

Hydrocarbon Pollutants Are Major Air and Soil Pollutants from Filling Stations in Abakaliki, Southeast Nigeria

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Abstract: We can never underestimate the role of filling stations and hydrocarbons pollutants on air, water and soil quality. In most developing countries with little, or no access to self-service dispensers; drivers, commuters, workers and neighbours are constantly exposed to dangers of inhaling these pollutants. In addition, the leakage and contamination of water, aquifer and agricultural and non-agricultural soils is a serious environmental problem. The cost of cleansing and remediation are catastrophic. At Ebonyi State University we investigated the roles of four filling stations located at high traffic and accessible agricultural soils to hydrocarbon air and soil pollutants. The results link air gaseous concentrations of carbon monoxide amongst others and soil properties.

Key words: Filling stations • Hydrocarbon pollutants • Air and soil quality • Human health • Remediation

INTRODUCTION

In both developed and developing countries hydrocarbon products, be it crude oil or refined petroleum are mined and distributed via pipelines, trucks, cylinders, cans and automobiles. Most of the products are in gaseous, liquid or solid state; mostly volatile, persistent, explosive, mobile, accumulative, hard to degrade, cleanse or convert to harmless substances [1,2]. Unlike other fossil fuel, the hydrocarbon pollutants from petroleum comprise of range of saturated alkanes, from methane – CH_4 ; ethane – C_2H_6 and propane – C_3H_8 ; through straight and branched chains to $\text{C}_{17}\text{H}_{34}$. Aromatic hydrocarbons and organic components containing nitrogen and sulphur are important constituents of some petroleum deposits. The hydrocarbons derived from coal and petroleum is major organic macropollutants in air, soil and water [1-3].

In comparison with air and water, soil is more variable and complex in composition and functions as a sink for pollutants, a filter which retards the passage of chemicals to the groundwater and a bioreactor in which many organic pollutants can be decomposed. According to these scientists, soils occurrence at the interface between the land and the atmosphere, makes it a recipient of a diverse range of polluting chemicals transported in the

atmosphere. Further inputs of pollutants to the soil occurs as a result of agricultural and waste disposal practices, but in general, the most severe pollution usually results from industrial and urban uses of land.

Air pollution exists in gaseous or particulate form. The former includes substances such as sulphur dioxide and ozone. Particulates air pollutants are highly diverse in chemical composition and size. They include both solid particles and liquid droplets and range in size from a few nanometers to hundreds of micrometers in diameter [2]. In Abakaliki Metropolis there are over 1000 filling stations, including the Nigeria National Petroleum Company (NNPC) depot, popularly called Mega Station. They are actively involved in the discharge and dispensing of petroleum products: petrol, diesel, kerosene and lubricants. The fuel tanks are buried beneath the soil in concrete platforms and sometimes on earthen platforms. On the other hand, the total number of registered automobiles in Ebonyi comprise of over 1.5 million cars, 8010 keke-na-pepe, 3600 diesel motor and over 1.7 million motor bikes [4].

Transportation is one of the sectors that haul passengers, goods and services. Transportation goes with fuel needs and demands. Similarly, are the air, water and soil pollution arising from such businesses. Also the

effects on health of drivers, commuters, workers and the citizens. Hence, this work reports hydrocarbon pollutants as major pollutants from filling stations in Abakaliki, Southeast Nigeria.

MATERIALS AND METHODS

Geographical and Climatic Information: Abakaliki lies within Longitude $08^{\circ} 06' E$ and Latitude $06^{\circ} 19' N$ at an altitude of 128 meters above sea level. It lies within the derived savannah belt of south eastern Nigeria. The mean annual rainfall for 25 years (1977 – 2012) was 154.75 mm spread across April – November; while the mean annual minimum and maximum temperatures for same period were 23.58 and $32.40^{\circ}C$, respectively; with higher and lower temperatures during the dry and rainy seasons respectively. On the other hand, the average annual sunshine hours for same period was 5.13, while the mean annual relative humidity@09/15 hrs was 80.2 and 59.93% respectively; with higher and lower relative humidity during rainy and dry season, respectively. The rainfall, temperature and relative humidity of the area are presented in Figures 1, 2 and 3 [5]. The soil belongs to the order (Ultisol) classified as Typic Haplustult [6].

