any other inert gas between the absorber plate and transparent cover. The benefit of using the gas in between the glass cover and absorber plate is reduced in the transfer rate of heat and also in moisture condensate. Other gases can also be used but inert gases

are more striking and demonstrate better performance. For example CO_2 is an inexpensive gas and can be used in trim collectors but their performance was not so good. But the disadvantage of using the inert gases instead of air in the design will be more complicated [14].

Lot of papers have been written for building heating in the very last few decades and many type of solar air heating systems exists. Here, solar flat plate collector is designed for room heating. The present study is aimed to analyze the most important contributions of FPC to investigate the heat transfer enhancement techniques for room heating. At present time, there is no well-known record of intended FPC which acts as air heating system to heat the room. The design model is easy to process low cost and control system for temperature maintaining. Therefore, the primary inspiration in this research is to formulate a first foray into this territory.

2. EXPEREMENTAL WORK

The solar air heating system was designed by using easily accessible materials in the market during the year of 2019. The designed solar air heating system is very easy to construct to heat the room. The solar air heating system consists of FPC, battery, solar cell, warm air collecting fan, exhaust fan and thermometers. Figure 1 shows the block diagram of the system.

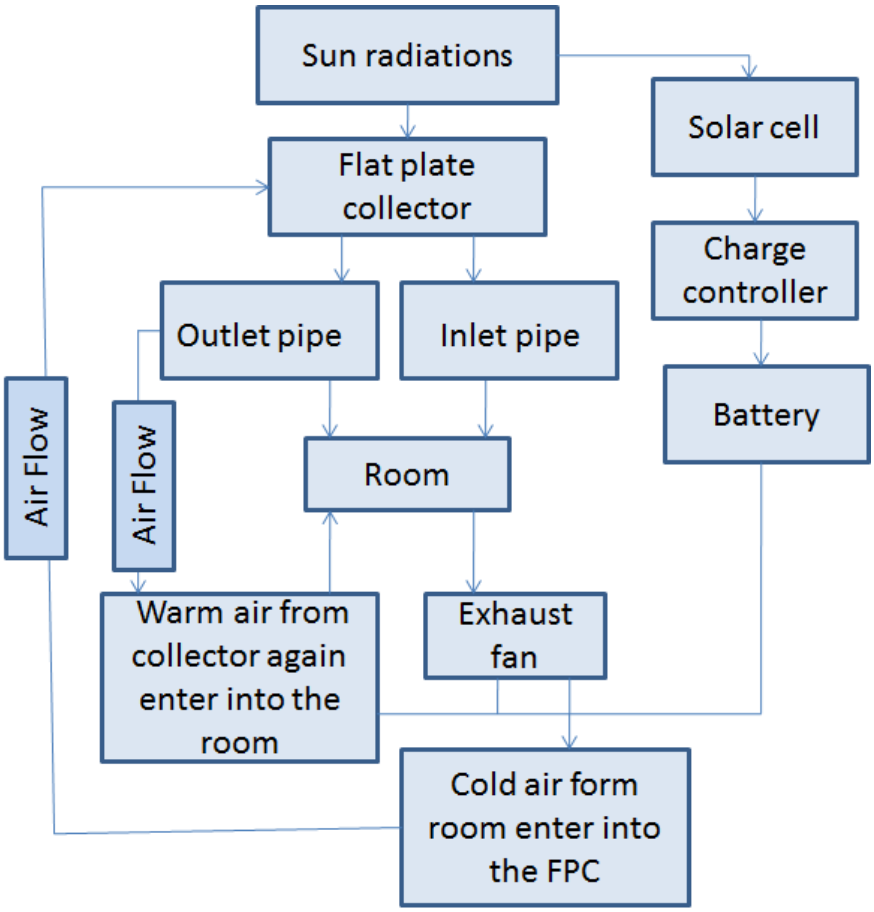

Fig.1. *Block diagram of solar air heating system*

The system is designed in such a way that the sun radiations can easily trap and increase the temperature of air. The room used for heating purpose was south faced with dimensions of 1000 ft^3 (10ft x10ftx 10ft) named as system room. Another same dimension room was considered as reference room. To compare the temperature of both system and reference room, two set of experimental data was obtained. Figure 2 shows the schematic diagram of the system.

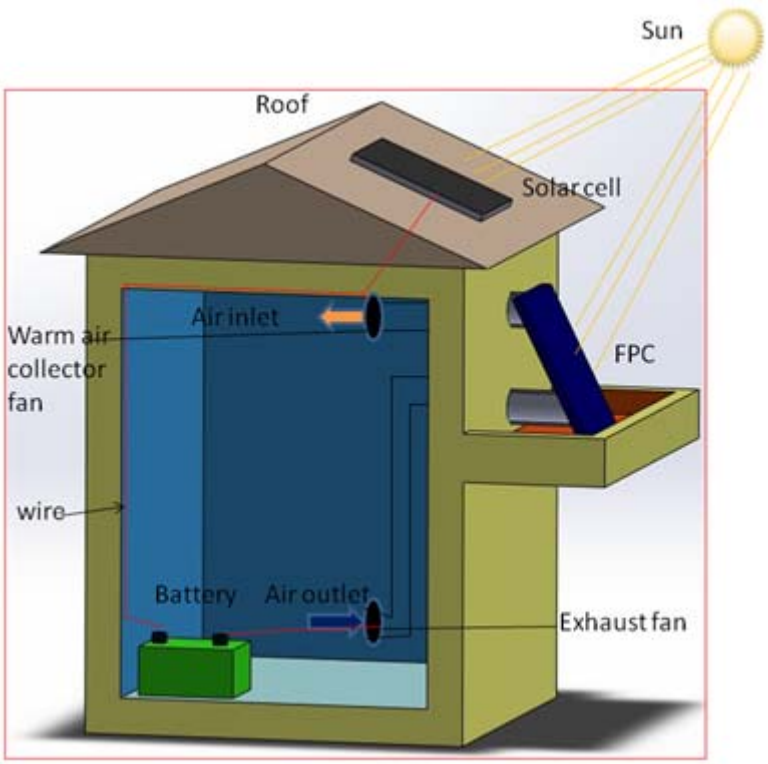

Fig.2. *Schematic diagram of solar air heating system*

2.1. Manufacturing of FPC

FPC gathers the sun's energy, transforms its radiations into heat and subsequently transfers into fluid. To increase the temperature of the room two FPCs were made, which consist of glazing, absorbing plate, fluid (air), and insulating materials. The absorbing plate of collector was painted with a wavelength selective black color which increases the absorption of sun radiation spectrum of ultra-violet and at the same time it decreases heat losses in the infrared spectrum. Absorbing plate has two headers and five risers. Styrofoam was also fixed behind the absorber to control heat losing and then sealed the glass (glazing) by silicone and metal screws. The glazing allowed the radiations to transmit from it and enters in the collector. As compare to plastic, low-cost glass is preferred to cover the material because it has low transmittance to infrared radiation and stability and high transmittance to visible light. To avoid heat losses due to convection and conduction double glazing was used in the experiment. By controlling these heat losses, fluid can absorb more thermal energy which increases the efficiency of FPC. Wood, saw dust and foam was used as insulating materials in FPC. Flat plate collector was mounted on the terrace of the system room. Parameters of FPC are given in table 1.

Table 1. *Parameters of flat plate collector*

Length of FPC	45.5 inches
Width of FPC	26.5 inches
Diameter of header	1.25 inches
Diameter of riser	0.75 inches
Distance between Plates	9 inches
Distance between inlet and exhaust	10.2 inches
Distance between outlet and exhaust	48 inches
Number of headers	2
Number of riser	5
Distance between two riser	5 inches
Distance between header	48 inches
Distance between edge and riser	2 inches
Distance between edge and header	2.5 inches

Later on the connection of both collectors were connected with each other and then placed on the stand. Stand is placed at an appropriate angle with floor as shown in Fig.3.

Fig.3.*Experimental setup of FPC*

2.2. Air Circulation System

For proper warm air circulation, inlet and outlet pipes from FPC are entered inside the system room. Inlet of the room is the outlet of FPC and outlet of the room is the inlet of FPC and vice versa. An exhaust fan was installed on inlet pipe of FPC which takes the air from the room. This air is then passed through FPC and the heated air is entered back to the room through the outlet pipe as shown in the Fig.4.

