URBAN PLANNING, DOWNSTREAM PETROLEUM INDUSTRY AND HUMAN HEALTH

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ABSTRACT

Urban growth in Nigeria has been phenomenal over the past five decades. Zoning controls and urban planning regulations are however not being enforced or sustained. Consequences include lawless development of urban space, congestion, squalor, pollution and attendant environmental and health challenges. A glaring example is the current spate of hazardous, uncontrolled location and construction of petrol filling stations across urban space in Nigeria. The Department of Petroleum Resources stipulate among others, that petrol filling stations must be located at a minimum of 150 m from any public building such as school, place of worship, and hospital; total number of petrol stations within 2 km stretch of a station on both sides of the road will not be more than four; and the distance from the edge of the road to the nearest pump will not be less than 15 meters. This study shows that dispensing pumps particularly diesel, are now sited at the edge of roads such that trailer-trucks and other diesel-operated vehicles are re-fuelled while virtually parked on the road. Even, public places of worship are now routinely built within the confines of petrol stations. A graver danger is that posed by the fumes (volatile organic compounds) emitted during every opening of vehicle tanks and dispensing of fuel, and also discharging of fuel into filling station tanks. Pump-side benzene concentrations attain 300.65 μg/m^3, and a petrol attendant at such a station would be inhaling ~1.08 ppm of benzene per 8-hour work shift. The maximum allowable amount of benzene in workroom air during an 8-hour workday, 40-hour workweek is 1 ppm. Further, benzene seeps into groundwater through leakage of petroleum products' tanks. Many households in the Alimoso area of Lagos had well water with 312.9 μg/L Total Petroleum Hydrocarbon (TPH) concentration. Maximum contaminant level (MCL) for benzene in drinking water is 0.005 mg/L (5 μg/L). Scientific studies link benzene to headaches, mucosal symptoms, aplastic anaemia, acute leukaemia, bone marrow abnormalities, irregular menstrual periods and decrease in the size of ovaries, neural birth defects - spina bifida and anencephaly, and abnormal amount of chromosomes in sperm. It currently appears that little or no attention is being paid to the safety of lives around petrol stations in Nigeria. There is an urgent need for renewed enforcement of urban petrol station controls and regulations if the nation is to avert mass mortality in the near future.

INTRODUCTION

An urban area by definition is characterized by high population density and specific high order human agglomeration functions that are not available in other areas. Southwestern Nigeria is a region with a history of urbanization (Mabogunje, 1968), but urban growth over the past five decades has been phenomenal. The main driver of this phenomenon is rural-urban migration caused by perceived employment opportunities in urban areas, and rural-urban wage differential. Taking Ibadan (Figure 1) as an example, it was reported that the built up area of the city covered 36.2 km^2 in 1952. By 1973, 100 km^2 of land was completely built up, and by 2000, it had risen to 400 km^2 (Afolayan & Thurston, 2010; Areola, 1994; Onibokun and Faniran, 1995). The city's population grew from 745,000 in 1952 to 2,551,000 in 2006 (National Population Commission, 2009). Similarly, Ile Ife (7° 50'N 4° 69'E), perhaps the oldest city in southwestern Nigeria, had a built-up area of 35.9 km^2 in 1986, and 57.4 km^2 in 2002. By 2014, it was 87.7 km^2 (Figure 2). The city's population grew from 186,856 in 1991 to 355,818 in 2006 (National Population Commission, 2010).

The current annual urban growth rate in Nigeria is 5.5%, approximately twice the national population growth rate of 2.9%. The proportion of the population living in urban areas rose from 15% in 1960 to 43.5 % in 2000 and is projected to rise to 60% by 2020 (Agbola and Agunbiade, 2009; Onibokun and Faniran, 1995; Table 1). Urbanization in Nigeria has however been described as different from that observed in developed nations (Agbola, 2005). High level services including urban cleaning, sewage and waste disposal, efficient mass transit, water and electricity supply that attend urbanization in such nations are not available in most of Nigeria's urban centres. There also is an apparent lack of