Identification of Filling Stations

Four Filling Stations Namely: Mega Filling Station (MFS) and Presco Filling Station (PFS) along Abakaliki – Enugu Highway; Spera-in-deo Filling Station (SFS) along Abakaliki – Afikpo Highway and Rice Mill Filling Station (RFS) along Abakaliki – Ogoja Road; with Ebonyi State University Secondary Football Field (EBSF) as control, were selected in view of their high traffic, commuters and nearness to agricultural fields.

Sampling Tools and Methods: The outdoor gaseous air concentrations in the filling stations were monitored with portable environmental gas monitors (GASMAN Model) CO19256H; NO₂19835H; NH₃19736H and SO₂19752H, at 8 – 11 am peak commuter times, for 5 days a week x 3 months x 3 years. The detection range was set by manufacturers at 0 – 50 ppm ($mg L^{-1}$) with alarm set at 3 ppm ($mg L^{-1}$). The four monitors were hung above a 2 meter wooden platform at four points (that served as replicates) at equal distance of 10 meters. Hourly readings were taken at stability. Similarly, auger and core soil samples at 0 – 30 cm soil depths, were collected at four points for the determination of soil physicochemical properties.

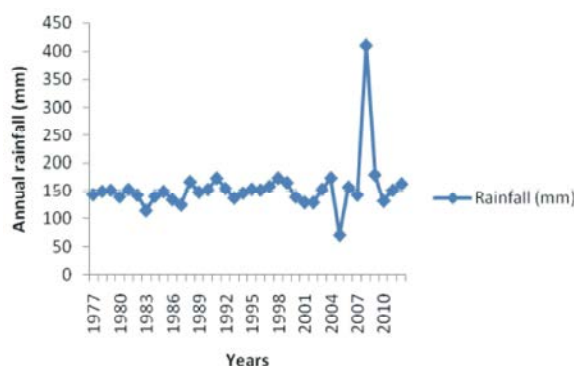


Fig. 1: Annual rainfall for Abakaliki (1977 - 2012) - mm

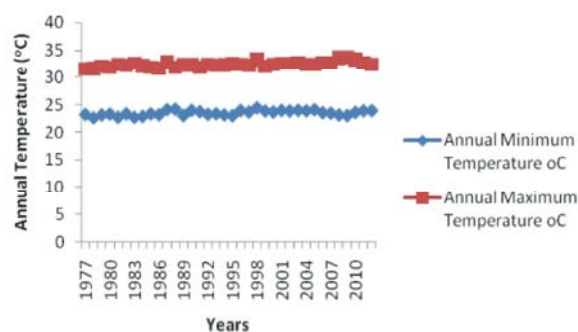


Fig. 2: Annual minimum and maximum temperature for Abakaliki (1977 - 2012) - $^{\circ}C$

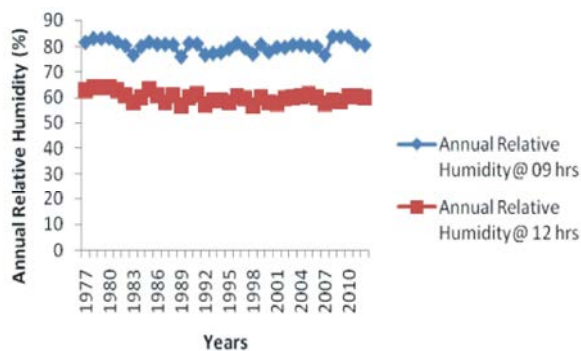


Fig. 3: Annual relative humidity@09/12 hrs at Abakaliki (1977 - 2012) - %

Laboratory Procedure and Protocols

Chemical Properties: The Total Nitrogen was analyzed using Modified Macro-Kjeldahl Digestion Procedure as described by Bremner and Mulvaney [7]. Soil pH (KCl) was measured using soil:KCl ratio of 1:1, using a glass electrode pH meter. Organic carbon was determined by Walkley and Black Method as described by Nelson and Sommers [8]; while organic matter was obtained by multiplying the values for organic carbon with Van-Bremner factor of 1.724.