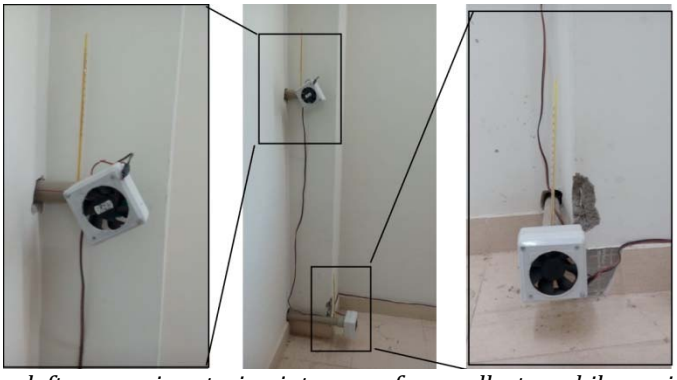

Fig.4. *Heating system in room, on left warm air entering into room from collector while on right cold air exhausts from room entering into collector.*

Solar panel has been used in the system to run the fans. Solar panel absorbs the energy from sun and converts this energy into electrical energy. Solar plate was mounted on the roof of the system room. A charge controller was used to control the overcharging of battery. Five thermometers were used in this experiment, first one is placed at inlet pipe, 2nd one is at out let pipe, 3rd one is placed in system room, 4thone is placed in reference room and last one is used to measure the ambient temperature.

3. RESULTS AND DISCUSSION

This study shows the results at different times of solar air heating system and also shows the comparison between the same dimensions reference room with system room. The graphs show the temperature variations after every 30 minutes

of exhaust fan, warm air collector fan, system room, reference room, and ambient air during daylight for the months of March, April and May 2019 as shown in Fig. 5, Fig.6 and Fig.7 respectively. The data was taken between 8:00 am to 6:00 pm. In the start of the day about 8:00am there was minor difference (about 1-2°C) between system room temperature and reference room temperature. The temperature values of air inside the FPC gradually increases from 8:30am till 2:00pm and remains constant at about 3:00pm and then decrease slowly. It is mainly due to the blowing of air of the atmosphere. At about 6:00pm temperature remains almost same as of the temperature of the start of the day. In sunshine hours the variations in temperature is due to the incessant in sun radiations during the morning until it attains its peak values at midday and after this starts to decline till the end of the day. The graphs clearly indicate that the temperature difference between system room and reference room was about 12°C which show the system performance. Warm air maximum temperature (at about 2:00pm) of FPC reaches to 50°C, 52°C and 59°C in clear (sunny) days in the months of March, April and May respectively. In FPC, plate absorbs the sun radiations and then transfers this energy in to the working fluid (air).Thus the temperature of working fluid (air) in FPC is directly proportional to the incident sun radiations. The temperature variations in the cloudy or rainy days are expected due to the existence of dust accumulation and shadows of the clouds. However the rainfall and cloudy day rate of Quetta is very low.

