Int. j. adv. multidisc. res. stud. 2022; 2(5):144-148

Received: 20-07-2022
Accepted: 30-08-2022

International Journal of Advanced Multidisciplinary Research and Studies

ISSN: 2583-049X

Analysis of the simulation of the impact of air environmental pollution on Human Health: A case study of Kaduna, Nigeria

[1] Quadri M Abidemi, [2] Y Umma, [3] I Mustapha, [4] MB Maiyaki, [5] Abayomi David Mark

[1] Department of Biomedical Engineering, Muslim Community College of Health Scienece and Technology, Funtua, Nigeria
[2, 3, 4] Department of Environmental Health, Muslim Community College of Health Science and Technology, Funtua, Nigeria
[5] Kogi State College of Health Science and Technology, Idah, Nigeria

Corresponding Author: **Quadri M Abidemi**

Abstract
A Research work on the Simulation of the Impact of Air Pollution on Human Health was embarked upon. The simulation involved the use of the first 50 generated Random Numbers using Excel. The simulation as well involved Mathematical Models to determine Total Relative Risk (RR-1) total, Pollutant sub-index (PSI), Concentration of the Pollutant (Cj), Health Air Quality Index (HAQI) and Analysis of Variance ANOVA. The pollutants in consideration were Co, SO_2 and PM_{10}. Maximum and minimum values of (RR-1) total for the presence of Co were 4503.722- 2276.809, that of PSI were 3287.717-1662.071 and ANOVA was not significant. Parameters for SO_2 were as follows: 2.851-1.542, 3.108-1.681 also not significant while that of PM_{10} were 2.333-1.645, 2.544-1.793.

Keywords: Simulation, Random Numbers, Total Relative Risk, Pollutants Sub-Index, Health Air Quality Index

1. Introduction

Environment is a very wide concept is a particular nautical or social setting arena or condition this concept of environment encompasses the aspects of physical and social condition in any given situation of an environment. However, Environment is the sum total of condition that surround us at a given point of time and space. It is comprised of the interacting systems of physical, biological and cultural elements which are interlinked both individually and collectively. Environment is the sum total of condition in which an organism has to survive or maintain its life process. It influences the growth and development of living forms. In other words, environment refers to those surroundings that surround living being from all sides and affect their lives in Toto.it consists of atmosphere, hydrosphere, lithosphere and biosphere. Its cheap components are soil, water, air, organisms and solar energy: it has provided us all the resources for leading a comfortable life.

According to P. Gisbert (2010) [9] " Environment is anything immediately surrounding an object and exerting a direct influence on it". Along these lines, Last (2001) [7] defined the Environment for the International Epidemiological Association as: "All which is external to the human host, that can be divided into Physical, Biological, Social, Cultural etc. Any or all of which can influence health status of population. "According to this definition, the environment would include anything that, even genes, are influenced by the Environment in the Short or Long-term. Environment is the immediate and distant of Man, the Water, Air, Land, Shelter and Food is regarded as the immediate Environment but other People, Individual, Family, Communities present an important and formidable aspect of the environment in which We operated. According to Arnola (2010) [1], from the earliest, Man has been striving to control the Environment. But man himself, makes the Environment a greater threat to his own Health and Life.

Pollution currently possesses one of the greatest public health and human right challenge disproportionately affecting the poor and the vulnerable. Pollution can no longer be viewed solely as an Environmental issue. It now affects the Health and Well-being of entire Societies. It is the global analysis of all form of Pollution (air, water, soil and occupational) and its impact on the burden of Disease, Economic Cost and the Environmental and Social Injustice of Pollution. Nearly 92% of Pollution related death occur in low-and middle- income countries. Children face the highest Risks because small exposure to Chemical in utero and early childhood are death, as well as reduced learning and earning potential. The Health Impact of pollution is likely to be much larger than can accurately be quantified today because of Insufficient Data Collection and Scientific Research from many Pollutants. Environmental Pollution as defined by Anderson (2007), is the presence in the air, water, soil of physical or chemical substance in such quantities and duration as to adversely affect Environment the Health of Man, Animal and Plants. Pollution is one of the great existential challenges of 21st century, it threatens the stability of the earth

ecosystem, undermine the economic and social development of nations and endangers the health of billion (Rockstrom *et al*., 2013) [5].