Available phosphorus was determined using Bray-2 extractant as described by Olsen and Sommers [9]. Exchangeable bases (Ca, K and Na) were determined by the Method described by Juo [10]; while Mg was analyzed using a method described by Tel and Rao [11]. Total exchangeable acidity was determined using the method described by Tel and Rao [11]. The Effective Cation Exchange Capacity (ECEC) was determined by summation (Total Exchangeable Bases + Total Exchangeable Acidity). The percentage base saturation was calculated by dividing total exchangeable bases by effective cation exchange capacity and multiplying by 100. The soil bulk density was determined using the procedure described by Black and Hartage [12]; while total porosity was calculated from bulk density (D_b) and assumed particle density (P_d) of 2.65 g cm^{-3} . Gravimetric moisture content was determined using pressure plate apparatus as described by Klute and Dirksen [13].

Statistical and Data Analysis: The data accruing from the work were subjected to analysis of variance for randomized complete block design for agricultural and biological sciences. Further mean differentiation was followed by Fishers Least Significant Difference (F-LSD). The standard error (SE) and Means were used to compute the coefficient of variation by multiplying by 100% [14, 15]. All values for gaseous air concentration were recorded in mg L^{-1} , where $1 \text{ ppm} = 1 \text{ mg L}^{-1}$ [16].

RESULTS AND DISCUSSION

Results

Carbon Monoxide Air Concentration: There was statistical ($P = 0.05$) carbon monoxide air concentrations amongst the filling stations. The Mega Filling Station gave highest CO air concentration of 0.85 mg L^{-1} ; followed by the Spera-in-deo Filling Station with 0.84 mg L^{-1} and least in control (EBSU Secondary School) that gave 0.77 mg L^{-1} . These values were less than the limits set by WHO of 30 ppm (mg L^{-1}); US/California National Ambient Air Quality Standard of 9.0 ppm (mg L^{-1}) and Nigeria Environmental Protection Council (NEPC) of 35 ppm (mg L^{-1}) – Table 1 [17-20]. The same trend was observed for cumulative periods of monitoring (Table 2).

Nitrogen Dioxide Air Concentrations: There was statistical ($P = 0.05$) nitrogen dioxide air concentrations amongst the filling stations. Two of the stations (Mega and Spera-in-deo) gave highest value of 0.04 mg L^{-1} . Others, including control gave uniform values of 0.03 mg

L^{-1} respectively. The values were within permissible limits of 0.12, 0.05 and $0.12 \text{ ppm (mg L}^{-1})$ set by WHO; US/California and NEPC (Table 1). The same trend was observed in cumulative periods (Table 2).

Sulphur Dioxide Air Concentrations: There was statistical ($P = 0.05$) significant sulphur dioxide air concentrations amongst the filling stations. The Mega Station gave highest sulphur dioxide air concentration of 0.04 mg L^{-1} and least values of 0.02 mg L^{-1} were recorded at rice mill station and control. The same trend was observed in cumulative assessment. All the filling stations passed the permissible limits of 0.20 and 0.14 mg L^{-1} set by WHO and US/California. They failed the NEPC standard of $0.01 \text{ ppm (mg L}^{-1})$.

Ammonia Air Concentration: There were no statistical significant ammonia air concentrations amongst the filling stations. Even the control recorded higher level of ammonia, 0.03 mg L^{-1} . They also passed the permissible limits of 0.28; $0.04 - 0.15$ and 0.20 mg L^{-1} set by WHO; US/California and NEPC.

Soil Texture: There were no significant differences in soil separates of the filling stations. The Presco Filling Station gave highest sand proportion of 748 g kg^{-1} and least, 508 g kg^{-1} in control. The silt portion was higher in control, 378 g kg^{-1} and least in Spera-in-deo station, 65 g kg^{-1} . The clay fraction was same in all stations, 114 g kg^{-1} ; except Mega Station that gave 104 g kg^{-1} . All stations fell within silty-clay textural classification (Table 3).