consideration or political will for enforcement and/or sustenance of zoning controls and urban planning regulations. Zoning controls and urban planning/land use regulations describe, among others, the restrictions on land use in specific locations and deter or segregate emergent land use that may not be compatible with existing ones. The goals are environmental sustainability, sustenance of human health, and protection of the integrity and sustainability of existing land use. Hence the idea that Nigeria's type of urbanization is 'false urbanization' (Hartshorn, 1992). A consequence is that development of the urban space is unorganized and tends towards lawlessness. Other consequences include congestion, squalor, pollution, heightening poverty, and attendant environmental and health challenges. A glaring example of the emergent lawlessness and unorganized development is the current spate of uncontrolled location and construction of petrol filling stations across urban space in Nigeria. This study attempts to highlight the failure of urban planning and control with regard to downstream petroleum industry, and the human health implications.

Figure 1: Nigeria

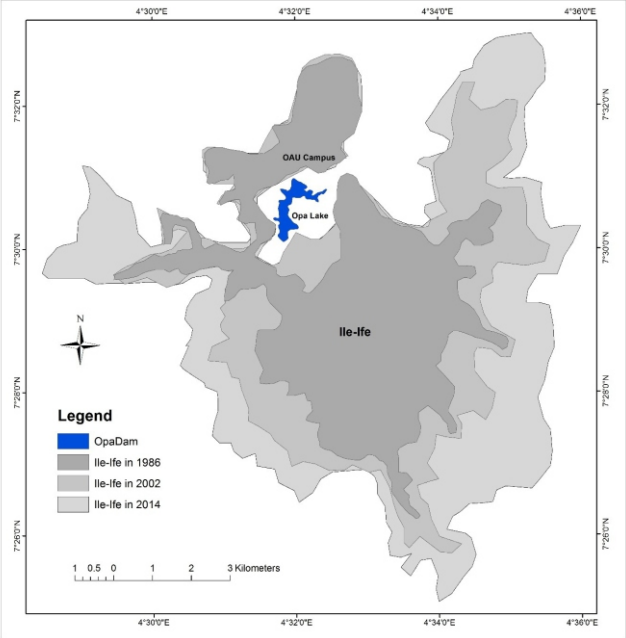

Figure 2: Expansion of Ile-Ife between 1986 and 2014
(Source: This study; from LANDSAT ™ and ASTER)

Table 1: Population characteristics of Nigeria, 1921-2020

Year	Total population (*000)	Total urban population (*000)	% of Total population	Number of cities with population > 200000	Number of cities with population > 500000
1921	18,720	890	4.8	10	-
1931	20,056	1,343	6.7	24	-
1952/54	30,402	3,701	10.2	54	-
1963	55,670	10,702	19.2	185	2
1972	78,924	19,832	25.1	302	3
1984	96,684	31,902	33.0	356	14
2020	160,000	108,800	68.0	680	36

MATERIALS AND METHODS

The main study area is Ile Ife (7° 50'N 4° 69'E), South Western Nigeria, but illustrative data were sourced from other locations within and outside the region. Ile Ife currently has a built-up area exceeding 90 km^2 and a population greater than 360,000. It has witnessed rapid urban growth since ca. 1995, but the growth has been characterized by poorly-developed urban environment. The roads in Ile Ife are mostly unpaved, sewers are generally open and un-lined, and open spaces are un-grassed. The poorly-developed and exposed urban surfaces have in concert with the prevailing high energy rainfall, promoted enhanced rill and gully erosion, siltation in wetlands, blockage of drainage channels and culverts, and localized flooding. The area is underlain by deeply weathered rocks of the Precambrian Basement Complex suite comprising mainly schists, granite-gneisses and amphibolite. Inselbergs formed on granite gneisses abound in the area. Notwithstanding, the general topography is in the form of a gently undulating plain with local relief less than 30 m. Valleys are broad, and have short side slopes (5^0 – 15^0) and alluvial floors. Many of the valleys have swampy reaches (Jeje, 1976). The climate is a dry species of the Koppen's A_f Humid Tropical type characterized by a short dry season (November – March) during which, mean maximum temperature is 33 ^{0}C. The rainy season extends from April to October and is characterized by a bimodal rainfall distribution marked by a break in rainfall in July-August, but during which humidity remains high. The mean annual rainfall is 1470 mm. Mean maximum temperature during the rainy season is 28 ^{0}C.