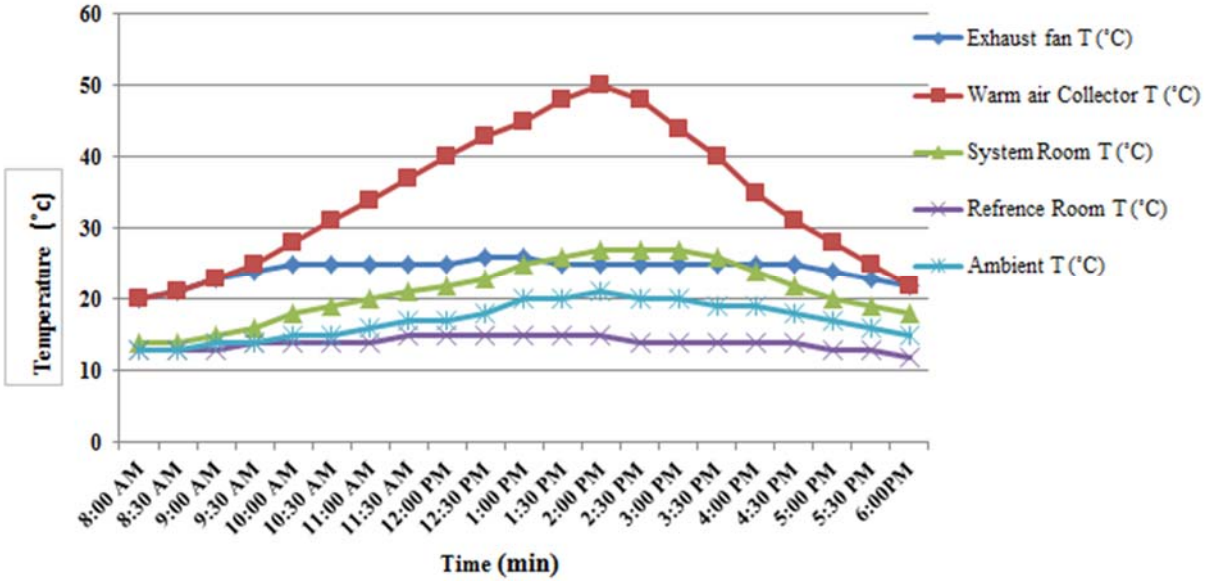

Fig.5. *Results for the month of March*

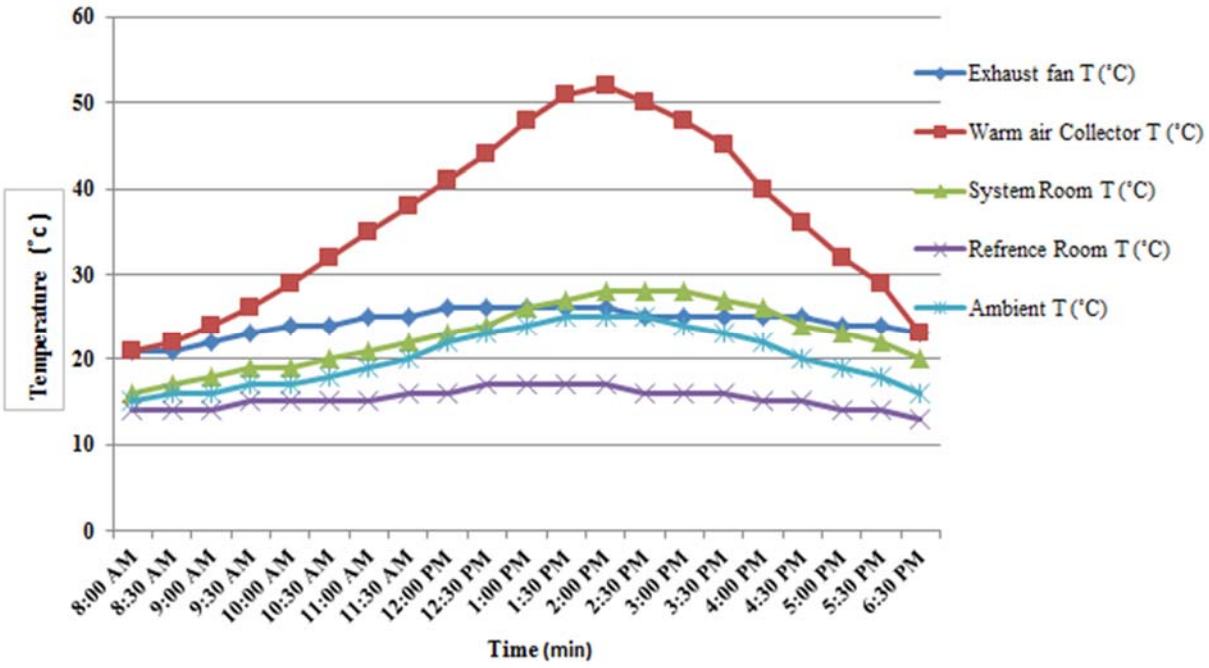

Fig.6.*Results for the month of the April*

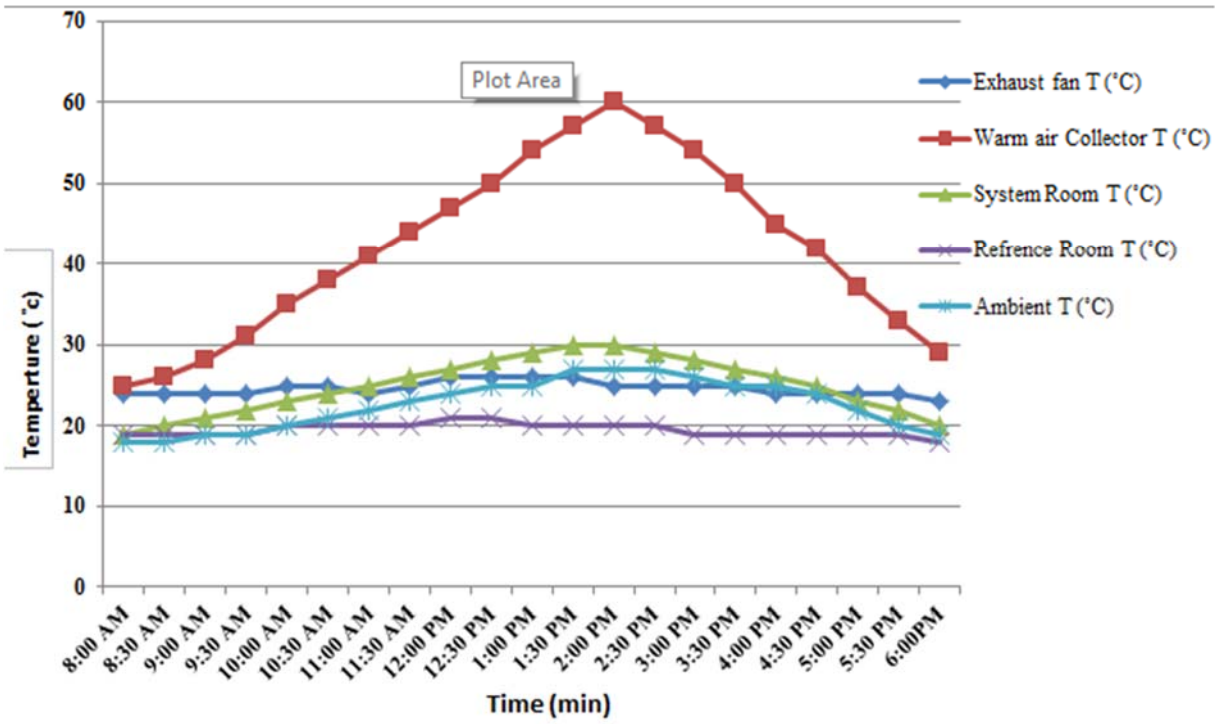

Fig.7. *Results for the month of May*

4. CONCLUSIONS

Theoretical and experimental studies were performed to assess the thermal performance of solar air heating system to heat the room by featuring the perforating absorbing flat plate collector under the weather conditions of Quetta. This experiment results clearly shows that for heating purpose of room the use of this type of collector is possible in winter conditions. The variations in the temperatures of system room and reference room was about 12°C and the fluid inside the FPC reaches the maximum value of about 59°C which shows its good performance. Moreover, the FPC is capable to meet our heating demands during cold months. The benefits of using FPC are that it is cost effective and easy to install near to the wall of the rooms.

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REFERENCES

[1]. Streimikiene, D., & Kasperowicz, R. (2016). Review of economic growth and energy consumption: A panel cointegration analysis for EU countries. *Renewable and Sustainable Energy Reviews*, *59*, 1545-1549.
[2]. Hegazy, A. A. (2000). Comparative study of the performances of four photovoltaic/thermal solar air collectors. *Energy Conversion and management*, *41*(8), 861-881.
[3]. Khan, Y., Kasi, J. K., & Kasi, A. K. (2019). Dehydration of vegetables by using indirect solar dryer. *Scientific Journal of Mehmet Akif Ersoy University*, *1*(1), 22-28.
[4]. Parida, B., Iniyan, S., & Goic, R. (2011). A review of solar photovoltaic technologies. *Renewable and sustainable energy reviews*, *15*(3), 1625-1636..
[5]. Spandagos, C., & Ng, T. L. (2017). Equivalent full-load hours for assessing climate change impact on building cooling and heating energy consumption in large Asian cities. *Applied energy*, *189*, 352-368.
[6]. Chan, H. Y., Riffat, S. B., & Zhu, J. (2010). Review of passive solar heating and cooling technologies. *Renewable and Sustainable Energy Reviews*, *14*(2), 781-789.
[7]. Ullah, S., & Kasi, J. K. Fabrication of Low Cost Solar Flat Plate Collector. *Scientific Journal of Mehmet Akif Ersoy University*, *2*(2), 27-31.
[8]. Pandey, K. M., & Chaurasiya, R. (2017). A review on analysis and development of solar flat plate collector. *Renewable and Sustainable Energy Reviews*, *67*, 641-650.
[9]. Visa, I., Moldovan, M., & Duta, A. (2019). Novel triangle flat plate solar thermal collector for facades integration. *Renewable Energy*, *143*, 252-262.

[10]. Adavbiele, A. S., & Aasa, S. A. (2012). Integrated flat plate solar thermoelectric system. *European Journal of Scientific Research*, *76*(2), 253-270.
[11]. Chen, Q. F., Yuan, Z. X., Guo, Z. Q., & Zhao, Y. (2019). Practical performance of a small PTC solar heating system in winter. *Solar Energy*, *179*, 119-127.
[12]. Chaichan, M. T., Abass, K. I., Al-Zubidi, D. S., & Kazem, H. A. (2016). Practical investigation of effectiveness of direct solar-powered air heater. *International Journal of Advanced Engineering, Management and Science*, *2*(7).
[13]. Motte, F., Notton, G., Cristofari, C., & Canaletti, J. L. (2013). A building integrated solar collector: Performances characterization and first stage of numerical calculation. *Renewable energy*, *49*, 1-5.Vestlund, J., Rönnelid, M., & Dalenbäck, J. O. (2009). Thermal performance of gas-filled flat plate solar collectors. *Solar Energy*, *83*(6), 896-904.
[14]. Vestlund, J., Rönnelid, M., & Dalenbäck, J. O. (2009). Thermal performance of gas-filled flat plate solar collectors. *Solar Energy*, *83*(6), 896-904.

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Review Article

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Fixing pollution: Women's role in the developing countries

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ABSTRACT

Pollution is a challenge globally. This is part of what the 17 Sustainable Development Goals set by the UN are meant to tackle. Good Health and Well-being, Clean Water and Sanitation, Affordable and Clean Energy, Sustainable Cities and Communities, Climate Action, Life Below Water, and Life on Land (Goals 3, 6, 7, 11, 13, 14, and 15 respectively) are greatly affected by environmental pollution. To achieve these targets, men, women, and children are needed as stakeholders. For the purpose of this paper, the roles women should play in developing countries are discussed. Although women have actively involved in pollution reduction or elimination in developing countries, their roles have been limited due to several factors. In this paper the questions: What is the specificity of women in environmental pollution? In what sense does it bring solutions to environmental pollution? To achieve this, the objectives of the present review are to systematize and explore in-depth the causes of pollution in developing countries and the roles to be played by women in solving or reducing the environmental problems.

1. INTRODUCTION

Pollution is a challenge for the developing countries. The World Bank Group (2018) gave the report that about 9 (16%) million premature deaths in 2015 of all deaths worldwide were caused by air, land, and water pollution. Of this, about 92% of all pollution-related mortality is in developing countries. The air pollution alone costs the global economy US$5.7 trillion—4.4 percent of global GDP (The World Bank Group, 2018). To partake in this menace, The World Bank has been providing the technical assistance needed for countries affected by pollution problem by providing technical assistance through raising awareness about the detrimental impact on global health, facilitating knowledge generation and sharing, and pollution management. The Pollution Management and Environmental Health (PMEH) program of the World Bank intends to end poverty, improve global health, and boosting shared prosperity by reducing pollution.

There is no gainsaying that environmental problem such as ozone depletion, destruction of biological resources and of forests, the impact of desertification, dumping of hazardous wastes, and climate change have given the awareness that the environment is in danger. Peoples and governments throughout the world over have taken bold steps to reduce or eliminate this problem (Wuyep et al., 2014). For these efforts to be effective, it is paramount to involve women who are part of the contributors to the environmental pollutions to contribute their roles in this herculean task.

Past years in developing countries, especially in Africa, women were relegated to the background. They play the second fiddle to men. It was believed that their roles were in the kitchen. Recently, there was increased attention to the roles they play as homebuilders, economic providers and their role in reproduction in the communities and different countries of the world (Chelala, 2011). Their roles have surpassed these, they are now needed in the solving or reduction of environmental problems. Women's involvement in the formulation, planning, and execution of environmental policies is slow, despite the increase in national and international recognition that without their full participation, there may not be a possibility of progressing consistently and constantly in environmental sustainability.

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Women are more prone to sickness, disease or death from agro-chemicals poisoning than their male counterparts because of their involvements in agriculture. The direct contact of women to environmental hazards makes them more susceptible to abortion and foetal damage (Adesoji, 2001). As the overseer of the homes, they are more prone to health problems due to poor sanitation, air and water-related diseases which may be transferred to children and husbands (Egaga and Aderibigbe, 2015).

According to The Global Development Research Center (GDRC) (2018), policymakers and governments began to create the awareness as far back as the '80 of the relationship between the environment and gender issues and pronounced changes began to happen with regards to natural resource and environmental issues. Women play an essential role in the management of natural resources, including soil, water, forests and energy... and often have a profound traditional and contemporary knowledge of the natural world around them (Tesfamichael, 2015). In the developing countries, women are victims of the environmental pollution, they form 50% of the population. This made them be an important human resource to combat environmental pollution (Devi, 1994).

The Millennium Development Goals (MDGs), with its measurable targets, ended in 2015. It was observed that much was not achieved, especially in the poor countries (MGDFund, 2018). On this note, the 17 Sustainable Development Goals (SDGs) was built on the eight MDGs, which are supposed to eradicate extreme poverty and hunger; achieve universal primary education; promote gender equality and empower women; reduce child mortality; improve maternal health; combat HIV/AIDS, malaria and other diseases; ensure environmental sustainability; and to develop a global partnership for development (United Nations, 2018). To achieve the Sustainable Development Agenda by 2030 women should be mobilized.