Soil Bulk Density, Total Porosity and Gravimetric Moisture Content: There were neither statistical variations amongst filling stations on bulk density, total porosity and gravimetric moisture. The Presco Filling Station gave highest bulk density of 1.38 g cm^{-3} , while Rice Mill Filling Station gave least value of 1.27 g cm^{-3} . Similarly, total porosity was highest in Rice Mill Station, 51.75% and least at Presco Filling Station, 48%. The gravimetric moisture content was highest in control, 24.75% and least in Presco, 18.25%.

Chemical Properties of the Soil: The highest pH of 7.90 was in Presco Filling Station and lowest, 6.10 in control with coefficient of variation (cv) of 10.07% between stations; while the highest available phosphorus of 49.80 mg kg^{-1} was in Spera-in-deo Filling Station and lowest, 23.8 mg kg^{-1} in control with cv of 28.95%. The highest total nitrogen, 0.28 g kg^{-1} was in Spera-in-deo station and

Table 1: Gaseous air concentrations of the filling stations

Pollutants	CO	NO ₂	SO ₂	NH ₃
MFS	0.85	0.04	0.04	0.03
PFS	0.82	0.03	0.03	0.03
SFS	0.84	0.04	0.03	0.02
RFS	0.81	0.03	0.02	0.02
EBSF	0.77	0.03	0.02	0.03
FLSD(0.05)	0.029*	0.009*	0.008*	0.011ns
CV(%)	1.79	12.59	14.32	20.41
WHO	30	0.12	0.20	0.28
US/California	9.0	0.05	0.14	0.04 – 0.15
NEPC	35	0.12	0.01	0.20

MFS = Mega Filling Station; PFS = Presco Filling Station; SFS = Spera-in-deo Filling Station; RFS = Rice Mill Filling Station; EBSF (Control) = Ebonyi State University Secondary School Field. WHO = World Health Organisation Standard; US/California National Ambient Air Quality Standard; NEPC = Nigeria Environmental Protection Council Standard. CV = Coefficient of Variation. Values represent means of 4 replicates x 5 days m⁻¹ x 3 months x 3 yrs (mg L⁻¹).

Table 2: Cumulative period air concentrations of the filling stations:

Pollutants	CO					NO ₂					SO ₂					NH ₃				
CMP	MFS	PFS	SFS	RFS	EBSF	MFS	PFS	SFS	RFS	EBSF	MFS	PFS	SFS	RFS	EBSF	MFS	PFS	SFS	RFS	EBSF
2	0.855	0.833	0.843	0.815	0.793	0.038	0.035	0.045	0.025	0.033	0.028	0.023	0.028	0.025	0.015	0.023	0.02	0.02	0.03	0.03
4	0.833	0.805	0.828	0.803	0.760	0.040	0.038	0.050	0.030	0.025	0.018	0.020	0.028	0.015	0.010	0.033	0.02	0.01	0.03	0.04
6	0.855	0.840	0.840	0.810	0.745	0.038	0.030	0.045	0.033	0.035	0.038	0.033	0.035	0.025	0.023	0.030	0.04	0.02	0.02	0.03
8	0.850	0.818	0.820	0.805	0.700	0.040	0.033	0.035	0.028	0.025	0.040	0.023	0.025	0.020	0.018	0.028	0.03	0.02	0.03	0.03
10	0.855	0.843	0.850	0.813	0.698	0.040	0.030	0.043	0.033	0.028	0.045	0.030	0.033	0.025	0.020	0.023	0.03	0.02	0.00	0.00
12	0.853	0.831	0.850	0.800	0.710	0.040	0.035	0.038	0.035	0.030	0.043	0.038	0.045	0.025	0.015	0.028	0.03	0.01	0.02	0.03
FLSD	0.014*	0.037*	0.044*	0.029*	0.011*	ns	0.011*	0.01*	ns	0.009*	ns	0.007*	0.009*	0.008*	0.008*	0.01*	0.01	0.01	ns	ns
WHO	30	30	30	30	30	0.12	0.12	0.12	0.12	0.12	0.20	0.20	0.20	0.20	0.20	0.28	0.28	0.28	0.28	0.28
US/C	9.0	9.0	9.0	9.0	9.0	0.05	0.05	0.05	0.05	0.05	0.14	0.14	0.14	0.14	0.14	0.04	0.04	0.04	0.04	0.04
NEPC	35	35	35	35	35	0.12	0.12	0.12	0.12	0.12	0.01	0.01	0.01	0.01	0.01	0.20	0.20	0.20	0.20	0.20

