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Assessment of Heat Stress and Some Selected Toxic Gases in Moshood Abiola Polytechnic, Abeokuta, South-West, Nigeria

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ABSTRACT

This research focuses on the assessment of heat stress and toxic gases (CO, CO_2, NO_2, CH_4, H_2S, NH_3 and LPG) in Moshood Abiola Polytechnic (MAPOLY) using a direct in-situ measurement of heat stress and toxic gases measuring systems. The results obtained showed that MAPOLY exhibits a temperature humidity index (THI) ranging from 21.5 ℃ to 26.9 ℃ and wind chill index (WCI) ranging between 31.1 ℃ and 35.9 ℃ which presents the study area to be a hot and strong heat stress zone. Toxic gases levels for CO_2 (4615 ppm -31950 ppm), and NH_3 (39.89 ppm -104.64 ppm) show that the pollution is high and non-tolerable to humans. However, the measured values of CH_4, LPG, NO_2, H_2S and CO which were (8.07 ppm - 60.3 ppm), (17.66 ppm-56.8 ppm), (0.04 ppm - 0.14 ppm), (0.03 ppm -1.26 ppm) and (3.56 ppm - 5.73 ppm) respectively are not lethal to human health.

1. INTRODUCTION

Under normal condition, temperatures 36 ℃ and 38 ℃ are the regimes at which human beings naturally maintains a perfect comfort in their bodies and as the temperature of the body gets to 40℃ ,it will be difficult for the body to overcome the excessive heat produced, thus leading to heat stroke which could result into health disorders like dizziness, fatigue and stroke if not properly managed, it could be threatening to human life (Abderrezak and James, 2002) .

Proper knowledge of heat stress and toxicity of the environment are worth knowing so as to know the degree of the safety of the environment humans are exposed to. Olayinka et al. (2015) earlier reported a high concentration for carbon (IV) oxide (CO_2), nitrogen (IV) oxide (NO_2) and hydrogen sulphide (H_2S) in

Abeokuta and attributed the high concentration to vehicular movement. In a heat stress survey conducted by Gillies (1991), it was found out that the wind chill equivalent temperature, is the temperature required under no –wind conditions that will equal the cooling effect of the air and the wind on average size, nude person in the shade. The effect of sunshine is much more pronounced at low wind speeds and gradually diminishes as wind speed intensifies and its effects become dominant (Shitzer, 2007).

It is important to know that two parameters form the heat stress which are temperature humidity index (THI) and wind chill index (WCI). Temperature humidity index combines atmospheric parameters like temperature and humidity while wind speed and humidity constitute the wind chill index (WCI).

A combustion process is subject to changes like unburnt fuel which later turns to partly burnt fuel which breaks into other forms of gases and mixes with the impurities in the air to form oxides of nitrogen and sulphur (NOx and SOx) and other gases such as carbon (II) oxide (CO), CO_2, liquefied petroleum gas (LPG) and methane (CH_4). It is important to know that the emission of gases into the environment may transpire into global warming (Prather ,1995).

Moshood Abiola Polytechnic (MAPOLY) is a fast-growing higher institution in the city of Abeokuta, the capital of Ogun State which experiences an exponential increase in students' population yearly that gives birth to traffic density. Despite this traffic congestion, there is no research work or findings on the safety of its workers over the years on environmental pollution and heat stress. This research is thus centered on the assessment of heat stress and investigation of toxic gases in MAPOLY.

2. MATERIALS AND METHODS

2.1. Description of Study Area

The study area is Moshood Abiola Polytechnic also known as MAPOLY, a tertiary institution of learning located in Abeokuta, Ogun State. The Ojeere campus is situated in the South-Eastern part of Abeokuta which covers about 960 hectares of rolling land bounded by Ogun river to the south which covers the latitude of 7°6′0″N and longitude of 3°20'10"E respectively.

Sixteen investigation sites were selected in MAPOLY which include School of Science and Technology (SST), Information Technology Centre (ICT), School Library (Library), School Bank (Bank), General Admin (Admin), School Auditorium (Auditorium), School of Business and Management Studies (SBMS), School Last Bus Stop (Bus Shed), School of Engineering (Engineering), Students' Affairs, School of Communication (Sch. Comm), School General Market (Market), Creche, Maintenance Department (Maintenance) and MAPOLY Guest House (MAPINSCO). Figure 1 shows the investigated sites in MAPOLY.