Pollution especially Pollution of Air, Water, and Soil caused by Industrial emissions, Motor vehicle exhaust and Toxic Chemicals has risen sharply in the past century, and in the absence of aggressive intervention ambient air pollution is on track to increase an additional 50% by 2050. The greatest increase will be seen in the growing cities of rapidly Industrializing, Low- and Middle-Income Countries (Lelieveld *et al*., 2015) [6]. Man has generally been described as a species with a lot of destructive tendencies. Much of the history of western civilization has been characterized as exploitative, destructive and non-caring for the environment. The Environment is constantly stressed in various ways that it is presently poising a major threat to human health. Environmental Pollution is the Contamination of the Environment in such a manner as to cause real or potential Harm to Human Health or Well-being; or to damage non-Human. Environmental Pollution is a global issue as the world battles from one environmentally related challenge to the other. By a landmark report commissioned as part of the 2015 Paris Climate Agreement, it was found that rapid and unprecedented changed is required to reduce global warming to a maximum of 1.5 degree Celsius; that if global temperature rise above that point, even by a fraction of a degree, future drought, flood and heat waves will be seriously worsened. Some 10,000 years ago, only few million people inhabited the earth (Our World in Data, 2019) [8] and there were less anthropogenic activities. Today, there are population explosion, and the world is facing an Environmental pollution 7.8billion and Projection of an increase of more than 25% by 2050 (Our World in Data, 2019) [8] the present Anthropogenic epoch will witness billions of inhabitants who consume Resources and consequently produced Enormous Waste. Current population demands are depleting many of the Earth Natural Resources and Ecological Service. The Impact of Humans on the Environment is related to Population size per capital Consumption and the Environmental Damage caused by the technology used in producing what is consumed.

2. Materials and methods

2.1 Materials

Data on Nigerian Ambient Air Quality Standard

This was used to determine the kinds of Air pollutants, time of average and limits to their exposure (Table 1).

Table 1: Nigerian Ambient Air Quality Standard

Pollutants	Time of average	Limits
Particulates as SPM	Daily average of hourly values	250 μg/m^3 -600 μg/m^3
SO_x as SO_2	Daily average of hourly values	0.01 - 0.1 ppm
NO_x as NO_2	Daily average of hourly values (range)	0.04 – 0.06 ppm
COx as CO	Daily average of hourly values 8 - hourly range	10 – 20 ppm
Petrochemical oxidants	Hourly value	0.66 ppm max
Non-Methane hydrocarbon	Daily average of 3-hourly values	160 μg/m^3

Source: Igile *et al*., 2015

Data on Air pollutants levels along major cities in Nigeria

This was used to examine the maximum amount of concentrations of major Air pollutants in the study area (Table 2).

Table 2: Ambient Pollutants Levels along major cities in Nigeria

Sampling location	SO_2	NOx	O_3	NH_3	CO	Reference number
	μg/m^3				ppm	
Ibadan, Nigeria	30±19	63± 16	31±18	463±180	0.59±0.21	This study
Ibadan, Nigeria	34.1	-	-	-	-	20
Ibadan, SW, Nigeria	<0.262-1570.6	<0.188-564.4	-	-	<0.115-1145.2	21
Ilorin, Nigeria	155.22±4.97	-	-	-	-	51
Ilorin, Nigeria	11.07±1.36					52
Kaduna, Nigeria	110	89.0	-	-	14640	53
Port Harcourt, Nigeria	25	141.1			5725	54
NAFCON, Nigeria				33.6		55
Incheon, South Korea	17	71.4			566	41
Uttarakhand, India	15	23	-	-	-	56
Bursa, Turkey		78.8±70.4	55.1±32.5			38

Source: Ipeaiyeda and Adegboyega, 2017

Data on Individual Air Quality Index and exposure-response coefficient (β)

This was used to examine the maximum amount of concentrations individuals can be exposed to (Table 3a&b).