CMP = Cumulative Monitoring Period (weeks). MFS = Mega Filling Station; PFS = Presco Filling Station; SFS = Spera-in-deo Filling Station; RFS = Rice Mill Filling Station; EBSF (Control) = Ebonyi State University Secondary School Field. WHO = World Health Organisation Standard; US/California National Ambient Air Quality Standard; NEPC = Nigeria Environmental Protection Council Standard. Values represent means of 4 replicates x 10 days x 3 yrs (mg L⁻¹); FLSD(0.05) = Fishers Least Significant Difference at 95% Confidence Interval.

Table 3: Physical properties of the soils at the filling stations

Parameters	Sand	Silt	Clay	Texture	BD	TP	GMC
MFS	708	188	104	SL	1.35	49.00	19.00
PFS	748	138	114	SL	1.38	48.00	18.25
SFS	818	65	114	SL	1.31	51.00	20.75
RFS	728	158	114	SL	1.27	51.75	18.25
EBSF	508	378	114	SL	1.32	49.25	24.75
Mean	702	186	112	SL	1.33	49.80	20.20
SE	11.61	11.61	0.45	Na	0.02	3.23	5.96
FLDS(0.05)	ns	ns	ns	na	ns	ns	ns
CV(%)	16.54	62.39	3.99	na	0	3.05	14.27

MFS = Mega Filling Station; PFS = Presco Filling Station; SFS = Spera-in-deo Filling Station; RFS = Rice Mill Filling Station; EBSF (Control) = Ebonyi State University Secondary School Field. SE = Standard Error; FLSD(0.05) = Fishers Least Significant Difference at 95% Confidence Interval; CV = Coefficient of Variation; SL = Silty-Loam. P = Available Phosphorus (mg kg⁻¹); N = Total Nitrogen (g kg⁻¹); OC = Total Organic Carbon (g kg⁻¹); OM = Total Organic Matter (g kg⁻¹); Ca, Mg, K, Na = Exchangeable Calcium, Magnesium, Potassium and Sodium (cmol kg⁻¹); EA = Exchange Acidity (cmol kg⁻¹); ECEC = Effective Cation Exchange Capacity (cmol kg⁻¹) and BS = Base Saturation (%). All values except for texture is for 4 replicates x 10 days x 3 yrs. Values for texture is only for first sampling at first yr.

Table 4: Chemical Properties of the soils at the filling stations

Parameters	pH	P	N	OC	OM	Ca	Mg	K	Na	EA	ECEC	BS
MFS	7.10	29.50	0.140	1.17	2.02	5.60	2.40	0.138	0.290	0.16	8.588	98
PFS	7.90	36.50	0.156	1.66	2.86	5.80	2.80	0.156	0.339	0.08	9.175	99
SFS	7.70	49.80	0.280	0.53	0.91	4.40	2.80	0.164	0.268	0.16	7.792	98
RFS	7.70	30.90	0.140	1.44	2.44	6.80	3.20	0.115	0.299	0.16	10.57	98
EBSF	6.10	23.80	0.112	2.02	3.48	5.20	2.00	0.131	0.308	0.24	7.879	97
Mean	7.30	34.10	0.166	1.36	2.34	5.56	2.64	0.141	0.301	0.16	8.789	98
SE	0.75	9.87	0.07	0.56	1.11	0.88	0.46	0.04	0.03	0.06	1.14	0.71
FLSD	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
CV(%)	10.07	28.95	39.69	41.22	47.58	15.76	17.28	27.82	8.69	35.36	12.97	0.72