What is the specificity of women in environmental pollution? In what sense does it bring solutions to environmental pollution? The main objective of the present review is to systematize and explore in-depth the causes of pollution in developing countries and the roles to be played by women in solving or reducing the environmental problems.

1.1. What is pollution?

This term is the contamination (unconcerned and uncontrolled) of limited environmental resources present for the safe survival of animals and humans. Its detrimental effects on lives and the planet may not be completely reversible. In a nutshell, it can be termed as contamination of the natural environment with pollutants hazardous to human and animal health (Abulude et al., 2017a). There should be an urgent attention to curtail and minimize it for a better healthy living and to prevent endangering lives within the environment. In all countries of the world, pollution is on the increase due to rise in human activities from their involvement in technology and increased population. The contributions of non-anthropogenic and anthropogenic activities are the factors to never-ending pollution of all sorts.

2. TYPES OF POLLUTION

Globally, pollution is a significant problem facing the environment. Day by day out, the more the world's population the more the increase in potentially toxic substances that are released into the ecosystem (Lake, 2017). Different types of pollutants come from a number of sources. The knowledge of the different types of pollution and sources can assist in the understanding of the potential effect of these pollutants on the health of man and animals, and that of the planet (Lake, 2017).

The sources of pollution are numerous. Examples are enumerated in this review.

2.1. Air pollution

One of the major contributors of pollution to the environment is air pollution. The phenomenon is the contamination of natural air with dangerous gases. Automobiles, industries, and natural disasters like volcanoes are culprits which release gases like carbon monoxide (CO), carbon dioxide (CO_2), sulfur dioxide (SO_2), methane (CH_4) and other harmful into the air (Abulude et al., 2018). Dust is a particulate present in the air. This is harmful, especially to the respiratory system (Berg, 2017). Materials near industries are at the receiving end of dust particles. The sources of air pollution are from the burning of fossil fuels, vehicles (Fig 1), and factory emissions. The burning of fossil fuels contributes to the formation of smog, a dense layer of particulate matter that hangs like a cloud over many major cities and industrial zones. Air pollution contributes to respiratory problems (asthma, lung cancer, chronic bronchitis, and other lung ailments). NO_2 and SO_2 in the air, when coming in contact with water or precipitations, form acid rain, a lower (more acidic) pH than normal. Acid rain harms forests, species that live in water bodies, and degrades outdoor statues, monuments, and buildings (Berg, 2017; Abulude et al., 2018).

Fig 1. *A vehicle emitting pollution, Source: Study Read (2018)*

2.2. Water Pollution

This is a scenario formed when the discharge of a large quantity of human, industrial wastes enters the rivers, ponds and sea water thereby making them contaminated. Thereafter, making the water harmful to drink and also endangering lives on the water (sea and marine) animals (Fig 2).

Fig 2. *A polluted water, Source: One Water (2015)*

A major source of water pollution is runoff from agricultural fields, industrial sites, or urban areas. Runoff disrupts the body's natural water balance. Fertilizer can cause algal blooms (an explosive growth of algae), choking out other plants and decreasing the amount of available oxygen necessary for the survival of other species (Berg, 2017). Raw sewage is another type of water pollutant. When sewage gets into the drinking water supply, serious stomach and digestive issues may result, including the spread of diseases such as typhoid or dysentery. A third source of water pollution is a trash. Improperly disposed of items, such as plastic bags, fishing line, and other materials may accumulate in the water and lead to the premature death of animals that get tangled within the garbage (Berg, 2017).

2.3. Land pollution

Excess dumping of toxic waste, chemical, or other wastes causes land pollution (Fig 3). Polluting the land by harmful chemicals (fertilizer, pesticide, insecticide, fungicide and so on) can lead to the entry of pollutants into the food chain. Also, carefree attitude of disposing of industrial wastes, defecating in the open spaces cause pollution, which eventually leads to health problems like malnutrition as pollutants pass through plants to humans and animals. Other sources of soil pollution include asbestos, lead, and PCBs (Berg, 2017).

Fig 3: *A land polluted with waste dump, Source: Study Read (2018)*

2.4. Sound pollution

Sound pollution (Noise) is a disturbance of the cool or silent environment with too much noise. Sources include vehicular sounds, the load speakers used for fun or public speeches, temples, mosques, churches, advertisement, sirens, and so on (Fig 4). This pollution has a severe impact on sick, the old people, small children (Berg, 2017). Noise pollution typically refers to human-made noises that are either very loud or disruptive in manner. This type of pollution has been shown to impact the movement of sea mammals, such as dolphins and whales and also impacts the nesting success of birds.

Fig 4: *Sound Pollution caused by loudspeakers, pedestrians, and buses, Source: Chatterjee, (2017)*

2.5 Dust pollution

This is a pollution wherein the contamination is due to dust particles in the air. Vehicular movements release dust in the environment, also the industrial, farming, mining, and pollination activities end up in the release of dust into the air (Fig 5). The dusty airs are transported several kilometers from the sources to other parts of the location. Meteorological parameters have significant effects on the dust pollution. Contamination of the by dust translates into health problems (breathing difficulty leading to infections, congestion of breath).

Fig 5: *Dust pollution caused by plowing of the farm, Source: Kiama Municipal Council (2017)*

2.6 Radiation pollution

This is a scenario due to abnormal radiation in the environment caused by the use of radioactive elements from the surrounding areas, especially near atomic energy stations. Batteries, wireless internet, and mobile towers are the culprit for the release of radiation into the environment (Fig 6). Excess radiation in the air has a serious health effect on lives, even the pollution has caused the extinction of birds, bees and other insects from their natural habitat.

Fig 6: *A phone releasing radiation into the environment*

2.7 Thermal pollution

When there is excess heat released into the environ, the temperature of the surroundings increases drastically, which eventually leads to thermal burn, draught, and reduction of oxygen in rivers, streams, and oceans this makes the water and marine animals to struggle for their survival. Thermal power plants and industries involved in metal molding are the cause of thermal pollution (Study Read, 2018). According to HelpSaveNature (2018), deposition of warm water from industries into natural water bodies causes thermal pollution (Fig 7). This not only disturbs the aquatic life but also reduces the quality of water.

Fig 7: Deposition of warm water from industries into natural water bodies causing thermal pollution, Source: HelpSaveNature (2018)

2.8 Light pollution

This pollution is the large quantity of light produced in most peri-urban, urban, and other heavily-populated areas (Fig 8). It prevents people from observing the features of the night sky and has effects on the activities (reduction of migration patterns) birds and those of nocturnal animals (Berg, 2017) At night, light pollution affects the drivers by causing distractions for them. It is believed that light pollution is one of the causes of obesity, insomnia and other health issues.

Fig 8: *Urban area with large quantity of light, Source: Mirana (2012).*

2.9 Plastic pollution

This is the compilation of plastic products in the environment, land, waterways, and oceans, which adversely endangers wildlife, wildlife habitat, or humans. This pollutant is categorized into micro-, meso-, or macro debris, based on size

(Hammer et al., 2012). The inability of plastic and polyethylene to decompose for many years add up to pollution. Plastic pollution is one of the contributors to air, water, and soil pollution (Fig 9). Humans are also affected by plastic pollution, such as through disruption of various hormonal mechanisms. Even animals which graze this plastic die due to problems in the intestine.

Fig 9: *Plastic polluted environment*

3. POLLUTANTS

A pollutant is a material or energy which enters the environment in the long run adversely affects the usefulness of a resource causing long- or short-term damage to plant or animal species, interfering with human amenities, comfort, health (cancer, birth defects, other serious health problems), property values, adverse environmental and ecological effects. Pollutants are the substances which pollute or contaminate the environment (Kapoor, 2011). Pollutants are divided into gaseous (H2S, CO2, NOx, CO, SOx, CFCs), liquid (chemicals, oil and petroleum, human and animal wastes) and solid (metals, plastics etc) - (biodegradable and non-biodegradable) (Gsenviro (2015).

3.1. The six criteria pollutants

Criteria pollutants are the only six air pollutants (PM, O3, CO2, NOx, CO, SOx) with the National Ambient Air Quality Standards (NAAQS) that depict standard limits of these substances in ambient air (Idaho.gov, 2018). They are identified by The Clean Air Act (CAA) of 1970. The criteria pollutants are problematic in the sense that they have health (lung disease, respiratory damage, or premature death) and environmental (acid rain, radiation, and ozone depletion) effects and property damage (Idaho.gov, 2018). It is expected that the six pollutants should be reviewed periodically and the standards should not be exceeded more than once in a calendar year.