Table 3a: Individual Air Quality Index

IAQI	SO_2 (μg/m^3) 24 h	NO_2 (μg/m^3) 24 h	PM_{10} (μg/m^3) 24 h	CO (mg/m^3) 24 h	O_3 (μg/m^3) 8 h	$PM_{2.5}$ (μg/m^3) 24 h
0	0	0	0	0	0	0
50	50	40	50	2	100	35
100	150	80	150	4	160	75
150	475	180	250	14	215	115
200	800	280	350	24	265	150
300	1600	565	420	36	800	250
400	2100	750	500	48	1000	350
500	2620	940	600	60	1200	500

Source: Shaobo Zhong *et al*., 2019 [10]

Table 3b: exposure-response coefficients (Shaobo Zhong *et al*., 2019) [10]

Lag (Day)	0	1	2	3	4	5
β for RTI (10^{-4})	2.178	2.489	2.835	3.05	3.073	2.468
β for CTI (10^{-4})	1.151	1.867	2.496	3.157	2.991	2.408

Data on Statistical Air Pollution from China Meteorological Observation

This was used in determining the Inter quartile range IQR of the pollutants at International Level (Table 4).

Data on Particle Penetrability and affected Region

This gave details about the amount of concentrations that are harmful in exposure and the parts of the body that are affected (Table 5).

Table 4: Statistical Air Pollution from China Meteorological Observation

Data	Days	Mean ± SE	Min	P25	Median	P75	Max	IQR
Air pollution								
AQI	792	105.5 ± 2.72	15.0	50.5	83.7	135.9	475.2	85.4
$PM_{2.5}$ ($\mu g/m^3$)	792	74.8 ± 2.45	6.7	26.9	54.2	98.6	477.5	71.7
PM_{10} ($\mu g/m^3$)	792	97.1 ± 2.70	0.0	41.6	79.7	129.2	518.3	87.6
CO (mg/m^3)	792	1.2 ± 0.038	0.23	0.59	0.89	1.32	8.14	0.73
O_3 ($\mu g/m^3$)	792	57.5 ± 1.31	2.1	28.9	53.3	79.5	168.0	50.6
NO_2 ($\mu g/m^3$)	792	48.5 ± 0.87	10.4	31.6	42.8	59.8	153.5	28.2
SO_2 ($\mu g/m^3$)	792	10.3 ± 0.37	1.8	3.1	6.4	14.0	85.2	10.9
Meteorological observations								
[a] Wind level	788	1.84 ± 0.021	0.75	1.43	1.72	2.09	4.67	0.66
Temperature (°C)	788	13.5 ± 0.37	-14.5	3.6	14.9	23.1	32.4	19.5
Relative humidity (%)	788	52.1 ± 0.73	8.0	35.8	52.7	68.5	98.6	32.7

Source: Shaobo Zhong *et al*., 2019 [10]

Table 5: Particle Penetrability and affected Parts

Particle size	Region to which penetration can occur
> 11 µm	Captured in the nostrils, do not penetrate into the lower respiratory tract.
7-11µm	Nasal passage
4.7-7 µm	Larynx region
3.3-4.7 µm	Trachea and primary bronchial region
2.1-3.3 µm	Secondary bronchial section
1.1-2.1 µm	Terminal bronchial section
0.65-1.1 µm	Bronchioles
0.43-0.65 µm	Alveolar

Source: Victor Hugo *et al*., 2020.

Random Numbers (First 50)

These were generated from Excel, mg/m^3, and used as variables representing the treatments during the simulation (Table 6). The first three Numbers after decimals were randomly selected and used as the values for the individual pollutants in consideration (Co, SO_2 and PM_{10}).

Table 6: Random numbers (First 50)

0.108736	0.606919	0.282562	0.749434	0.455426
0.283661	0.928917	0.283241	0.318557	0.556608
0.99906	0.018477	0.979118	0.02425	0.849309
0.054598	0.868423	0.809595	0.102468	0.44446
0.861865	0.823043	0.965418	0.151923	0.475932
0.148019	0.214437	0.195845	0.355043	0.022095
0.056965	0.125728	0.067417	0.632646	0.119079
0.873146	0.626431	0.362263	0.847829	0.769265
0.124343	0.059334	0.953532	0.38228	0.594397
0.619473	0.31388	0.869998	0.29823	0.127389