MFS = Mega Filling Station; PFS = Presco Filling Station; SFS = Spera-in-deo Filling Station; RFS = Rice Mill Filling Station; EBSF (Control) = Ebonyi State University Secondary School Field. SE = Standard Error; FLSD(0.05) = Fishers Least Significant Difference at 95% Confidence Interval; CV = Coefficient of Variation; SL = Silty-Loam. P = Available Phosphorus (mg kg⁻¹); N = Total Nitrogen (g kg⁻¹); OC = Total Organic Carbon (g kg⁻¹); OM = Total Organic Matter (g kg⁻¹); Ca, Mg, K, Na = Exchangeable Calcium, Magnesium, Potassium and Sodium (cmol kg⁻¹); EA = Exchange Acidity (cmol kg⁻¹); ECEC = Effective Cation Exchange Capacity (cmol kg⁻¹) and BS = Base Saturation (%). All values is for 4 replicates x 10 days x 3 yrs

least; 0.112 g kg^{-1} in control with cv of 39.96%. On the other hand, the highest organic carbon, 2.02 g kg^{-1} was in control and least; 0.53 g kg^{-1} in Spera-in-deo station with cv of 41.22%. The same order in soil organic matter, 3.48 and 0.91 g kg^{-1} in control and Spera-in-deo stations, respectively (Table 4).

In terms of exchange calcium, the highest value, $6.80 \text{ cmol kg}^{-1}$ was in Rice Mill Station and least, $4.40 \text{ cmol kg}^{-1}$ in Spera-in-deo Station with cv of 15.76%. That of magnesium was $3.20 \text{ cmol kg}^{-1}$ in Rice Mill Station and 2.0 cmol kg^{-1} in control with cv of 17.28%. The exchangeable potassium of $0.164 \text{ cmol kg}^{-1}$ was in Presco Filling Station and $0.131 \text{ cmol kg}^{-1}$ in control with cv of 27.82%; while sodium was $0.339 \text{ cmol kg}^{-1}$ in Presco Station and $0.268 \text{ cmol kg}^{-1}$ in Spera-in-deo Station with cv of 8.69%. The exchangeable acidity was $0.24 \text{ cmol kg}^{-1}$ in control and $0.08 \text{ cmol kg}^{-1}$ in Presco Station with cv of 35.36%. The effective cation exchange capacity (ECEC) was $10.574 \text{ cmol kg}^{-1}$ in Rice Mill Station and $7.879 \text{ cmol kg}^{-1}$ in control; with cv of 12.97%, while base saturation (BS) was 99% in Presco Station and 97% in control with cv of 0.72% (Table 4).

DISCUSSION

Air Quality of Filling Stations: The fact that all the filling stations gave higher carbon monoxide air concentrations ($0.81 - 0.85 \text{ mg L}^{-1}$) shows the contribution of hydrocarbons. The level in control (0.77 mg L^{-1}) show other sources linked to hydrocarbons like automobiles. That of nitrogen dioxide and sulphur dioxide followed same pattern, except ammonia where control gave higher value (0.03 mg L^{-1}); showing other sources not related directly to hydrocarbons. The fact that all the gaseous air concentrations passed the standards established by WHO, US/California and NEPC, except for SO_2 that failed NEPC limit is temporarily consoling [17-20] The poisonous nature of carbon monoxide and ammonia and the environmental implications of NO_2 and SO_2 in ozone layer depletion, acid rain (preferably called acid deposition); global warming, climate change, melting of arctic ice, rise in sea level and tsunami calls for local, national and global monitoring of the gases (since nature knows no boundaries) – [1,2,3,21]. The cumulative period monitoring is vital in view of the temporal and spatial variations of the air concentration of these gases.

Physicochemical Properties of the Soil: The silty-loam texture of all the filling stations, plus control has balanced the differences in sand, silt and clay separates. The silt

fraction varied to high level (cv = 62.39%) with 65 g kg^{-1} in Spera-in-deo Station compared to control value of 378 g kg^{-1} . The clay portion that was uniformly 114 g kg^{-1} in all stations, plus control gave the uniform soil texture. Texture is relevant to these studies as they contribute to soil physicochemical properties like hydraulic conductivity, infiltration, surface area charges, adsorption and absorption potentials of the soils. This property also affected the bulk density of $1.27 - 1.38 \text{ g cm}^{-3}$, total porosity of 48 – 51.75% and gravimetric moisture content of 18.25 – 24.75%, even in control.