The Ondo Road, Modakeke, Ile Ife and the petrol stations along it constituted the main object of study. A 2014 IKONOS image of Ile Ife was obtained through the 'Google Earth Pro' ™. The image provided a 2-D spatially-referenced aerial view of features/objects, and particularly petrol stations and their appurtenances of the study zone. Further, the coordinates of the fuel stations were determined using the GARMIN 76CSX GPS (accuracy +/- 3 m). The data were structured into the GIS environment and processed (overlay operations, neighbouring Analysis, Linear measurements, and buffering) using ArcGIS 10.3 version (licensed to OAU Ile Ife by ESRI). Information from 1986 and 2002 LANDSAT (TM) and 2014 ASTER (Advanced Space-borne Thermal Emission and Reflection Radiometer) imageries facilitated the determination of urban zone dynamics of Ile Ife. The LANDSAT imageries were acquired from Global Land Cover Facility (GLCF) through the URL: http://glcfapp.glcf.umd.edu:8080/esdi/index.jsp , while the ASTER data were obtained from NASA Land Processes Distributed Active Archive Centre User Services (https://LPDAAC.usgs.gov).

RESULTS AND DISCUSSION

Urban Planning and Downstream Petroleum Industry in Nigeria

Prior to the deregulation of the downstream petroleum industry in Nigeria, marketing of refined petroleum products and their sales outlets

(petrol stations) were managed by multi-national petroleum exploration, production, refining and marketing companies such as the British Petroleum (BP), Shell, Mobil, Texaco, Total, and ENI (Agip). BP has mutated severally after nationalization in 1976 to African Petroleum (AP), and now Forte Oil. Most of the others have since early in the 21st century been acquired by Nigerian business groups and have had their brand names changed. The location, construction and operations of petrol filling stations were then supervised by the multi-national companies, and these parameters conformed to urban planning regulations. Full deregulation of the downstream petroleum industry and capacity loss by local refineries led to the building of tank farms mainly in Lagos and importation of refined products by all-comers. Initially, tank farms were located at the Atlas Cove (off the Commodore Channel) and Apapa Wharf, but are now in close proximity to residential areas between the Navy Town, Ojo and Satellite Town, all in Amuwo-Odofin Local Government Area of Lagos State (Figure 3). A collateral development is the massive increase in the number of filling stations and a tendency towards their ubiquity and haphazard location over urban space.

Figure 3: Tank Farms at Amuwo Odofin LGA, Lagos

The strict zoning laws and land use planning regulations that guided the site, situation, size, and operations of retail outlets of petroleum products in Nigeria were enforced by the Federal Government's Directorate of Petroleum Resources (DPR), States, and the various Town and Country Planning Authorities. For instance, the DPR stipulates among others, that:

1. The site of a petroleum products filling station must not lie within pipeline or PHCN high tension cable Right of Way (ROW)
2. The total number of petrol stations within 2 km stretch of a station on both sides of the road will not be more than four
3. The distance between an existing station and another will not be less than 400 (four hundred) meters
4. The distance from the edge of the road to the nearest pump will not be less than 15 meters
5. Petrol filling stations must be located at a minimum of 150 m from any public building such as school, place of worship, and hospital
6. The drainage from the site will not go into a stream or river. (https://dpr.gov.ng/index/wp-content/uploads/2013/10/FILLING-STATION-GUIDELINES.pdf)

Section 24 (4) of the Town and Country Planning Regulations of Oyo State further specify that:

1. The size of the plot must be a minimum of 1080 m^2 for a two-pump/dispenser station and 1200 m^2 for a four-pump/dispenser station.
2. The distance of the pump from the centre of the adjoining road must be a minimum of 25m for local/street roads, 40m for Trunk "A/B" roads, and 50m for limited access express roads.
3. The distance from the centre of the road to Filling Station office (which usually houses the manager's office, display and sales point for containerized lubricants and other petroleum products; and lubrication and service outlet) must be a minimum of 50m for Trunk "A/B" roads, 50m for Express roads, and 35m for other roads.
4. The distance of filling station to residential structure (dwelling house) must be a minimum of 50 m.
5. The topography of the Filling Station must be such as can promote free drainage of water.