2.2. Sampling and Analysis

This study was conducted in the wet season. Specifically, sampling and analysis for gaseous pollutants and heat stress was carried out in July, 2018 since it belongs to the peak zone of the wet season in Abeokuta where MAPOLY is situated. Direct in-situ measurements (air pollution and heat stress) were carried out using gas monitors and heat stress monitors. Heat stress and air pollutants were measured. Each measurement was allowed to stabilize for five minutes before reading in order to ensure stable reading was recorded. The measurement was carried out when traffic volume was high in the morning from 10 am -11 am at an interval of five minutes as programmed in the instruments used for the measurement.

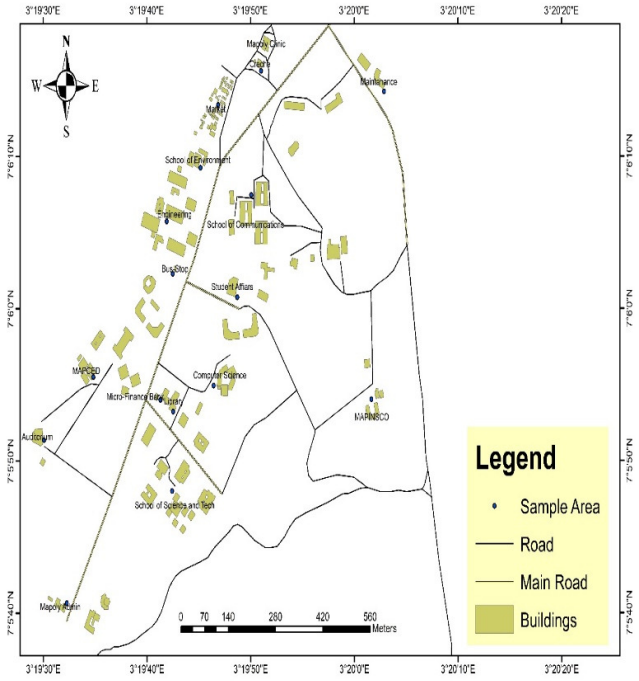

Figure 1: Map showing the investigated locations in MAPOLY

2.3. Statistical Analysis

The air pollutants and heat stress (THI and WCI) data collected were analyzed and graphs were plotted using Microsoft Office Excel while the forecast or prediction model was done using MINITAB 17 software. Temperature humidity index (THI) and wind chill Index (WCI) were calculated using Equations (1) and (2) respectively (Unger, 1999).

$$\text{THI (℃)} = t - (0.55 - 0.0055f)(t - 14.5) \quad (1)$$

Where t= air temperature (°C) and f = relative humidity.

$$\text{WCI (℃)} = 13.12 + 0.6215T - 11.37(V^{0.16}) + 0.365T(V^{0.16}) \quad (2)$$

Where V = Wind speed (km/h) and T= temperature (°C)

Forecasted 5 years values of the concentration of air pollutants and heat stress parameters were done using the additive decomposition analysis method of the time series model with seasonal length of 4. The model is defined as:

$$y(t) = Level + Trend + Seasonality + Noise \quad (3)$$

Where:

Level: The average value in the series.
Trend: The increasing or decreasing value in the series.
Seasonality: The repeating short-term cycle in the series.
Noise: The random variation in the series.

3. RESULTS AND DISCUSSION

Figures 2 to 10 show the results for the toxic gases and heat stress (WCI and THI) as analyzed by the automatic in situ gas monitors and heat stress (WCI and THI) monitors. Sixteen areas in MAPOLY were investigated for the presence of 7 toxic gases (CO, CO_2, NH_3, NO_2, CH_4, LPG and H_2S) and assessment of heat stress i.e. wind chill index (WCI) and temperature humidity index (THI).

