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Atmospheric corrosion from aerosol loading Over Yekepa

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Atmospheric corrosion from aerosol loading Over Yekepa

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Abstract-
In this research, the impact of aerosol loading on the atmospheric corrosion over Yekepa is presented. Fifteen years primary (aerosol optical depth) dataset was obtained from the Multi-angle Imaging Spectro-Radiometer (MISR). Aerosol loading were generated fom the primary dataset. The univariate statistic over Yekepa shows the mean value of 0.52038392857143 0.44143303571429 0.39041071428571 in X, Y and Z directions prespectively. It was confirmed that the current trends of environmental events over Yekepa-Liberia could increase atmospheric corrosion.
Key words: aerosol loading, aerosol, atmospheric corrosion, model

1. Introduction
Aerosol loading is refered to the accumulation of atmospheric aerosols in the atmosphere for a period which can span a decade to several decades. The effects of aerosol loading has been reported to have impact on human health [1,2] and the climate system [3]. It has proven via NASA satellite images that the aerosol loading over West Africa is high at the moment. The major contents of the atmospheric aerosols over West Africa includes CO, SO_2, SO_4, NO_2, soil dust, sahara dust, sea salts, soot and VOC [4-6]. Each of the the aerosol constituents are both dangerous to human health and infracsturucture. In this paper, the effect of aerosol loading on infrastructure was examined with particular interest on atmospheric corrssion. One of the effects of atmospheric corrosion is presented in Figure 1. The cost implication of atmospheric corrosion is huge especially in underdeveloped countries as presented in Figure 2.

Figure 1: Corrosion of industrial infracstucture

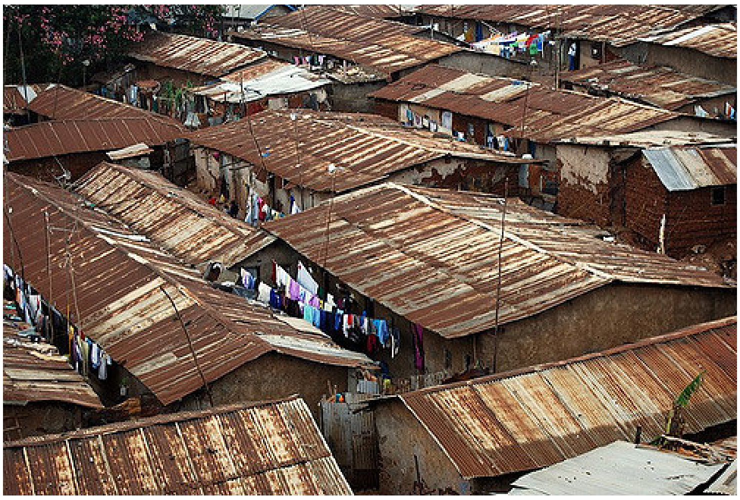

Figure 2: Corrosion of roof tops

In this research, it is proposed that the increment of aerosol loading has significant effect on the atmospheric corrossion over a geographical region. Most gaseous pollutant in the atmosphere results predominantly from biomass burning e.g. coal, oil, agricltural waste, industrial waste, building waste, domestic waste, and gasoline [7]. The gaseous emission from the anthropogenic pollution (atmospheric aerosol) has been identified to contribute to the corrosion of metals. Sometimes, the volume of gaseous pollution is measured in terms of its concentration in air in units of $\mu g/m^3$ or ppm. In the case of aerosol loading, the units is usually unitless because it is derived from aerosol optical depth [4]. A typical example of how gas pollutants are emitted is presented in Table 1.

Table 1:ISO classification of SO2 pollution in annual average [9].

Category	Deposition rate of SO_2 (mg/m^2.day)	Concentration of SO_2 in air (µg/m^3)	Typical environment
P_0	$P_d \leq 10$	$P_d \leq 12$	Rural
P_1	$10 < P_d \leq 35$	$12 < P_c \leq 40$	Urban or Industrial
P_2	$35 < P_d \leq 80$	$40 < P_d \leq 90$	
P_3	$80 < P_d \leq 200$	$90 < P_d \leq 250$	Heavily polluted local environment

In this paper, we examine the relationship between aerosol loading and atmospheric corrosion.