Downstream Petroleum Industry and Human Health

As earlier noted and in spite these regulations, and due to apparently weak approval and monitoring controls, the site and situation of filling stations in urban areas have become uncontrolled and indeed hazardous. Dispensing pumps particularly diesel, are now sited at the edge of roads such that trailer-trucks and other diesel-operated vehicles are re-fueled while virtually parked on the road. Even, there are public places of worship built within the confines of the stations. These observations apparently prompted a commentary titled 'Discouraging the building of Petrol Stations in Residential Areas' aired by Radio Nigeria, Ibadan (http://www.radionigeriaibadan.com/commentary-list/2137-discouraging-the-building-of-petrol-stations-in-residential-areas. The commentary noted among others that filling stations are sandwiched between residential and office buildings, and schools without recourse to rule of proximity and environmental impact assessment, and situated at road junctions. Thus, in areas of Ibadan such as New Ife Road and New Garage/Orita on the Old Lagos Road, large numbers of petrol stations compete with residential buildings. It was further noted that many of the stations usually off-load their fuel tankers any time of the day with little or no regard to rule of safety and public sensibilities, posing grave danger of fire outbreak to those living nearby.

However, an often-overlooked but graver danger is that posed by the fumes (volatile organic compounds) emitted during every opening of vehicle tanks and dispensing of fuel, and also discharging of fuel into filling station tanks. In a study on the impact of petrol filling stations on surrounding residential buildings in Murcia, Spain, Terres *et al.* (2010) observed that volatile organic compounds, particularly the carcinogenic benzene, have ambient air concentrations (37.3 $\mu g/m^3$) near filling station pumps and tanks far in excess of background levels (1.16 $\mu g/m^3$) at 100m away from the filling stations. Concentrations however depend on the number of petrol pumps, the frequency and volume of sales, the structure of the surroundings (whether there are tall buildings surrounding the filling station and the area closed up as to restrict pollutant dispersion), and weather conditions. Terres *et al.* (2010) also noted that though Spanish petrol stations were traditionally located in largely uninhabited areas, the continuous urban growth recently experienced in the country resulted in many urban area petrol stations being surrounded by buildings. This situation has led to controversy between citizens whose houses are close to petrol filling stations and the authorities responsible for land management.

The situation in Murcia, Spain where urban planning regulations subsist may pale into insignificance when compared to that at busy petrol stations along major road sections heavily populated with stations, in Nigeria. This may be the situation along Ondo Road between Mayfair Roundabout and Famia Junction in Modakeke, Ile Ife (Figure 4). There are nine stations on this 1.74 km stretch of road with two pairs of stations located across the single-carriage road from each other in flagrant disregard to regulations. Only one pair of these nine stations have distance separating them greater than 400 m. Even then, their nearest neighbours are 73 and 46 m away, respectively (distances between the stations, and

buffer distances are shown on the Figure 4). The others have separating distances ranging from 29 to 398 m. Petrol-dispensing pumps are within 20 m from the centre of the Trunk "A" road, while diesel dispensing pumps are all sited at the edge of the road such that trailer-trucks and other diesel operated vehicles are re-fuelled while virtually parked on the road.