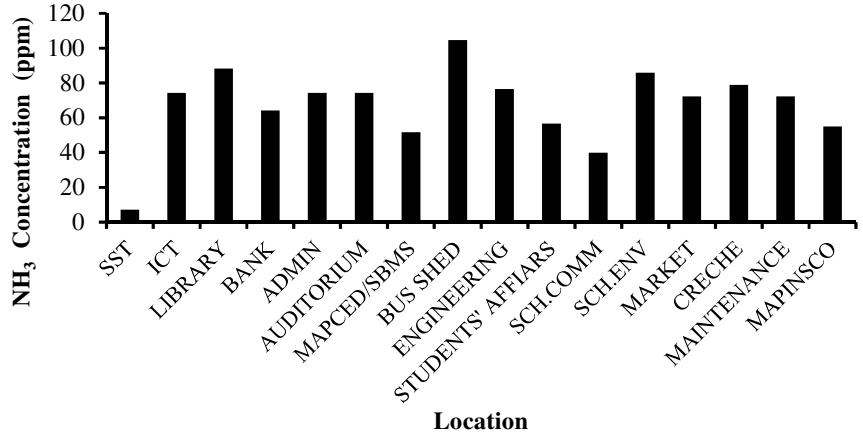

Figure 2: NH_3 concentration for the investigated areas in MAPOLY

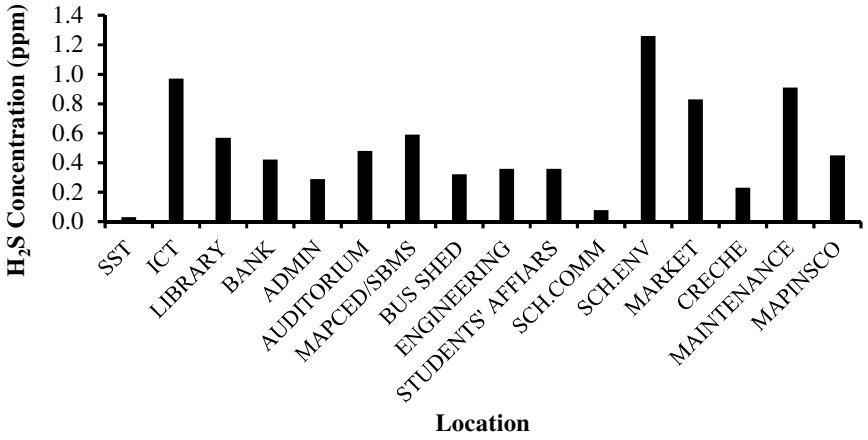

Figure 3: H_2S concentration for the investigated areas in MAPOLY

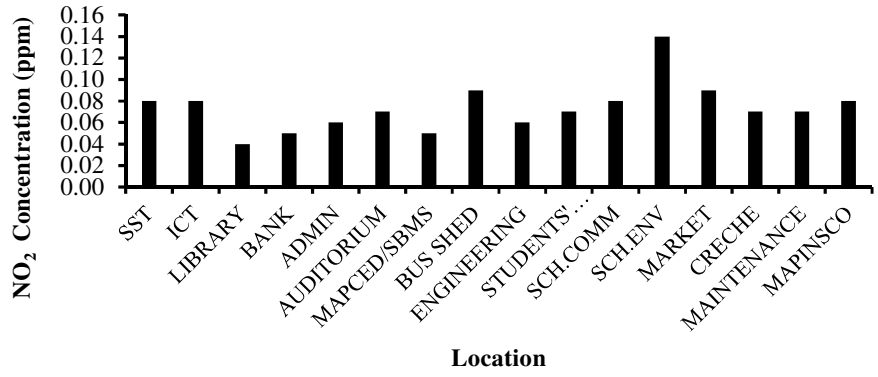

Figure 4: NO_2 values for the investigate areas in MAPOLY

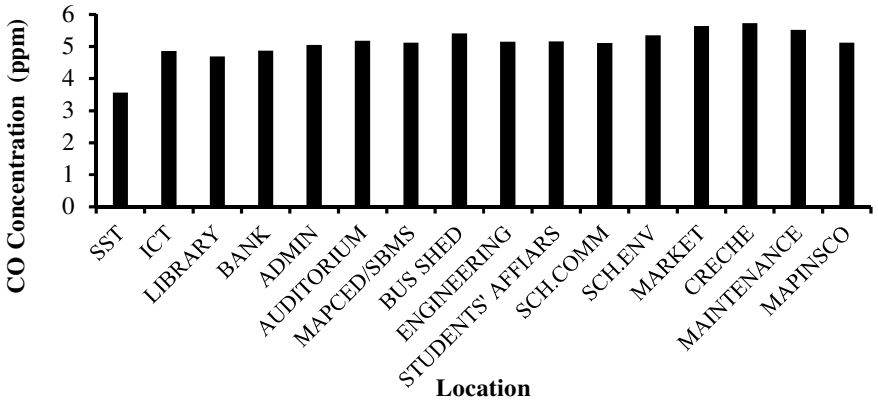

Figure 5: CO concentration for the investigated areas in MAPOLY

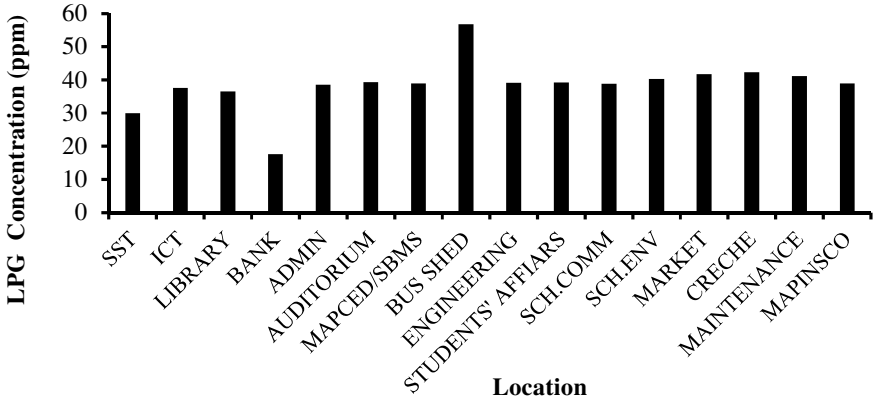

Figure 6: LPG concentration for the investigated areas in MAPOLY