2.2 Methods

Simulation of Total Relative Risk of Individual Pollutants

According to Shaobo Z. *et al*., 2019 [10], there is a repressed Relative Risk (RR) for each pollutant. The short-term total exposure risk of the day will be simulated using the equation below:

$$(RR-1)_{total} = max\left[\frac{C_i}{IQR_i} * (RR_i - 1)\right] \quad (1)$$

Where:

Ci = concentration of individual pollutant i
IQRi = Inter Quartile Range of individual pollutant i

$$RR = exp(\beta * IQR) \quad (2)$$

Simulation of Pollutant Sub-Index (PSI)

In order to reflect the contribution of Individual Pollutants to the overall risk, Pollutant Su-Index (PSI) will be simulated as follows:

$$PSIj = Cj * aj \quad (3)$$

Where:
Cj = Concentration of Pollutant j
aj = RRj-1
RRj = exp (β * IQRj)
β = exposure response coefficient

Simulation of Health Air Quality Index (HAQI)

The HAQI will be simulated using the formula below:

$$HAQI = \max(PSIj) \quad \text{(Shaobo Z. } et\ al\text{., 2019)} \quad (4)$$

Experimental Design Analysis of the Research

The Experimental Design that was used for this Research Work is Completely Randomized Design. This is because the Results of the Simulation is only the Treatments that were used in the analysis. And Analysis of Variance, ANOVA, was used in analyzing the Results.

Sampling

Randomized Sampling Method was used in this Research Work. Random Sampling Method is generally accepted in terms of Sampling and it is reliable in getting rid of biasness in treatments' selection.

Sample Size (n)

The sample size, n, was determined using a simplified sample size determination method described by Singh A.S. and Masuku M.B., 2014:

$$n = \frac{N}{[1+Ne^2]} \quad (5)$$

n = Sample Size
N = Population
e = Precision = 0.05 under 95% Level of Confidence

$$n = \frac{50}{[1+50(0.05^2)]}$$

n = 40

Hypothesis of the Study
Ho: The state is free from the presence of Air pollutants.
Ha: The state is not free from the presence of Air pollutants.

3. Results and discussion

Simulation Result of presence of Co in the Atmosphere
Table 7 and Fig 1 present the results of simulation of quantity of Co present in the Atmosphere in μgm^{-3}. The table shows the mean values of the quantities present which are used in determining the PSI and (RR-1) respectively. The highest value of PSI is 3287.717 under the mean value of 649.875 while the lowest value of PSI is 1662.071 under the mean value of 328.5. The highest value of (RR-1) of 4503.722 is recorded under the mean value of 649.875 while the lowest value of 2276.908 was recorded under the mean value of 328.5.

Table 7: Presence of Co Simulation's Results (μgm^{-3})

	556	127	749	869	606
	455	594	318	953	928
	382	769	024	362	018
	298	119	102	067	868
	283	022	151	195	823
	282	475	355	965	214
	059	444	632	809	125
	313	849	847	979	626
∑	2628	3399	3178	5199	4208
χ	328.5	424.875	392.25	649.875	526
PSI	1662.071	2149.442	2009.687	3287.717	2661.034
(RR-1) total	2276.809	2944.441	2752.996	4503.722	3645.252

X = mean value

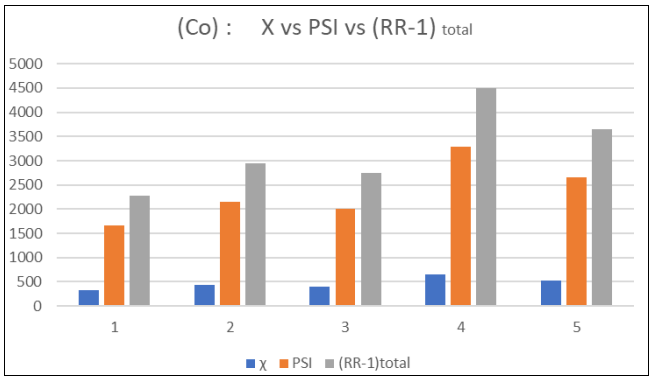

Fig 1: X vs PSI vs (RR-1) total values for Co

Analysis of the values of the presence of Co in the Atmosphere
From the Table 8, it is shown that there is no significant effect from the side of alternate hypothesis, meaning that the null hypothesis stays as it is accepted that the state is free from the effects of Co based on the result of simulation.