2. Experimental Design, Materials and Methods

Yekepa is located in Liberiaon latitude and longitude of 7.5790° N and 8.5364° W respectively. The community dwells in an agrarian community (as shown in Figure 3) and close to the Guinean border. Before the Liberian civil war, Yekepa was the base for Lamco's iron ore mining operation. Hence, the pollution expected in the area should be category P_2 as defined in Table 1.

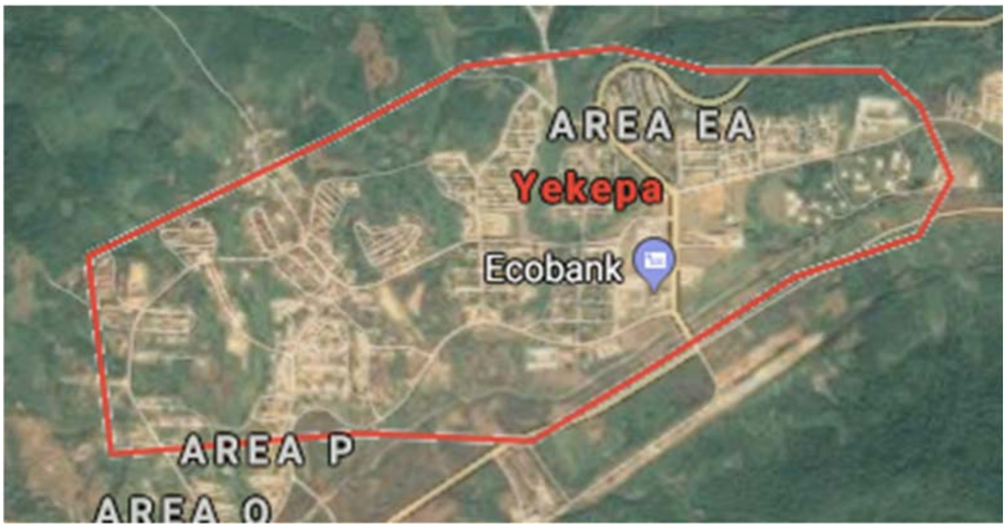

Figure 3: Imagery of Yekepa

The aerosol loading dataset was derived from a fifteen years aerosol optical depth dataset that was obtained from Multi-angle Imaging Spectro-Radiometer (MISR). The derivation of the aerosol loading was accomplished using the West African regional scale dispersion model (WASDM) expressedin equation (1) [4].

$$\psi(\lambda) = {a_1}^2 \cos\left(\frac{n_1 \pi \tau(\lambda)}{2} x\right) \cos\left(\frac{n_1 \pi \tau(\lambda)}{2} y\right) + \cdots \ldots {a_n}^2 \cos\left(\frac{n_n \pi \tau(\lambda)}{2} x\right) \cos\left(\frac{n_n \pi \tau(\lambda)}{2} y\right) \quad (1)$$

Where atmospheric constant gotten from the fifteen years aerosol optical depth (AOD) dataset from MISR, n is the tuning constant, $\tau(\lambda)$ is the AOD of the area and $\psi(\lambda)$ is the aerosol loading. The data treatment of the dataset was done using the excel programme for the spectral bands in the blue, green, red, and near-infrared wavelengths. The averages of the monthly aerosol optical depth was computed. The validation of the summarized dataset was done using mathematical models and statistical softwares. The analysis of equations (1) was done using the C++ codes which was able to process the data precision and derivation of the atmospheric corrosion rate.

The atmospheric corrossion rate of metals over the Yekepa was calculated using the Faraday equation [10]. It is given as :

$$CR\left(\frac{\mu m}{yr}\right) = k\frac{i_{corr}}{d}EW \qquad (2)$$

Where k is a conversion factor (3.27 x 106 μm·g·A^{-1}·cm^{-1}·yr^{-1}), icorr is the corrosion current density in μA/cm^2 (calculated from the measurements of Rp), EW is the equivalent weight, and d is the density of Alloy 22 (8.69 g/cm^3).

Based on equation (2), the modification in the work is the inclusion of aerosol loading.

$$CR\left(\frac{\mu m}{yr}\right) = k\frac{i_{corr}}{d}EW/exp\left(\frac{EW*\varphi(\lambda)}{2.32}\right) \qquad (3)$$

In this study, the corrosion current density of iron was considered and it is given as 3.2 x10^{-3} μA/cm^2. The EW of iron is given as 27.9225.