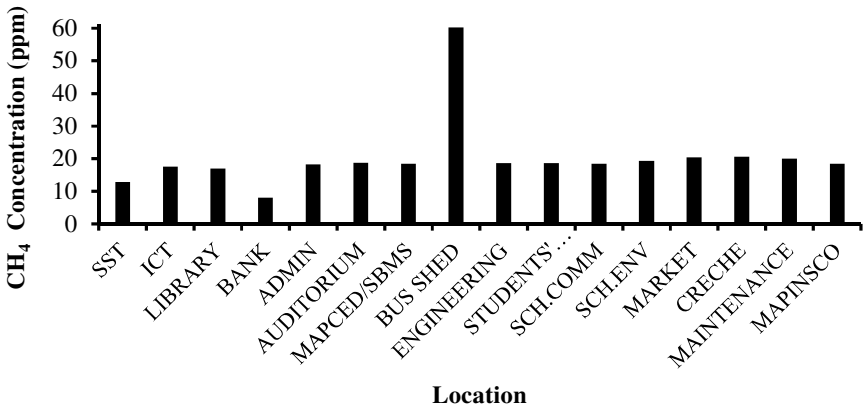

Figure 7: CH_4 concentration for the investigated areas in MAPOLY

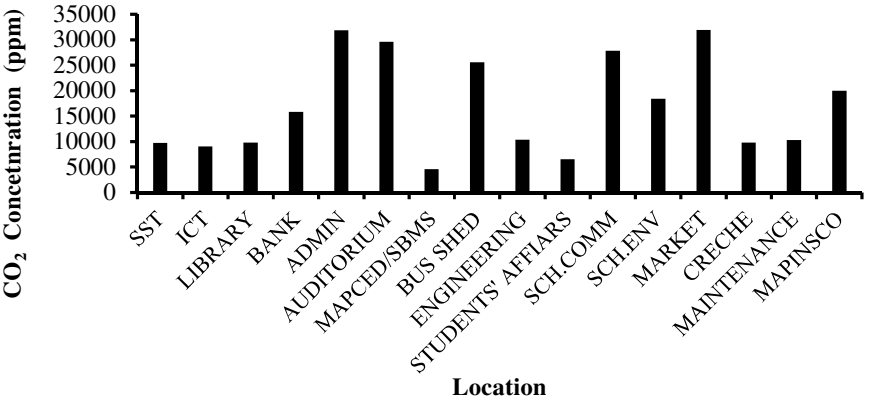

Figure 8: CO_2 concentration for the investigated areas in MAPOLY

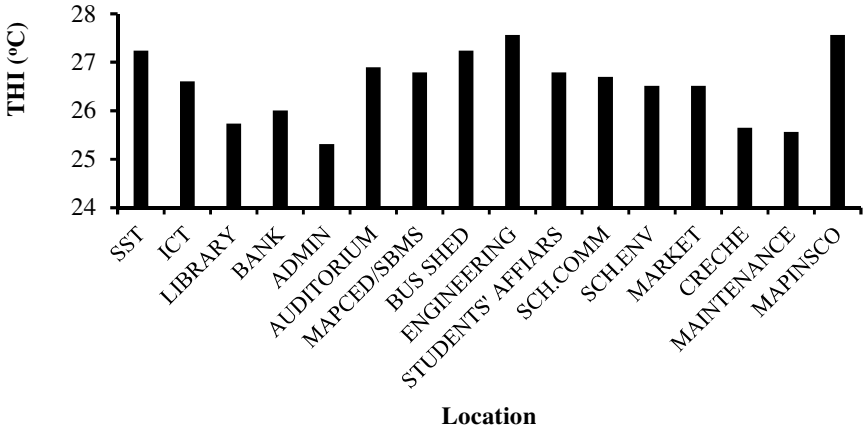

Figure 9: THI values for the investigated areas in MAPOLY

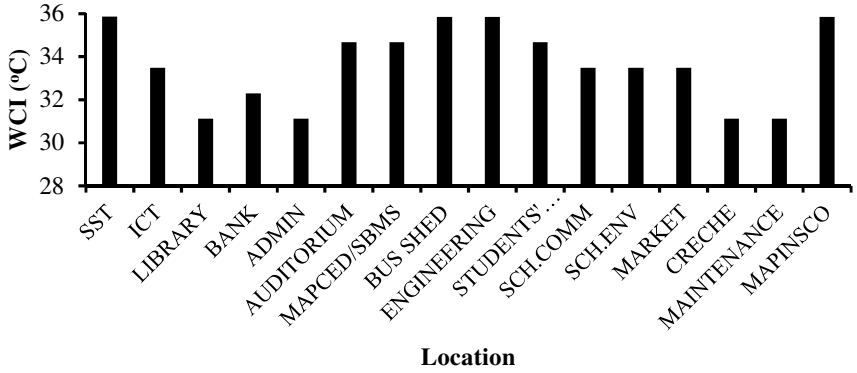

Figure 10: WCI values for the investigated areas in MAPOLY

The measured values for the toxic gases and heat stress are given as: NH_3 (7.11 ppm - 104.64 ppm), H_2S (0.03 ppm-1.26 ppm), NO_2 (0.04 ppm - 0.14 ppm), CO(3.56 ppm - 5.73 ppm), LPG (17.66 ppm-56.8 ppm), CH_4 (8.07 ppm 60.3 ppm), CO_2 (4615 ppm-31950 ppm), THI (21.5 ℃-26.9 ℃) and WCI (31 ℃-35.9 ℃). It is observed that SST exhibited the lowest NH_3 level of 7.11 ppm which is below the permissible limit while the other studied areas exceeded the tolerable value of 25 ppm as recommended by WHO (2006). The predicted values for upcoming years (2019, 2020, 2021, 2022 and 2023) in all the investigated sites are expected to be higher value than the tolerable value of 25 ppm.