When it comes to chemical dynamics, hydrocarbons can easily react and precipitate alcohols, esters, weak acids like ethanoic, methanoic, propionic or butanoic; hence the pH of 7.0 – 7.90 recorded in the filling stations compared to 6.10 recorded in control with coefficient of variation of 10.07% which is little based on Aweto [22] ranking of coefficients of variation. The available phosphorus as determined by Bray-2 method in this work are classed high ($>25 \text{ ppm}$ or mg kg^{-1}) based on Soil Science Society of Nigeria (SSSN) – [23] ranking for an Ultisol of Southeastern Nigeria where the work was done. The available phosphorus in all the filling stations, plus control were within $23.8 - 49.8 \text{ mg kg}^{-1}$ with cv of 28.95 (moderate) based on Aweto [22] ranking for cv that gave 20=50 as moderate.

The total nitrogen was low in all filling stations, plus control where values fell within $0.112 - 0.28 \text{ g kg}^{-1}$ based on SSSN [23] standards of $0.112 - 0.28 \text{ g kg}^{-1}$ as low. Hence, this was not totally due to hydrocarbons. The total carbon and organic matter, on the other hand were also low in all the filling stations, plus control ($0.91 - 3.48 \text{ g kg}^{-1}$) based on SSSN [23] standard of $<20 \text{ g kg}^{-1}$ total organic matter as low for an Ultisol. Hence, agricultural soils around such filling stations (with or without) contamination of the hydrocarbon may be generally low in total organic matter and will require organic matter amendment and N-fertilization.

In terms of exchangeable cations, Ca, Mg, K were very low in all the filling stations plus control ($4.40 - 5.8$; $2.0 - 3.2$ and $0.131 - 0.164 \text{ cmol kg}^{-1}$) respectively; based on SSSN [23] standards of 380; 50 and 50 cmol kg^{-1} for Ca, Mg and K as very low. The low sodium is good in all soils, as high sodium (sodification) disperses soil and not needed in high concentrations, especially in agricultural soils. The Ca, Mg and K levels of the soils can be supplemented by liming with limestone, slaked lime, quick lime, gypsum and dolomite. The exchangeable acidity of $0.08 - 0.24 \text{ cmol kg}^{-1}$ in all filling stations, plus control is good for agricultural soils.

The effective cation exchange capacity (ECEC), that is sum of exchangeable bases plus exchange acidity was also low ($7.792 - 10.574 \text{ cmol kg}^{-1}$) in all stations, plus control. These are raised in the course of liming of such soils. The base saturation in all stations, plus control was high (97 – 99%) showing that most of the basic cations were present, but probably unavailable in fixed concentrations. The liming of such soils will release most of those basic cations (though the pH recorded in this work of 6.0 – 7.90) do not call for liming. Probably, the hydrocarbons tied these cations and calls for integrated bioremediation, where agricultural fields are contaminated.

Sources of Hydrocarbon Pollutants: Leaking underground storage tanks, spillages and distribution depots and road accidents lead to pollution of air, soils and aquifers by petrol and diesel fuels [1,2,19,20]. In view of the very large volume of petroleum fuels used from filling stations, these scientists, attribute the source for high proportion of air, soil and water pollution especially in cities and urban areas.

Other sources of hydrocarbon pollutants reported by RSC [2] are do-it-yourself and mechanical garages that dispose used motor oils into garages, soils and land around garages, farm lands and scrap yards. Other sources include: leakage of solvents from industrial sites and coal stores [3].

Specific Air Pollutants: The major source of sulphur dioxide as reported by experts [1,2] is the combustion of fossil fuels containing sulphur. These are predominantly coal and fuel oil, since natural gas, petrol and diesel fuels have a relatively low sulphur content. Emissions of sulphur dioxide from diesel engines in busy roads. Coal burning is another contributor [2]. According to these experts, measurement of sulphur dioxide is routinely done in hydrogen peroxide solution to form sulphuric acid. Then followed by the resultant acid-base titration which is subject to interferences by other gaseous, acidic or basic compounds such as nitric acid or ammonia, respectively. Many measurements are now made by determination of sulphate by ion chromatography which yields a result specific to sulphur dioxide. The most commonly used instrumental technique for measurement of SO_2 is based upon measurement of fluorescence excited by radiation in the region of 214_{nm} .