3. Results and Discussion

The 2D graph for aerosol optical depth (AOD) is presented in Figure 4. The main peaks in the graphs depicts the maximum AOD for each year. The maximum AOD is observed between July to october every year. It is observed that the magnitude of the AOD is somewhat high. The AOD distribution over Yekepa is presented in contour form (Figure 5) and 3D surface plot (Figure 6). The contour representation of the AOD dataset shows a broadly uniform conotur that signifies that the air pollution over the region is fairly uniform. Fairly uniform AOD distribution may signify that the pollution over fifteen years may result from the same source. The 3D surface plot show that there are selective altitudinal distribution of the AOD dataset where some area in Yekepa would experience higher impact of air pollution below the surface of the earth. This altitudinal pollution is quite important to understand the effect of atmospheric corrosion. In the light of the above, we examined the possibilities of marine, industrial, domestic pollution by considering all the spectra bands of the MISR. The statistical analysis of the spectra bands is shown in Tables 2-7. The summation of the univariate statistics, inter-variable correlation, inter-variable covariance, planar regression, inter-parameter correlations and ANOVA show that the AOD of Yekepa has almost exceeded the limits described by World Health Organization (WHO, 2018).

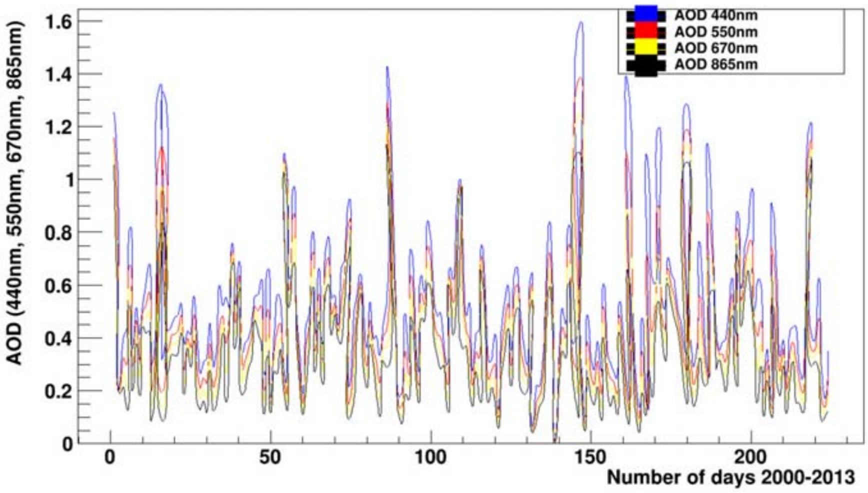

Figure 4: Aerosol optical depth monthly averages for fifteen years

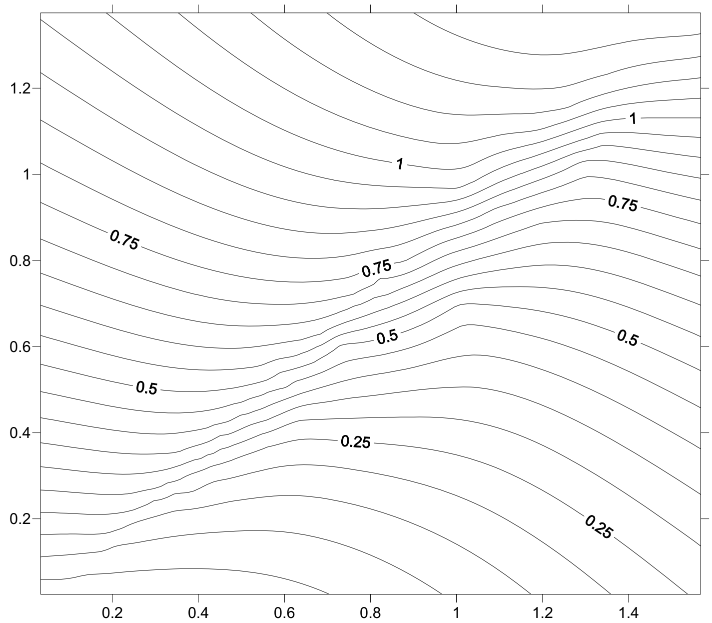

Figure 5: Aerosol optical depth contour distribution over Yekepa

The comparative AOD of each of the spectra band was analyzed in Figure 7. This results shows that the aerosol loading that would be obtained from the AOD is reliable.