Since the tolerable limit of H_2S is 10 ppm, all the areas under study are safe as recommended by WHO (2000). Table 1 future prediction shows that years 2019, 2020, 2021, 2022 and 2023 for all the investigated locations would experience high values of H_2S but still within tolerable limit of 10 ppm. NO_2 levels in all the investigated sites (present and future predictions) were found to be lower than the values reported in Lagos, Ibadan and Ekiti (Osuntogun and Koku, 2007). NO_2 offers high corrosivity and toxicity as well as irritation of eyes and lungs (Osuntogun and Koku, 2007). The resulting effect of high level of NO_2 toxicity are cough, reduction of breathing level and intensification of the chances of having respiratory diseases (Han and Naecher, 2006). CO_2 gas for all the studied areas exhibited values higher than the threshold limit value of 500 ppm as recommended by WHO (2006) indicating that CO_2 pollution was serious in MAPOLY which could be as a result of bush burning or nearby generating sets fumes from the exhausts as earlier reported for Iyana Mortuary area of Abeokuta by Olayinka et al. (2015). Since the tolerable values for liquified petroleum gas (LPG) is 19000 ppm, all the studied areas showed values extremely low to these threshold limit values as recommended by WHO (2006). The results also showed high values of CO in Bus Shed, School of Environmental Studies, School Market and Creche because of the high vehicular movement. CO obtained showed that it was still within WHO (2000) limits of 10 ppm. This implies that none of the studied areas is life threatening since CO deoxygenates blood.

Table 1 shows a 5 year prediction from 2019-2023 using Equation 3. There is high possibility of increase of CO levels in the future. Years 2021, 2022 and 2023 would mark a high concentration values of CO gas concentration emission. Workers whose offices are close to these areas should reduce their exposure time so as to reduce the chances of decrease in human efficiency (Ojo and Awokola, 2012).The THI results range from 21.5℃ to 26.9℃ while WCI results range from 31.1℃ to 35.9 ℃.This implies that MAPOLY falls in a hot and strong heat stress thermal categories presented in tables three and four respectively.

Table 1: Forecasted 5 years values of the concentration of air pollutants and heat stress parameters