3.1.1. Particulate matter (PM)

The PM is an inhalable and respirable particle which is composed of sulphate, nitrates, ammonia, sodium chloride, black carbon, mineral dust, and water. There are large particles that can be seen as soot or smoke, while others can only be detected with the use of a microscope. Particles classified by their 'aerodynamic diameter' (PM10, PM2.5, and PM0.1) pose the greatest risks to health, as they are capable of penetrating peoples' lungs and entering their bloodstream (Abulude et al., 2017b). They are also classified according to their chemical composition. The toxicity of PM depends on their size and chemical composition. PM sources from human activities like combustion engines (both diesel and petrol), solid-fuel (coal, lignite, heavy oil and biomass) combustion for energy production in households and industry, as well as other industrial activities (building, mining, manufacture of cement, ceramic and bricks, and smelting). Some particles are emitted naturally. The sources are bushfires, dust storms, pollens and sea spray.

Australian Government (2005), researchers have linked exposure of particle pollution to a number of health problems, including respiratory illnesses (such as asthma and bronchitis), cancer and cardiovascular disease, which are pronounced in vulnerable groups, like the very young and the elderly. PM is the major cause of reduced visibility. This can be a serious safety issue on roads and in traffic tunnels and can also affect our enjoyment of the natural landscape.

3.1.2. Black Carbon (BC)

One climate pollutant is Black carbon. It is a major component of PM2.5. BC is one of the largest contributors to global warming. It is also known to decrease agricultural yields and accelerate glacier melting. BC soot is a pollution arising from the burning of wood and other plant material, and industrial exhausts. The burning leads to the spread of fine carbon soot into the air (Study Read, 2018), causing irritation to the respiratory system to those who inhale the contaminated air and also darkening the skies thereby reducing vision on the roads (Study Read, 2018).

3.1.3. Nitrogen dioxide (NO2)

Nitrogen dioxide is a gas that smells nasty. Nitrogen dioxide, mainly emitted by power generation, industrial and traffic sources, is an important constituent of particulate matter and ozone (WHO, 2018). It is the symptoms of bronchitis and asthma, lead to respiratory infections and lung function reduction, growth. Also, it may be responsible for a large disease burden, with exposure linked to premature mortality and morbidity from cardiovascular and respiratory diseases (WHO, 2018). NO_2 is an important air pollutant simply because it adds to the formation of photochemical smog, which can have significant impacts on human health, causing wheezing, coughing, colds, flu and bronchitis (Australian Government, 2005).

3.1.4. Ozone (O_3)

One of the major components of photochemical smog is O_3. It is not directly emitted like BC it has a health problem which includes breathing, asthma, reduced lung function and respiratory diseases (WHO, 2018). Chest pains can also occur in some people (Australian Government, 2005). O_3 is formed when CO, CH_4, or VOCs are oxidized in the presence of NOx and sunlight. In addition to their role as ozone precursors, CO, VOCs, and NOx are dangerous air pollutants themselves. Sources of NOx, CH_4, and VOCs are from motor vehicle exhaust, industrial facilities, chemical solvents, waste, the fossil fuel and agricultural activities. Apart from O_3 health impacts, tropospheric ozone is a short-lived climate pollutant and one of the most important greenhouse gases (WHO, 2018).

3.1.5. Sulphur dioxide (SO_2)

Sulphur dioxide is a gas, which is primarily produced by the burning of fossil fuels (coal and oil) and the smelting of mineral ores that contain sulphur. Exposure to SO_2 affects the respiratory system and the function of the lungs and causes irritation of the eyes. Inflammation of the respiratory tract from SO_2 can aggravate asthma and chronic bronchitis, as well as increases the risk of infection, leading to increased hospital admissions and visits to emergency rooms. SO_2 also combines with water in the air to form a sulphuric acid - the main component of acid rain (WHO, 2018).

The main source of SO_2 in the air is the generation of electricity from coal, oil or gas that contains sulfur, the processing of mineral ores in which sulfur dioxide is released and burning fossil fuels. Sulphur dioxide is also present in motor vehicle emissions (Australian Government, 2005). Those most at risk of developing problems if they are exposed to sulphur dioxide are people with asthma or similar conditions (Australian Government, 2005).

3.1.6. Carbon monoxide (CO)

Carbon monoxide is a colorless and odorless gas, which at high levels can be harmful to humans by impairing the amount of oxygen transported in the bloodstream to critical organs. Although high concentrations of CO are more of a concern indoors, emissions outdoors, particularly in developing countries can be high. New evidence also reveals that long-term exposure to low concentrations is also associated with a wide range of health effects. The main sources of ambient CO include motor vehicle exhaust and machinery that burn fossil fuels (WHO, 2018).
The natural concentration of carbon monoxide in the air is around 0.2 parts per million (ppm), the amount is not harmful to humans. Natural sources of carbon monoxide include volcanoes and bush fires, industrial activities, tobacco smoke.

4. ROLES OF WOMEN GLOBALLY

No doubt globally, women play important roles in homes and outside. They play motherhood roles and because they are close to nature, they are involved in the socio-cultural activities to sustain life (Agüera-Cabo, 2010). They take care of the house and surroundings (Devi, 1994). Worldwide, there is an increase in the awareness of the necessity of using women to contribute to the reduction of environmental problems, as well as working on the activities towards the sustainability and development of their communities. The results of a world survey conducted and by the United Nations Environment Program on public attitudes on the environment revealed that women are more prone to a lower standard of living than men this means that they are more prone to health risks (Chelala, 2011). The adopted 2030 Agenda (MDGs/SDGs) of the General Assembly showed that much is expected in eradicating or reducing atmospheric problem worldwide. Also, the Rio

declaration on general rights and obligations says 'that women have a vital role in environmental management and development' (Rio, 1992). This shows that women have a significant role to play in environmental protection.

Few successes have been noticed by women in reducing environmental problems world over (Wuyep et al., 2014). According to (Wuyep et al., 2014), women in Jos, Nigeria engage in the drainage and waste disposal. In India, women have been involved in the creation of awareness on environmental pollution, they have also involved in the national policy on how to eradicate pollution. A scenario is a legal case (Krishna Gopal Vs. State of Madhya Pradesh) where one Mrs. Sarla Tripathi took a factory to court on the ground that the factory was polluting their community with smoke, ash, ground vibration, and noise (Krishna Gopal, 1986). Also in India, women have been the major conservers of agro/bio-diversity (Adiyat, 2016). In Myanmar, women are known to be rehabilitators, managers and innovators of the natural environment (Aye, 2018). In Ethiopia, it was claimed that women understand the art of sustainable consumption patterns more than men, this has made them use more of environment-friendly and organic food and eco-labeled products (OECD, 2008; Bayeh, 2016). Women in Eritrea are useful in the area of reducing land degradation, and desertification as well as soil conservation and water harvesting, they are the principal drivers and actors of communal work, especially in the area of building modified stove which assists in the provision of cleaner air (Tesfamichael, 2015). Lawyers in Kenya (The Federation of Women Lawyers in Kenya (FIDA) are now providing free legal support to women on to assist them to fight for their land rights, especially in the area of land degradation (Irish Aid Key Sheet, 2018). Also in Ethiopia, women have been empowered by issuing them land certificates which gives them the rights to own their lands by this, they will try as much as possible not to lose these lands to environmental pollution (Irish Aid Key Sheet, 2018b).

Women and their little one's children are most prone to environmental disasters, vulnerable to reproductive and sexual health problems, and whenever they lose their breadwinners (husbands) they are made to take care of their families and even compel to struggle for recognition in patriarchal systems (DCI (2005). On many occasions, women are the principal drivers and actors of communal work. They are directly affected by the impact of environmental pollution. For these reasons, the roles of women to reduce or fix pollution should include the followings:

4.1. Roles of Women in Developing Countries

4.1.1. Illegal mining

No doubt women have played active roles in mining in developing countries. In Africa, it was documented by Hinton et al. (2003) that women have direct involvement in mining activities ranging from 40-50%. Gueye, (2001) noted that over 90% of women in Burkina Faso are involved in mineral processing women, while Mali, Tanzania, and Sudan had 50%, 70%, and 35% respectively. The majority of the women are involved in ancillary roles like cooks, service provider, and sales of liquor. Nowadays, there are many illegal mining locations throughout the developing countries. On this premise, there is an increase in pollution of the environment. To reduce the effect, women should not be left out. Since there is an illegal mining site, definitely, there will be little or no report on the toxic mining waste, then the public will always be in the dark. Women should utilize the power and efforts to fight for greener mining and enforcement of regulations. Illegal miners should be educated about the approach to mining activities within the country. They should be informed of the potential hazards in the shady deals.