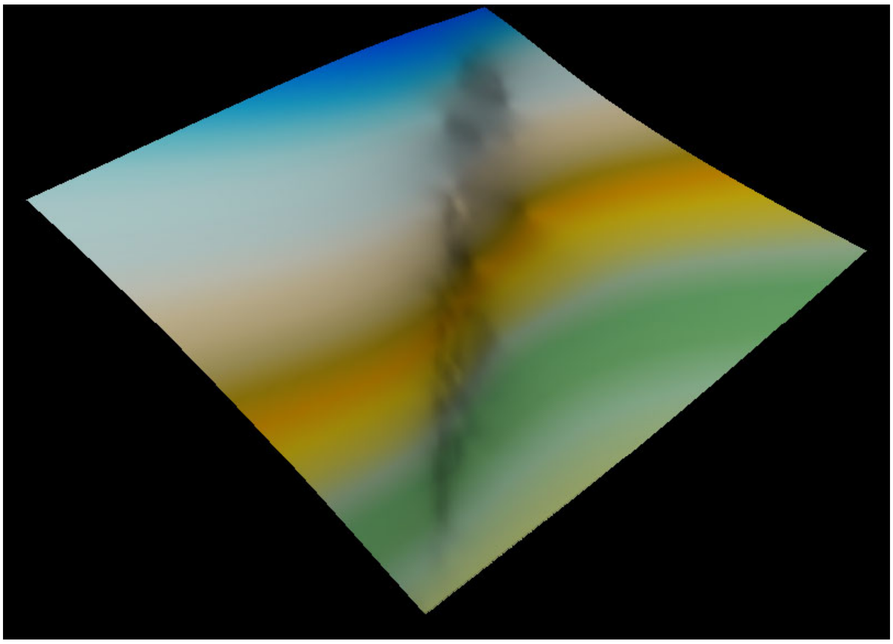

Figure 6: Aerosol optical depth contour distribution over Yekepa

Table 2: Univariate Statistics over Yekepa

	X	Y	Z
Minimum:	0.033	0.025	0.019
25%-tile:	0.354	0.291	0.232
Median:	0.483	0.401	0.343
75%-tile:	0.623	0.536	0.495
Maximum:	1.568	1.375	1.243
Midrange:	0.8005	0.7	0.631
Range:	1.535	1.35	1.224
Interquartile Range:	0.269	0.245	0.263
Median Abs. Deviation:	0.135	0.126	0.124
Mean:	0.52038392857143	0.44143303571429	0.39041071428571
Trim Mean (10%):	0.50008415841584	0.42338118811881	0.37314356435644
Standard Deviation:	0.25372947649359	0.22812280327255	0.216420310869
Variance:	0.064378647241709	0.052040013372927	0.046837750956633
Coef. of Variation:			0.55434009096024
Coef. ofSkewness:			1.2336909703348

Table 3: Inter-Variable Correlation over Yekepa

	X	Y	Z
X:	1.000	0.984	0.952
Y:		1.000	0.991
Z:			1.000

Table 4: Inter-Variable Covariance over Yekepa

	X	Y	Z
X:	0.064378647241709	0.056963744459503	0.052289605707908
Y:		0.052040013372927	0.048932853396046
Z:			0.046837750956633

Table 5: Planar Regression: Z = AX+BY+C over Yekepa

Fitted Parameters

	A	B	C
Parameter Value:	-0.62854231316866	1.6283042915099	-0.0012932739820234
Standard Error:	0.0076807683176205	0.008542930808938	0.00080526581071058

Table 6: Inter-Parameter Correlations over Yekepa

	A	B	C
A:	1.000	0.984	-0.355
B:		1.000	-0.202
C:			1.000

Table 7: ANOVA Table over Yekepa

Source	df	Sum of Squares	Mean Square	F
Regression:	2	10.485741381758	5.2428706908791	1.9589E+005
Residual:	221	0.0059148325276084	2.6763948088726E-005	
Total:	223	10.491656214286		

Coefficient of Multiple Determination (R^2): 0.99943623462237

The atmospheric corrosion rate was calculated from equation 3 as presented in Figure 8. It is observed that the highest atmospheric corrosion can be observed between the months of November and March. This is the period the moistened metallic surface is acted upon by the aerosols in the region. Most imporantly, it can be seen that the magnitiude of corrosion rate can be as high as 3.8 μm per year. Hence, the aerosol loading over the region is directly proportional to the atmospheric corrosion expected.