GASES	NH_3 (ppm)	H_2S (ppm)	NO_2 (ppm)	CO (ppm)	LPG (ppm)	CH_4 (ppm)	CO_2 (ppm)	THI (℃)	WCI (℃)
				2019					
SST	76.334	0.67212	0.08388	5.8208	44.9922	24.6131	33282.6	21.9250	34.2981
ICT	76.560	0.63377	0.07771	5.8993	45.7718	20.7995	15028.7	21.5535	33.5595
LIBRARY	49.731	0.72667	0.07280	5.8403	44.8839	24.2947	19510.6	21.6321	32.9662
BANK	94.266	0.62082	0.11414	5.9739	46.2597	25.0711	20913.4	21.7106	33.7070
ADMIN	79.117	0.73371	0.08923	6.1349	47.7655	25.9437	35375.2	21.5641	34.2973
AUDITORIUM	79.343	0.69536	0.08307	6.2135	48.5451	22.1301	17121.3	21.1926	33.5588
MAPCED/SBMS	52.513	0.78826	0.07815	6.1545	47.6571	25.6253	21603.2	21.2712	32.9655
BUS SHED	97.049	0.68240	0.11949	6.2881	49.0330	26.4017	23006.0	21.3497	33.7063
ENGINEERING	81.899	0.79530	0.09458	6.4491	50.5388	27.2743	37467.7	21.2032	34.2966
STUDENTS' AFFIARS	82.125	0.75695	0.08842	6.5276	51.3183	23.4607	19213.9	20.8318	33.5581
SCH.COMM	55.296	0.84985	0.08351	6.4687	50.4304	26.9558	23695.8	20.9103	32.9647
SCH.ENV	99.831	0.74399	0.12485	6.6022	51.8062	27.7322	25098.5	20.9888	33.7056
MARKET	84.682	0.85689	0.09993	6.7633	53.3120	28.6049	39560.3	20.8424	34.2959
CRECHE	84.907	0.81854	0.09377	6.8418	54.0916	24.7913	21306.4	20.4709	33.5574
MAINTENANCE	58.078	0.91143	0.08886	6.7829	53.2037	28.2864	25788.3	20.5494	32.9640
MAPINSCO	102.614	0.80558	0.13020	6.9164	54.5795	29.0628	27191.1	20.6279	33.7049
				2020					
SST	87.464	0.91848	0.10529	7.0775	56.0853	29.9355	41652.8	20.4815	34.2952
ICT	87.690	0.88012	0.09913	7.1560	56.8649	26.1219	23399.0	20.1100	33.5567
LIBRARY	60.860	0.97302	0.09421	7.0970	55.9769	29.6170	27880.9	20.1885	32.9633
BANK	105.396	0.86717	0.13555	7.2306	57.3528	30.3934	29283.6	20.2671	33.7042
ADMIN	90.247	0.98007	0.11064	7.3916	58.8586	31.2661	43745.4	20.1206	34.2945
AUDITORIUM	90.472	0.94171	0.10448	7.4702	59.6381	27.4525	25491.5	19.7491	33.5560
MAPCED/SBMS	63.643	1.03461	0.09957	7.4112	58.7502	30.9476	29973.4	19.8276	32.9626
BUS SHED	108.178	0.92876	0.14090	7.5448	60.1260	31.7240	31376.2	19.9062	33.7035
ENGINEERING	93.029	1.04165	0.11599	7.7058	61.6318	32.5967	45838.0	19.7597	34.2938
STUDENTS' AFFIARS	93.255	1.00330	0.10983	7.7844	62.4114	28.7831	27584.1	19.3882	33.5552
SCH.COMM	66.425	1.09620	0.10492	7.7254	61.5235	32.2782	32066.0	19.4668	32.9619
SCH.ENV	110.961	0.99035	0.14626	7.8589	62.8993	33.0546	33468.8	19.5453	33.7027
MARKET	95.811	1.10324	0.12135	8.0200	64.4051	33.9272	47930.5	19.3988	34.2930
CRECHE	96.037	1.06489	0.11518	8.0985	65.1847	30.1136	29676.7	19.0274	33.5545
MAINTENANCE	69.208	1.15779	0.11027	8.0396	64.2967	33.6088	34158.6	19.1059	32.9612
MAPINSCO	113.743	1.05193	0.15161	8.1731	65.6726	34.3852	35561.3	19.1844	33.7020
				2021					
SST	98.594	1.16483	0.12670	8.3342	67.1784	35.2578	50023.1	19.0379	34.2923
ICT	98.819	1.12648	0.12054	8.4127	67.9579	31.4442	31769.2	18.6665	33.5538
LIBRARY	71.990	1.21937	0.11563	8.3538	67.0700	34.9394	36251.1	18.7450	32.9604
BANK	116.526	1.11352	0.15696	8.4873	68.4458	35.7158	37653.9	18.8235	33.7013
ADMIN	101.376	1.22642	0.13205	8.6483	69.9516	36.5884	52115.7	18.6771	34.2916
AUDITORIUM	101.602	1.18807	0.12589	8.7269	70.7312	32.7748	33861.8	18.3056	33.5531
MAPCED/SBMS	74.772	1.28096	0.12098	8.6679	69.8433	36.2700	38343.7	18.3841	32.9597
BUS SHED	119.308	1.17511	0.16232	8.8015	71.2191	37.0464	39746.5	18.4626	33.7006
ENGINEERING	104.159	1.28801	0.13740	8.9625	72.7249	37.9190	54208.2	18.3162	34.2909
STUDENTS' AFFIARS	104.384	1.24965	0.13124	9.0411	73.5045	34.1054	35954.4	17.9447	33.5524
SCH.COMM	77.555	1.34255	0.12633	8.9821	72.6165	37.6006	40436.2	18.0232	32.9590
SCH.ENV	122.090	1.23670	0.16767	9.1156	73.9923	38.3769	41839.0	18.1018	33.6999
MARKET	106.941	1.34960	0.14276	9.2767	75.4982	39.2496	56300.8	17.9553	34.2902
CRECHE	107.167	1.31124	0.13660	9.3552	76.2777	35.4360	38046.9	17.5838	33.5516
MAINTENANCE	80.337	1.40414	0.13168	9.2963	75.3898	38.9311	42528.8	17.6624	32.9583
MAPINSCO	124.873	1.29829	0.17302	9.4298	76.7656	39.7075	43931.6	17.7409	33.6992
				2022					
SST	109.723	1.41118	0.14811	9.5909	78.2714	40.5802	58393.3	17.5944	34.2895
ICT	109.949	1.37283	0.14195	9.6694	79.0510	36.7666	40139.5	17.2229	33.5509
LIBRARY	83.120	1.46573	0.13704	9.6105	78.1631	40.2617	44621.4	17.3015	32.9576
BANK	127.655	1.35987	0.17838	9.7440	79.5389	41.0381	46024.1	17.3800	33.6984
ADMIN	112.506	1.47277	0.15346	9.9050	81.0447	41.9108	60485.9	17.2335	34.2887
AUDITORIUM	112.731	1.43442	0.14730	9.9836	81.8243	38.0972	42232.0	16.8621	33.5502
MAPCED/SBMS	85.902	1.52732	0.14239	9.9246	80.9363	41.5923	46713.9	16.9406	32.9569