4.1.2. Reduce noise levels

Noise pollution throughout the world is bad and unhealthy for the body. Developing countries are the major culprits of this. Most inhabitants put up, carefree attitudes in handling the noise levels. Evidence have shown strong correlations between environmental noise and elevated risks of high blood pressure, headache, children's growth and learning development, the risk of depression, anxiety and insomnia (Huss et al., 2010; Stansfield, 2016). Women with their roles in the community should contribute their quota to cutting back noise pollution. They should try to enlighten their household, colleagues, and others the difficulties regarding noisy situations. In homes and workplaces, soundproof the rooms with a less expensive option of covering the walls with carpets and other covers (mineral wool, blankets, acoustic foam panels, bookcases filled with books) which soften and absorb sound (Houzz, 2013). In the event of noise in the surrounding, women and others should wear ear protection devices. When noisy items like blenders are used they should be padded. All electronic gadgets should be turned off when not in use even television and radio should be operated in low volumes, and noise from workplaces should be reduced. All mechanical engines should have good silencers. All damaged ones should be fixed immediately. In a situation where vehicles are modified to be louder, the owners should be informed of the problem, if they refuse to reduce their noise, they should be reported to the law enforcement agents. Women are advised to move to a quiet spot that is as free of sound as possible before one is back the emotional balance would have been restored. The use of earplugs and noise-canceling headphones will assist where necessary. Finally, in communities, neighbors can agree to limit the noise levels or use speakers, lawn mowers, horns and other noisy motors during certain hours, for the benefit of the whole neighborhood.

4.1.3. Avoid the use biomass burning

Women do most of the cooking in developing countries. They use or rely on solid biomass fuels for their cooking. According to Bond et al., (2007), the method used contributes to 50% anthropogenic and 25% global emissions of BC. Also, about 1.6 million deaths have been estimated by WHO due to inhalation of smoke due to biomass fuel (WHO, 2002).

4.1.4. Reduction of plastics and cellophane bags

Plastics and cellophane bags are commonly used in developing countries. These find their way into homes and offices unknowingly through the wrapped items purchased from the local markets or supermarkets. To reduce the influx of these into homes, efforts should be geared towards using a reusable version like paper, bottles, and the rest. Women should opt for natural exfoliants (oatmeal or salt), instead of buying items enclosed in plastics. All plastic containers should not be disposed off, they should be gathered and submitted to the waste disposal board for onward recycling. Or in the alternative, the containers could be sent to the manufacturers of the products for recycling or reuse. Another option for women to reduce their plastic containers is to buy in bulk (Engler, 2016). Buying in one big container is better than multiple containers over time. Efforts should be made in preparing and storing foods and beverages using non-plastic utensils, pans, containers, and covers (including wrap materials) whenever possible (Nnaji, 2018). Goods and foods should be purchased with minimum package instead of cellophane bags and plastics they can be stored in glass, papers and other stainless steel materials. In many developing countries laws on plastic pollution have been enacted in this case, what women need to do is to support the enforcement and the workability of the laws. Part of support, women can give is to mount pressure on manufacturers by joining in the campaign. This can be done by making the voices heard in terms of packaging using the social media (Engler, 2016).

4.1.5. Choose environmentally friendly cleaners.

In an African set-up, most of our roads are unpaved and surroundings are not cemented for this reasons sand, dust and dirt abound everywhere. To get them cleaned, most of the women use brooms to do the sweeping or pushing dirt into a pile and cleaning. In the course of doing this, dust is blown or released which can be transported afar by the wind within the vicinity. The health problem arising from the inhalation of the dust could be severe. For a woman to make the environment clean, she should wet the ground or surface of the area with water, which makes the dust entrapped on the floor or using a vacuum cleaner. Again, when making a purchase of any product, before paying, the environmental health scoring rate (Green is good. Red is bad) should be checked. Red color depicts the potential environmental problem or danger. In addition, energy should be conserved by electrical gadgets when not in use and equally participate in utility energy conservation programs. Regular routine maintenance of automobiles such as changing the oil and filters, and checking tire pressure and wheel alignment will assist in making the environment-friendly.

4.1.6. A Good farm practice

It is of note that women in the developing countries have more contact with the environment because they are heavily involved in their agricultural activities. Women are main actors when managing their natural surroundings and use different methods to deal with the kinds of environmental situations they might face. According to the World Bank (1991), women play an essential role in the management of natural resources, including soil, water, forest, and energy. In order to discharge their duties well in good farm practices, women should be well trained in the handling and the use of chemicals, the use of traditional pesticides, insecticides, and fertilizers can also be used as supplements. The disposals of the containers should be with care and they must duly follow manufacturers' specifications and safety gadgets should be properly used before and after their exercises. If women in the cause of their work on the farms and they notice usual happenings as per environmental problems, they should immediately notify environmental experts, government officials, and the traditional rulers who should immediately take appropriate steps. In order to avoid agricultural pollution, women should try as much as possible to use Integrated Pest Management. Organic fertilizers and wastes (agricultural and household) instead of manufactured ones which combine with air to form solid particles in the air (AGU 100, 2016). Women farmers should imbibe conservation practices by planting cover crops to help stop soil erosion, zero-tillage, use crop and pasture rotation methods, improve wildlife habitats and maintain agricultural productivity, ensure water cleanliness for livestock and others. Also, women should always use, preservation methods which will assist them to keep things the way they are, to keep them for future generations and also improve their quality (AnimaSmart.Org, 2018). Finally, women, farmers should use farm resources in moderations and even encourage their wards, husbands, and colleagues to do same.

4.1.7. Pipeline damage – explosion

When **pipeline explosions** happen, gas will be released which results in flames. The crude oil will be released too into the surrounding waters. The outcome of these incidents may be serious injuries, the **destruction of private property,**

environmental damage and many more. The world over, there were reported cases of pipeline damages resulting in many explosions and even death of animals and human (Bonner and Suhartono, 2006; Reuters, 2012; *National Transportation Safety Board, 2014; Niyi, 2016; Daniel, 2016;* The Indian Express, 2017). The causes of these could be as a result of natural and man-made damages - *natural disasters such as earthquakes, floods or fires, harsh environmental factors, excavations, vandalism, even terrorist attacks* (Lorusso, 2011). To prevent pipeline damages, efforts are in place to: put up safety issues like overhauling of pipes, pipeline safety programs, fine and jail pipeline vandals, constant monitoring of the pipeline areas – security and other professionals, fast response of the emergency crew to the scene of the problem, prevent excavation and digging, no farming or illegal activities near the pipelines (Osher, 2017). Additionally, the use of bulletproof and fireproof in the areas, barrier layers created, the conduct of emergency tests, the use of communication redundancy, and even battle ready for the potential threats (Lorusso, 2011). To prevent the environments from pollution through pipeline damage, women have many roles which include: immediate alert of security and monitoring team of vandalization of the pipelines, non-participation in the shady deals, women should discourage their family members in the involvement, they should be familiar with proper use of fire extinguishers, obey orders of government agents, avoiding the use of farm implements that can produce sparks in the vicinity,

4.1.8. Avoid wastes and refuse to burn

The burning of refuse or waste is illegal not only because it is a nuisance to people around, but may release harmful chemicals which are hazardous to man and animals' health and the environment (EPA, 2009). Burning wastes in fires form toxic and dangerous by-products which may not be destroyed by the fire, but become airborne on soot particles (Citizens Information Board, 2016). The aftermath effect may be inhaled or washed out of the air and deposited into the soil and crops, where they can readily enter the food chain (Citizens Information Board, 2016). As women are the custodian of the home, they are to maintain a clean environment. Arrangements must be made for the collection and disposal of the household wastes or refuse by the waste collectors or operators who do this frequently (weekly). Women must provide waste bins (wheelie bins) or bin bags for easy collection and transportation. Composting of kitchen waste (biodegradable waste) is another method by which women can use to reduce the wastes generated in homes. Instead of burning the refuse, a hollow container (compost container) or small area of land can be dug and used for composting. Other minor tools like a garden shovel or fork will be needed for turning and removing the compost. Composts are used as organic fertilizer. Although women may not be able to recycle their refuse or waste, they would be involved in the gathering, sorting and sending them to the factories for recycling. If women are able to do this, it means they have saved the environment and living things around from being endangered. Women should learn and be educated on recycling, minimizing, preventing, and re-use of wastes instead of endangering the environs through burning. Women can convert waste to wealth. In Kenya, it was reported that women turned wastes (plastics) into useful products (bags, hats, carpets, and others). These efforts have assisted in preventing short-lived climate pollutant emissions from the open burning of plastic (CCAC, 2018).