Table 8: ANOVA table for simulation of presence of Co

SV	SS	df	ms	f
treatment	501853.1	7	71693.3	0.67
error	3401101.3	32	106284.42	
total	3902954.4			

Simulation Result of presence of SO_2 in the Atmosphere
As shown in Table 9 and Fig 2, the maximum and minimum average mean values of SO_2 present in the Atmosphere are respectively 645 and 420.5. The Results of PSI and (RR-1) $_{total}$ is stated in both the table and figure. From the both, table and figure, the highest and lowest values of PSI are 3.108E14 and 1.681E14, and the highest and lowest values of PSI and (RR-1) $_{total}$ 2.851E13 and 1.542E13 respectively.

Table 9: Presence of SO_2 Simulation's Results (μgm^{-3})

	108	631	282	298	124
	283	059	283	382	619
	999	626	979	847	928
	054	125	809	632	600
	861	214	965	355	953
	148	823	195	151	869
	056	868	067	102	318
	873	018	362	024	749
∑	3382	3364	3942	2791	5160
χ	422.75	420.5	492.75	348.875	645
(RR-1) total E13	1.869	1.859	2.178	1.542	2.851
PSI (E14)	2.037	2.026	2.374	1.681	3.108

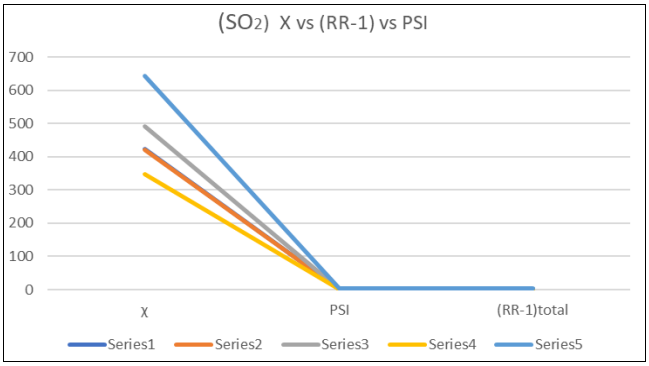

Fig 2: X vs PSI vs (RR-1) total values for SO_2

Analysis of the values of the presence of SO_2 in the Atmosphere
As shown in the table 10, the effect of the alternate hypothesis is not significant, meaning that the null hypothesis stays as it is accepted and conclusively, the state is free from the presence of SO_2 based on the result of simulation.

Table 10: ANOVA table for simulation of presence of SO_2

SV	SS	df	ms	f
treatment	127619.845	7	18231.40645	0.203
error	2872447.255	32	89763.98	
total	3000067.1			

Simulation Result of presence of PM_{10} in the Atmosphere
From the Table 11 and Fig 3, average values of the presence of PM_{10} are ranged from 372.125 the lowest to 499.25 the highest. The lowest average value produces PSI

value of 1.783E14, (RR-1) total value of 1.645E13, while the highest average value produces PSI value of 2.405E14, (RR-1) total value of 2.207E13.

Table 11: Presence of PM_{10} Simulation's Results (μgm^{-3})

	108	999	861	056	928
	606	018	823	125	283
	282	979	965	067	868
	749	024	151	632	054
	455	849	475	119	214
	556	444	022	769	148
	318	102	355	847	626
	283	809	195	362	873
∑	3357	4224	3847	2977	3994
χ	419.625	528	480.875	372.125	499.25
(RR-1) totalE13	1.855	2.333	2.125	1.645	2.207
PSIE14	2.023	2.544	2.317	1.793	2.405

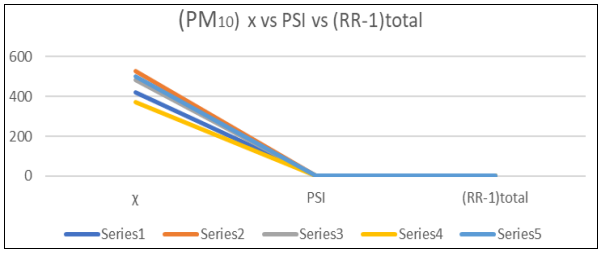

Fig 3: X vs PSI vs (RR-1) total values for PM_{10}

Analysis of the values of the presence of PM_{10} in the Atmosphere

From the table 12, it is shown that the result is highly significant, meaning that the Ha is accepted while the Ho is rejected. This shows that, through simulation, the state is not free from PM_{10}.