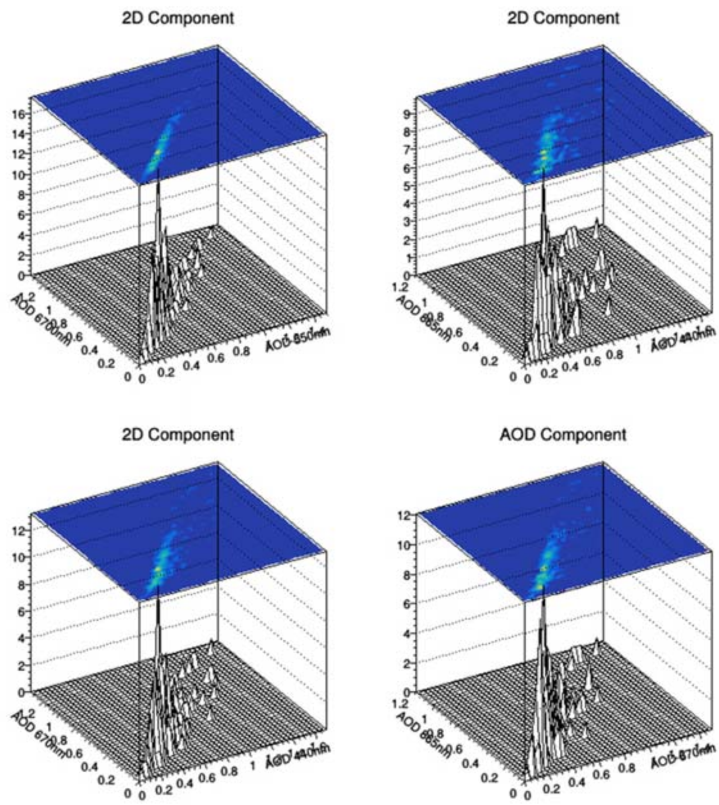

Figure 7: Comparative analysis of spectra bands

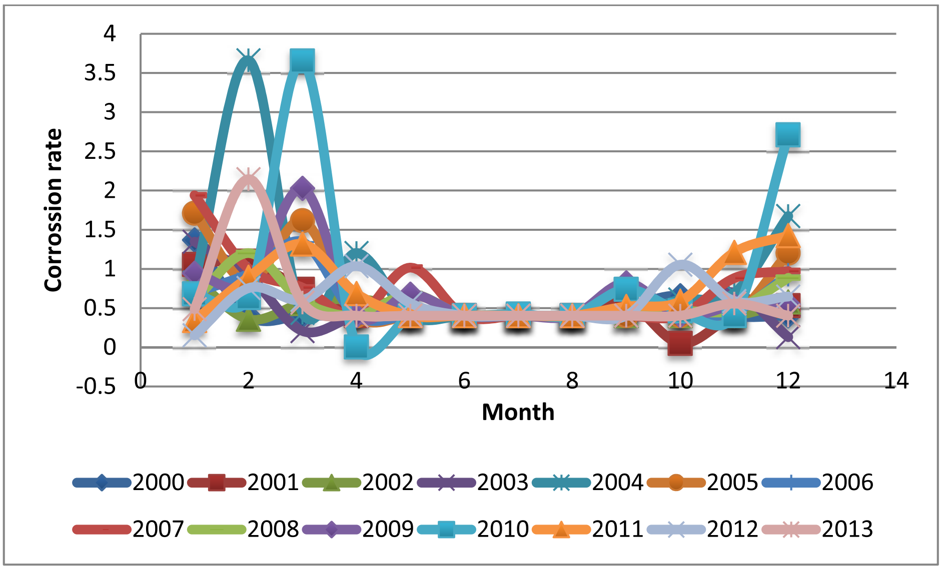

Figure 8: Atmospheric corrossion rate over Yekepa

4. Conclusion

It has been shown that the aerosol loading over the region is directly proportional to the atmospheric corrosion. It was shown that the aerosol loading over Yekepa is high and likely from same source over fifteen years. The statistical analysis of the AOD shows that if the aerosol loading over Yekepa is sustained, there may huge financial consequences if not controlled.

Acknowledgements
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