4.1.9. Women environmentalists

In spite of the progress so far on the reduction of environmental pollution globally, women environmentalists have in developing countries have not made much impact. To make women more proactive, the Network of Women Ministers of the Environment (NWME) has made frantic efforts in making practical recommendations to solve environmental problems confronting countries; collaborations between NGOs, intergovernmental agencies, and civil societies and forming leadership to influence international and national policies (UNEP, 2004). In 2011, the Nobel Peace Prize was awarded to three women whose roles were fighting for human rights, apart from this, another was given to Wangari Maathai, her efforts and others restored Kenya's lost forest by planting over 30 million trees and also empowered women in environmental preservation methods (Chelala, 2011). In Nepal, Saraswoti Bhetwal has assisted indigenous women in the use of composts, drip irrigation, roof water harvesting, other strategies in reducing their environmental problems. Olga Speranskaya of Russia and her team in their community identified and eliminated the Soviet legacy of toxic chemicals in the environment with NGOs. In Honduras, the Emergency Committee Garifuna formed by women provided seed banks for food security, reduced erosion of coastal areas by planting fruit trees, reforestation, and assisted communities in relocating to low-risk areas communities from high-risk areas. While elsewhere in Bolivia, the Centro de Mujeres Candelaria and the team, led women ins grassroots groups to predict hazardous events in their ancestral practices and protect their farms and food (Chelala, 2011). Although women from different countries have shown tremendous concern and participation in reducing pollution, more is still expected of them because they are susceptible to several environmental threats. They should be empowered to get involved in the development of and participation in environmental pollution programs and policies.

4.1.10. Planting of trees

Trees are noted to have 22 benefits which include conservation of energy, prevent pollution (air, soil, food, water), medical, and financial benefits (TreePeople, 2018). In considering the type of flora to plant, they must have the **ability to absorb CO_2** in a life cycle of 30 years, filter air pollutants, its ability to transform into biomass and **to attach chemicals such as benzene, nitrogen oxide**, dioxin and many others (Bressa, 2016). Again, trees that have the ability of to produce

volatile organic compounds (VOC), which can increase the concentration of ozone in the environment of small populated areas, should not be many (Bressa, 2016). In big cities, the following trees can be considered for planting: Elm (*Ulmus minor*), Common ash (*Fraxinus excelsior*), Wild linden (*Tilia cordata*), Norway maple (*Acer platanoides*), Turkey oak (*Quercus cerris*), Ginkgo (*Ginkgo biloba*), and Broad-leaved linden (*Tilia platyphyllos*). Shrubs, an herb garden, houseplants, vegetable crops, decorative flowers, can be considered for planting because they also reduce the amount of **CO_2** in the air, increase oxygen, and eliminate toxins (Stone, 2010). In Kenya, over 30 million trees were planted by women's group (Chelala, 2011). Also in Lagos, Nigeria former state governor's wife (Mrs. Fashola) encouraged women in tree planting by leading them in a tree planting campaign and environmental sanitation. Formation of women tree growers' association in Ghana rural communities, assisted imbibing and nurturing tree planting culture (Tola-Iwajobi, 2013). To involve women in the control of pollution using trees and plants, they should be made to understand the issues and concerns of tree planting by sensitizing them on the need. Again, they should be involved in tree planting decision making and mobilize them to belong to different tree planting groups. Furthermore, women should be discouraged from the cutting of trees for their sustainability. Lastly, women should be involved in tree planting campaigns in order to create awareness.

5. CONCLUSION

This paper discussed the roles women can play in fixing pollution, particularly in the developing countries. It looked at types of pollution (air, water, noise, thermal, and others), and the pollutants (PM, NOx, SOx, CO, and others). Women identified as home builders and good managers have a stake in fixing pollution as they are involved in their day to day activities. They are directly affected by the impact of environmental pollution. For these reasons, the roles of women in reducing or fixing pollution should include planting of trees, avoiding dumping and burning of refuse, good farm practice, the use of environmentally friendly cleaners, and others relevant roles. Finally, women environmentalist or movements should do more in the forcing the relevant government and environmental bodies to do the needful in the fixing of pollution.

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REFERENCES

- Abulude, F.O., Ogunmola, D.N., Alabi, M.M., Abdulrasheed, Y. 2017a. Museums and Monuments in Nigeria: Reducing Pollution Damage. *Continental Journal Applied Sciences* 12 (3), 42 – 56.
- Abulude, F. O., Bahloul, M., Olubayode, S. A. & Adeoya, E. A. (2017b). A review on top-down and bottom-up approach for air pollution studies. *World Journal of Environmental Research*. *7*(2), 52-60.
- Abulude F.O., Ogunmola D.N., Alabi M.M., and Abdulrasheed Y (2018). Atmospheric deposition: Effects on sculptures. *Chemistry International* 4(2) (2018) 136-145.
- Agüera-Cabo, M. (2010). Environmental Governance from a Gender Perspective: Theoretical Reflections and Case Studies. Doctoral Thesis. Doctorate in the Environment. Geography for Territorial Planning and the Environment. The degree of Doctor of Philosophy of the University of Girona. Spain. Dipòsit legal: GI-1351-2011. http://hdl.handle.net/10803/48534.
- Aditya S. K. (2016). Role of Women in Environmental Conservation. *International J. Political Science and Development*. 4 (4): 140-145.
- AGU 100 (2016). Farms a major source of air pollution, study finds. Advancing Earth and Space Science. https://news.agu.org/press-release/farms-a-major-source-of-air-pollution-study-finds/
- AnimaSmart.Org, (2018). Farmers helping the environment. http://animalsmart.org/animals-and-the-environment/farmers-stewards-of-the-environment. Accessed 20th June 2018.
- Australian Government (2005). Carbon Monoxide (CO). Air quality fact sheet *Department of the Environment and Heritage. http://www.environment.gov.au/protection/air-quality/air-pollutants#criteria.*
- Aye T.T. (2018). The Role of Rural Women in Environmental Management in Myanmar: A Case Study of Ngaputaw Township. *Open Science Journal* 3(1): 1-14.
- Bayeh E (2016). The role of empowering women and achieving gender equality to the sustainable development of Ethiopia. Pacific Science Review B: Humanities and Social Sciences 2 (2016) 37-42.
- Berg, Susan. (2017). "Types of Pollutants." Sciencing, http://sciencing.com/types-pollutants-5270696.html.
- *Bonner, Raymond; Suhartono, Muktita (2006-10-23). "Indonesia gas blast linked to volcanic mud - Asia - Pacific - International Herald Tribune". The New York Times. ISSN 0362-4331*. Retrieved 2017-06-14.
- Bressa R (2016). Which trees to plant to change the aspect (and air) of a city. Lifegate. https://www.lifegate.com/people/lifestyle/city-trees-smog-pollution. Accessed 20th June 2018.
- Chang H (2018). Earth Day 2018: Let's End Plastic Pollution. Sustainable Investment Group (SIG). https://www.sigearth.com/earth-day-2018-lets-end-plastic-pollution/