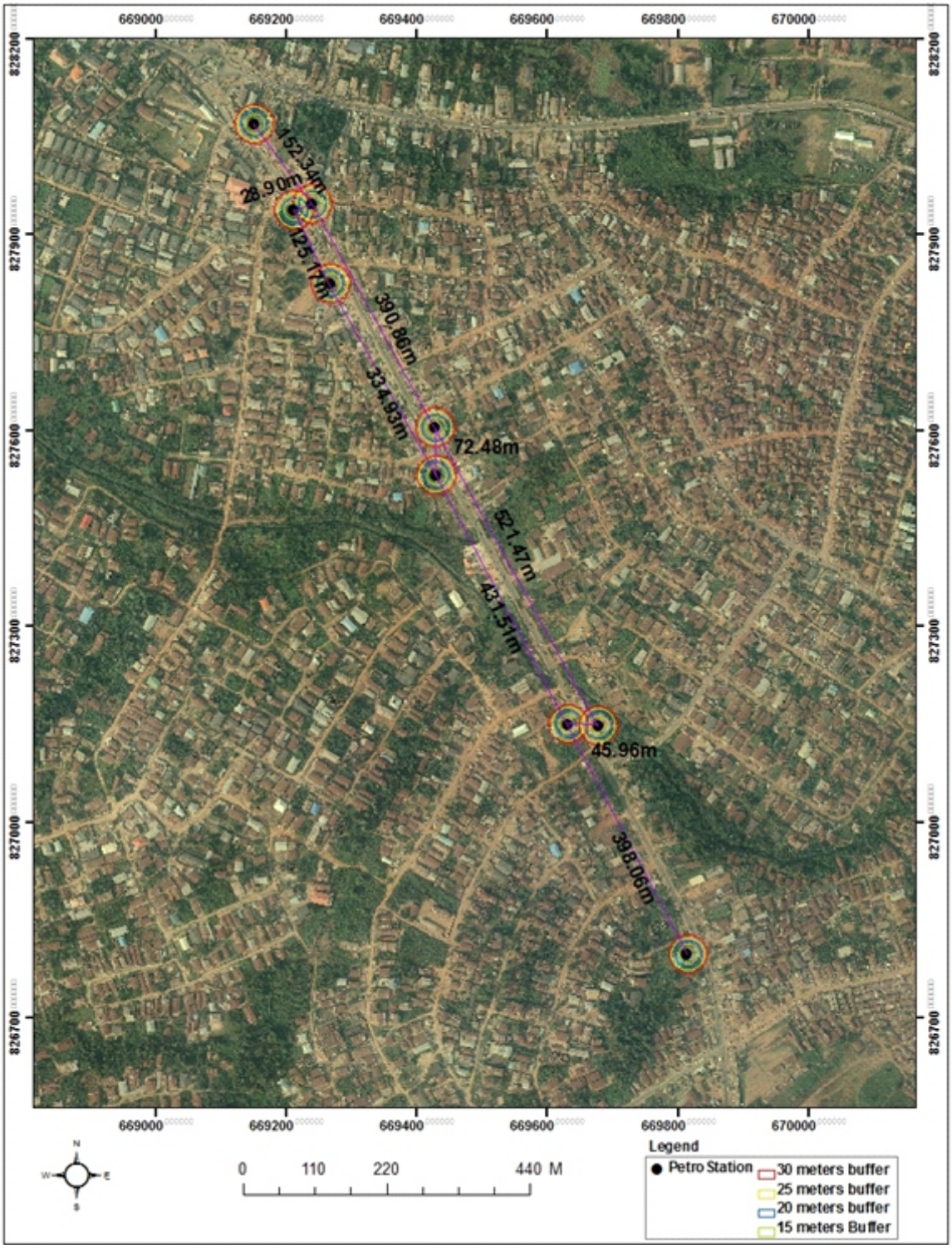

Figure 4: Ile-Ife, Zooming on the Locations of Petrol Filling Stations between Mayfair Roundabout and Famia Junction
(Source: This study: from Google Earth and Field work)