Commercial instruments are available, capable of measurement of SO_2 to less than 0.1 ppb, as well as source instruments with ranges into the thousands of ppm. The method is potentially subject to interferences from water

vapour, which quenches the SO_2 fluorescence and hydrocarbons capable of fluorescence at the same wavelength as SO_2 . Commercial instruments are generally equipped with diffusion dryers and hydrocarbon scrubbers to overcome these problems [1-3].

On the other hand, the most abundant nitrogen oxide in the atmosphere is nitrous oxide, N_2O . This is chemically rather unreactive and is formed by natural microbiologically processes in the soil. It is not normally considered as a pollutant, although it does have an effect upon stratospheric ozone concentrations and there is much evidence that use of nitrogenous fertilizers is increasing atmospheric levels of nitrous oxide [1,2]. According to these workers, the pollutant nitrogen oxides of concern are nitric oxide, NO ; and nitrogen dioxide; NO_2 . The major source of NO_x is the high temperature combination of atmospheric nitrogen and oxygen in combustion processes. There is lesser contribution from combustion of nitrogen contained in the fuel. Typically, hourly average air concentrations of NO_x are normally in the range 5 – 100 ppb ($0.0005 - 0.01 \text{ ppm}$ or mg L^{-1}) in urban areas and less than 20 ppb (0.002 ppm or mg L^{-1}) at rural sites [1,2].

Instrumental analyzers have been used for measurement of oxides of nitrogen. The favoured technique is based upon the chemiluminescent reaction of nitrogen oxide and ozone to give an electronically excited nitrogen dioxide which emits light in the $600 - 3000_{\text{nm}}$ region with a maximum intensity near 1200_{nm} . In the presence of excess ozone generated within the instrument, the light emission varies linearly with the concentration of nitrogen oxides from 1 ppb to 1000 ppb ($0.0001 - 0.1 \text{ ppm}$ or mg L^{-1}) – [1].

Carbon monoxide is a pollutant very much associated with emissions from petrol vehicles. Within urban areas where concentrations tend to be highest, motor traffic is responsible for about 98% emissions of carbon monoxide. Carbon monoxide is measured using non-dispersive infrared; especially in street air; where levels encountered normally lie within the range of 1 – 50 ppm or mg L^{-1} . The other most common type of instrumental analyser is based upon gas filter correlation. An analyser for continuous determination of CO at levels down to 1 ppm uses an electrochemical cell. Analysers based upon electrochemical cells are also available for measurement of SO_2 and NO_x [1,2].

Ammonia as a pollutant is a colourless gas with a strong pungent odour. It is very soluble in water and soluble in alcohol. The combustion of ammonia in air yields nitrogen and water. The participation of ammonia

in the nitrogen cycle is a natural process. Nitrogen-fixing bacteria release ammonium ions which are converted by nitrifying bacteria into nitrite and nitrate ions [24]. Ammonia is mainly generated as air pollutants in the decomposition of plants and animals debris, especially animal dungs. It is also generated from urea, one of the end products of urine, a metabolite. Other sources are sewages and municipal wastes dumps and landfills.

CONCLUSIONS

The role of hydrocarbon pollutants in air, water and soil are very conspicuous. Civilisation has come with industrial and agricultural revolutions that depend so much on fossil fuels as the quickest and most available, reliable; but not essentially affordable forms of energy. Civilisation has also come with massive exploration of fossil fuel resources, particularly crude oil and coal. It has increased road, air and sea travel that depend on fossil fuel. Civilisation has come with environmental disasters – basically air, water and soil pollution. Human civilisation is now hunting humanity. It stares us red in our eyes and humanity seems helpless; in the era of survival of the fittest; who live today as if there is no tomorrow. Nevertheless, the world must go on. So must civilisation go, in as much as solutions to menaces of civilisation must remain unabated.

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