BUS SHED	130.438	1.42146	0.18373	10.0582	82.3121	42.3687	48116.7	17.0191	33.6977
ENGINEERING	115.288	1.53436	0.15882	10.2192	83.8180	43.2414	62578.5	16.8726	34.2880
STUDENTS' AFFIARS	115.514	1.49601	0.15265	10.2978	84.5975	39.4278	44324.6	16.5012	33.5495
SCH.COMM	88.684	1.58890	0.14774	10.2388	83.7096	42.9229	48806.5	16.5797	32.9561
SCH.ENV	133.220	1.48305	0.18908	10.3724	85.0854	43.6993	50209.3	16.6582	33.6970
MARKET	118.071	1.59595	0.16417	10.5334	86.5912	44.5719	64671.0	16.5118	34.2873
CRECHE	118.296	1.55760	0.15801	10.6119	87.3708	40.7583	46417.2	16.1403	33.5488
MAINTENANCE	91.467	1.65049	0.15310	10.5530	86.4829	44.2535	50899.1	16.2188	32.9554
MAPINSCO	136.002	1.54464	0.19443	10.6865	87.8587	45.0299	52301.8	16.2974	33.6963
				2023					
SST	120.853	1.65754	0.16952	10.8476	89.3645	45.9025	66763.6	16.1509	34.2866
ICT	121.079	1.61918	0.16336	10.9261	90.1441	42.0889	48509.7	15.7794	33.5481
LIBRARY	94.249	1.71208	0.15845	10.8672	89.2561	45.5841	52991.6	15.8579	32.9547
BANK	138.785	1.60623	0.19979	11.0007	90.6319	46.3605	54394.4	15.9365	33.6956
ADMIN	123.636	1.71912	0.17488	11.1618	92.1378	47.2331	68856.1	15.7900	34.2859
AUDITORIUM	123.861	1.68077	0.16871	11.2403	92.9173	43.4195	50602.3	15.4185	33.5473
MAPCED/SBMS	97.032	1.77367	0.16380	11.1813	92.0294	46.9147	55084.2	15.4971	32.9540
BUS SHED	141.567	1.66782	0.20514	11.3149	93.4052	47.6911	56486.9	15.5756	33.6949
ENGINEERING	126.418	1.78071	0.18023	11.4759	94.9110	48.5637	70948.7	15.4291	34.2852
STUDENTS' AFFIARS	126.644	1.74236	0.17407	11.5545	95.6906	44.7501	52694.9	15.0576	33.5466
SCH.COMM	99.814	1.83526	0.16915	11.4955	94.8026	48.2453	57176.7	15.1362	32.9533
SCH.ENV	144.350	1.72940	0.21049	11.6291	96.1785	49.0217	58579.5	15.2147	33.6941
MARKET	129.200	1.84230	0.18558	11.7901	97.6843	49.8943	73041.3	15.0682	34.2844
CRECHE	129.426	1.80395	0.17942	11.8686	98.4638	46.0807	54787.4	14.6968	33.5459
MAINTENANCE	102.597	1.89685	0.17451	11.8097	97.5759	49.5758	59269.3	14.7753	32.9526
MAPINSCO	147.132	1.79099	0.21585	11.9432	98.9517	50.3522	60672.1	14.8538	33.6934

4. CONCLUSION

The assessment of heat stress and investigation of toxic gases in MAPOLY was conducted successfully with future predictions using statistical models. This can indeed improve the perception to the need for close monitoring of the environment vulnerable to hazardous vices with perpetual effect on the human health. Toxic gases like H_2S, NH_3 and CO_2 are well pronounced in MAPOLY while the thermal heat stress is a strong type.

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6. CONFLICT OF INTEREST

There is no conflict of interest with this work.

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