- Chatterjee B (2017). Sonu Nigam row: Mumbai noise pollution rampant across religious buildings, fests. Hindustantimes. https://www.hindustantimes.com/india-news/noise-pollution-in-mumbai-rampant-across-religious-buildings-festivals/story-a3YuwfsnPCuCNFMZYf8emI.html
- Chelala C (2011). Women's role key to saving the environment. Opinion - Chinadaily.com.cn http://www.chinadaily.com.cn/opinion/2011-10/18/content_13921111.htm. Accessed 20th June 2018.
- Climate and Clean Air Coalition (CCAC) (2018). Women entrepreneurs turning waste into useful products. CCAC Secretariat. Hosted by UN Environment. http://ccacoalition.org/en/news/women-entrepreneurs-turning-waste-useful-products. Accessed 20th June 2018.
- Citizens Information Board (2016). Burning household waste. http://www.citizensinformation.ie/en/environment/waste_management_and_recycling/burning_household_waste.html. Accessed 20th June 2018.
- *Daniel, Ayodele (July 29, 2016). "Military Launches Attack On Militants' Base In Ogun Coastal Communities". Information Nigeria*. Retrieved 2 March 2017.
- DCI (2005). Gender-Based Violence; a failure to protect - A Challenge to Action. Joint Consortium of Irish Human Rights, Humanitarian and Development Agencies and Development Cooperation Ireland. 2005. http://www.dci.gov.ie/uploads/Gender%20Based%20Violence%20study.pdf. Accessed 20th June 2018.
- Devi V.H (1994). Women in environmental protection. Affordable Water Supply And Sanitation. 20th WEDC Conference, Colombo, Sri Lanka, pp 42-43.
- EPA (2009). Waste Management (Prohibition Of Waste Disposal By Burning) Regulations 2009, S.I. No. 286 of 2009. http://www.epa.ie/waste/householder/burn/. Accessed 20th June 2018.
- Egaga P.I and Aderibigbe A.S (2015). Gender and Environmental Sustainability: Issues and Problems Involved For Persons with Special Needs In Nigeria. *Journal of Education and Practice*. Vol.6, No.30: 184-187.
- Engler, S (2016). 10 ways to reduce plastic pollution. NRDC. https://www.nrdc.org/stories/10-ways-reduce-plastic-pollution. Accessed 20th June 2018.
- Gsenviro (2015). "What are different types of pollutants?" *eNotes*, 9 Sep. 2015, https://www.enotes.com/homework-help/what-different-types-pollutants-500080. Accessed 10 June 2018.
- *Hammer, J; Kraak, MH; Parsons, JR (2012). "Plastics in the marine environment: the dark side of a modern gift". Reviews of Environmental Contamination and Toxicology. 220: 1–44.*
- HelpSaveNature Staff (2018). Thermal Pollution - Causes, Impact, and Preventive Measures. https://helpsavenature.com/thermal-pollution. Updated March 10, 2018.
- Hinton J.F, Veiga M.M, and Beinhoff C (2003). Women and Artisanal Mining: Gender Roles and the Road Ahead. Chapter 11 – book: The socioeconomic impacts of artisanal and small-scale mining in developing countries. Ed G. Hilson, Pu. A.A. Balkema, Swets Publishers, Netherland.
- Houzz (2013). Quiet, Please! How To Cut Noise Pollution At Home
- http://www.forbes.com/sites/houzz/2013/09/09/quiet-please-how-to-cut-noise-pollution-at-home/. Accessed 20th June 2018.
- Huss A, Spoerri A, Egger M., and Röösli M (2010). Aircraft Noise, Air Pollution, and Mortality From Myocardial Infarction*. Epidemiology*. 21(6):829-836. DOI: 10.1097/EDE.0b013e3181f4e634.
- Idaho.gov (2018). Critical pollutants. Protecting Public Health and the Environment. Idaho Department of Environmental Quality. http://www.deq.idaho.gov/air-quality/air-pollutants/criteria-pollutants/
- Irish Aid Key Sheet (2018a). Environment and Gender Equality. Irish Aid. Department of Foreign Affairs. An Roinn Gnothai Eachtracha. http://www.irishaid.gov.ie. Accessed 20th June 2018.
- Irish Aid Key Sheet (2018b). Environment and Gender Equality. Irish Aid. Department of Foreign Affairs. An Roinn Gnothai Eachtracha. Ongoing work as part of the Irish Aid-Ethiopia Operational Research Programme in SNNPR and Tigray regions. http://www.irishaid.gov.ie. Accessed 20th June 2018.
- Jerome, A. (2000). 'Use of economic instruments for environmental management in Nigeria' paper presented at the workshop on environmental management in Nigeria and administration (NCEMA).
- Kapoor A (2011). What are Pollutants? Indian Study Channel. http://www.indiastudychannel.com/resources/133972-What-are-Pollutants.aspx
- Kiama Municipal Council (2017). Pollution.
- http://www.kiama.nsw.gov.au/environment/pollution. Accessed 12th June 2018.
- Krishna Gopal Vs. State of Madhya Pradesh, Cr.L.J., pp.396, 1986. In Devi H (1994). Women in environmental protection. 20th WEDC Conference. Affordable Water Supply and Sanitation. Colombo, Sri Lanka. Accessed 20th June 2018.
- Lake R (2017). Types of environmental pollutants. Livestrong.com.
- Lurusso C (2011). Protecting Pipelines In Crisis. Efficient Plant. https://www.efficientplantmag.com/2011/09/protecting-pipelines-in-crisis/. Accessed 20th June 2018.
- MGDFund (2018). Millennium Development Goals. abetterplace.mdgfund.org. Retrieved on 2018-07-06
- Mirana P (2012). Dangers of Light Pollution on Insect Ecosystems. https://www.care2.com/causes/the-dangers-of-light-pollution-on-insect-ecosystems.html.
- *National Transportation Safety Board (February 19, 2014). Columbia Gas Transmission Corporation Pipeline Rupture Sissonville, West Virginia December 11, 2012 Accident Report (PDF). National Transportation Safety Board. p. 50*. Retrieved 11 August 2017.

- *Niyi (January 22, 2016). "Itsekiri Group Condemns Attacks On Emami Over Support To FG On Tracking Down Pipeline Vandals". Information Nigeria*. Retrieved 2 March 2017.
- Nnaji, J (2018). How do we beat plastic pollution?
- https://www.researchgate.net/post/How_do_we_beat_plastic_pollution#post-comment-editor. Accessed 20th June 2018.
- Northern Ireland Air Quality (2010). Air quality standards and objectives. Department of Agriculture, Environment and Rural Affairs. www.daera-ni.gov.uk. http://www.airqualityni.co.uk/air-quality/standards.
- OECD, 2008. Gender and sustainable development: maximizing the economic, social and environmental role of women. In: A Report to the United Nations Commission on Sustainable Development (UNCSD).
- One Water (2015). Water Pollution: What Cause it and How it Can be Prevented. http://www.onewater.my/news/water-pollution-what-cause-it-and-how-it-can-be-prevented.html.
- Osher C.N (2017). Failing to call 811 before digging in Colorado could cost up to $75k under gas pipeline safety proposal. The Denver Post. UPDATED: December 9, 2017
- Reuters (2011). *Nisource gas pipeline explodes near Charleston, West Virginia". Reuters. 2012-12-11*. Retrieved 2016-10-04.
- Rio, Rio declaration (1992). Ground rules to save the earth, Scavenger, Vol.23, No.3, pp.8, 1992.
- SADC Environmental Legislation Handbook (2012). Tanzania. Chapter 14. http://saiea.com/dbsa_handbook_update2012/pdf/chapter14.pdf.
- Stansfield S (2016). How noise pollution can affect your health. Evidence shows that noise pollution can be damaging. Independent. https://www.independent.co.uk/life-style/health-and-families/features/how-noise-pollution-can-affect-your-health-a6853746.html
- Stone B (2010). Help Reduce Pollution by Growing Plants. Edited by Jacqueline Chinappi. https://www.brighthub.com/environment/green-living/articles/61664.aspx. Accessed 20th June 2018.
- Study Read (2018). Types of Pollution | Their Causes and extent of Damage. https://www.studyread.com/types-of-pollution/. Accessed 11th June 2018.
- *The Global Development Research Center (*GDRC) (2018). Special Focus on Gender and the Environment. http://www.gdrc.org/gender/gender-envi.html.
- Retrieved 2018-04-10.
- *The Indian Express (2017). IOC pipeline ruptured near Jamnagar, oil spreads on agricultural land. The Indian Express. 2017-06-17*. Retrieved 2017-12-02
- *The World Bank Group (2018).* Pollution Management and Environmental Health Program. Retrieved 2018-06-07.
- Tesfamichael R (2015). Eritrean women: environment and sustainable energy. Eritrea - Ministry of Information. Shabit.com.
- Tennessee's Ambient Air Quality Standard (1985). 1200-3- 3- .Tennessee Ambient Air Quality Standards for Suspended Particulates, Sulfur Dioxide, Carbon Monoxide, Ozone, Non-Methane Hydrocarbons, Nitrogen Dioxide, and Lead. https://www.epa.gov/sites/production/files/2017-11/documents/chapt-03-2017.pdf
- Tola-Winjobi M (2013).The Role of Gender in Tree Planting Initiative and Climate Change Resilience. A Presentation for Trees on Earth Development Foundation on March 28, 2013. https://www.slideshare.net/Maybellyne/the-role-of-gender-in-tree-planting-initiative-and-climate-change-resilience
- TransportPolicy.net (2009). India: Air Quality Standards. Revised National Ambient Air Quality Standards, 2009 Retrieved 12th June 2018. https://www.transportpolicy.net/standard/india-air-quality-standards/
- TransportPolicy.net (2012). China: Air Quality Standards. Technical Standards. GB 3095-2012. Retrieved 12th June 2018. https://www.transportpolicy.net/standard/china-air-quality-standards/
- Tree People (2018). Top 22 benefits of trees. https://www.treepeople.org/tree-benefits. Accessed 20th June 2018.
- UN 2018. #Envision2030: 17 goals to transform the world for persons with disabilities. Department of Economic and Social Affairs Division For Inclusive Social Development.
- UNEP (2004). Gender, poverty, and environment in Global Environment Outlook Year Book 2004/5. www.unep.org/geo/yearbook/yb2004/ (accessed 9 July 2007).
- United Nations, (2018). 17 Goals to Transform Our World. Sustainable Development Goals. UN Web Services Section, Department of Public Information, United Nations.
- United States Environmental Protection Agency (EPA) (2016). NAAQS Table. Last updated on December 20, 2016. https://www.epa.gov/criteria-air-pollutants/naaqs-table
- WHO (2018). Ambient air pollution: Pollutants. Types of pollutants. Department of Public Health, Environmental and Social Determinants of Health (PHE). http://www.who.int/airpollution/ambient/pollutants/en/
- World Bank (1991). *Women and Development in Malawi: Constraints and Actions,* Washington, DC, World Bank.
- Wuyep S.Z, Dung V.C, Buhari A.H, Madaki D.H, Bitrus B.A (2014). Women Participation in Environmental Protection and Management: Lessons from Plateau State, Nigeria. *American Journal of Environmental Protection,* Vol. 2, No. 2, 32-36.

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