Table 12: ANOVA table for simulation of presence of PM_{10}

SV	SS	df	ms	f
treatment	403325.1	7	57617.87	440
error	4152.443	32	129.76	
total	4555768.975			

4. Conclusion

Having reached the end of the Research, the following conclusions were made:

1. Maximum value of (RR-1) total for the presence of Co was 4503.722 and the minimum value was 2276. 809.
2. Maximum and minimum values of PSI for the presence of Co were 3287.717 and 1662.071.
3. ANOVA shows that the presence of Co is not significant in the study Area.
4. Maximum and minimum values of (RR-1) total for the presence of SO_2 are 2.851E13 and 1.542E13.
5. Maximum and minimum values of PSI for the presence of SO_2 are 3.108E14 and 1.681E14.
6. ANOVA shows that the presence of SO_2 in the study Area is not significant.
7. Maximum and minimum values of (RR-1) total for the presence of PM_{10} are 2.333E13 and 1.645E13.
8. Maximum and minimum values of PSI for the presence of PM_{10} are 2.544E14 and 1.793E14.
9. In comparison with tables 3.1 and 3.2, the state is free from the presence of Co and SO_2.
10. In comparison with table 3.5, the values of PSI and (RR-1) total show that the presence of the pollutants will not cause penetration into the lower respiratory tract of inhabitant because the values are greater than 11µm.
11. That the values of HAQI of the individual pollutants are their highest values.

    N.B: The higher the RR, the higher the PSI and the lower the Risk.

5. References

1. Arnoda. Environment decision making in environmental health: from evidence to action. London, 2010.
2. Anderson PWS. Contaminants in drinking water, Annual water quality report MISSOUR, Department of Natural Resources, 2017.
3. Ayodele Rotimi Ipeaiyeda, Dayo Amos Adegboyega. Assessment of Air Pollutant Concentration Near Major Roads in Residential, Commercial and Industrial Areas of Ibadan City, Nigeria, J.Health Pollution. 2017; 7(13):11-21.
4. Igile GO, Uboh FE, Luke UO, Ufot SU, Robert, Ebong PE. Environmental Quality in Communities around Warri Refining and Petrochemical Company (WRPC), Niger Delta Region, Nigeria. Journal of Scientific Research and Reports. 2015; 7(6):400-412.
5. Rockstrom J, Steffen W, None K, Person A, Chaplin FS, Lanbin EF, *et al*. A safe operating space for humanity, 2013.
6. Lelieveld J, Evans JS, Fnais M, Giannadaki D, Pozzer A. The contributions of outdoor air pollution source to premature mortality on a global scale, 2015.
7. Last. Department of food, Environment and rural affairs review of diffuse water pollution from Agricultural in England, 2001.
8. Our World Data. Report of world economic forum Annual meeting, cape town, south Africa, 2019.
9. Gisbert P. Fundamental of sociology, kindle edition, 2010.
10. Shaobo Zhong, Zhichen Yu, Wei Zhu. Study of the effects of Air pollutants on Human Health based on Baidu Indices of Diseases Symptoms and Air Quality Monitoring Data in Beijing, China. International Journal of Environmental Research and Public Health. 2019; 16(6):1014.
11. Singh AS, Masuku MB. Sampling Techniques and Determination of Sample Size in applied statistics Research: An Overview, Int. Journal of Economics, Commerce and Management, United Kingdom. 2014; 2(11):1-22.
12. Victor Hugo Borja-Aburto, Jose Alberto Rosales-Castillo, Victor Mannuel Torres-Meza, German Corry, Gustavo Olaiz-Fernandez. Evaluation of Health effects of Pollution, unpublished post graduate project, Mexico, 2020.