Further, petrol stations are sandwiched between houses, with just a wall separating them from religious centres. There are no petrol station benzene concentration data for the Ile Ife area. However, ambient benzene concentration at a 3rd East Circular, Benin City, Nigeria bus stop/intersection is significantly higher (9.35 μg/m^3) (Olumayede and Okuo, 2012) than in Murcia, Spain. If the Murcia pump-side/background benzene concentration ratio is adopted for Benin City, filling station pump-side concentrations in Benin, could attain 300.65 μg/m^3. A petrol attendant at such a station would thus be inhaling ~1.08 ppm of benzene per 8-hour work shift. [An average man inhales 0.5 L of air per breath and breathes 15 times per minute. He thus inhales 450 L of air per hour and 3.6 m^3 of air per 8-hour work shift.] This is higher than the stipulated safe maximum levels (http://www.atsdr.cdc.gov/PHS/PHS.asp?id=37&tid=14). It could be worse in nearby houses usually with poor ventilation. The maximum allowable amount of benzene in workroom air during an 8-hour workday, 40-hour workweek is 1 ppm. It is recommended that all workers wear special breathing equipment when they are likely to be exposed to benzene at levels exceeding the recommended (8-hour) exposure limit of 0.1 ppm (http://www.atsdr.cdc.gov/PHS/PHS.asp?id=37&tid=14).

Another filling station source of benzene is from leakage of petroleum products into ground water. This has become a matter of serious concern in Nigeria given that many depend on groundwater for water supply because the official reticulated supply either does not function or is inadequate. Mbaneme and Okoli (2012) observed a high concentration of benzene (1.197 mg/L or 1.197 ppm) in deep groundwater aquifers of Okrika Mainland, Rivers State. It is believed that the aquifer contamination originated from improperly-treated effluent discharges of the nearby Port Harcourt Refinery Company Limited (PHRCL) production lines. In general, water from many boreholes in Port Harcourt have strong petrol aroma, which is believed to be due to contamination from leaking underground petrol filling station tanks (cf. Amangabara and Ejenma, 2012). In Baruwa, a community in Alimosho Local Government Area, Lagos, many households had well water with Total Petroleum Hydrocarbon (TPH) concentration averaging 312.9 μg/I. The exceptionally high TPH content is from refined petroleum products sipping into groundwater from ageing Nigerian National Petroleum Corporation (NNPC) pipelines and tanks (https://tundeakingbade.wordpress.com/2012/12/31/baruwawhere-residents-drink-water-with-high-petroleum-content-niger-delta-communities-affected-too/). These waters pose grave danger to human health. The United States Environmental Protection Agency has set a maximum contaminant level (MCL) for benzene in drinking water at 0.005 mg/L (5 ppb; 5 μg/L), as promulgated via the U.S. National Primary Drinking Water Regulations (https://www.epa.gov/dwstandardsregulations).

It should be noted that exposure to volatile organic compounds (VOCs) promotes health effects including asthma, headaches, mucosal symptoms (Steinemann, 2008) and in the case of benzene, increased risk of cancer (American Cancer Society, 2016; http://www.cancer.org/cancer/cancercauses/othercarcinogens/intheworkplace/benzene).

Substantial epidemiologic, clinical, and laboratory studies link benzene to aplastic anaemia, acute leukaemia, and bone marrow abnormalities (e.g. Kasper *et al.,* 2004; Rana and Verma, 2005; Huff, 2007; Smith, 2010). Benzene being a major component of the ubiquitous gasoline, has become a global health concern for man. Benzene targets the liver, kidney, lung, heart and the brain and can cause DNA strand breaks, and chromosomal damage among others. Some women who inhaled high levels of benzene for many months had irregular menstrual periods and a decrease in the size of their ovaries. Benzene exposure has been linked directly to neural birth defects - spina bifida and anencephaly. Men exposed to high levels of benzene are more likely to have an abnormal amount of chromosomes in their sperm, which impacts fertility and foetal development (Xing *et al.*, 2010).

CONCLUSION

Though a source of VOCs in urban environments in Nigeria is vehicular traffic (and commercial motorbikes, and the ubiquitous small electric

generators and petrol-fuelled grinding mills), petrol filling stations are more potent emission sources. VOC emissions at petrol filling stations stem from fuels evaporated during re-fuelling and petroleum unloading operations, and from spillage. It has been recommended that minimization/elimination of concentrations of chemicals of concern, regardless of their sources, is indispensable for effective health protection. The site and situation of many of the petrol filling stations in Nigeria are not in conformity with regulations. It thus appears that little or no attention is being paid to the safety of lives around petrol stations in Nigeria. There is now an urgent need for renewed enforcement of such controls and regulations if the nation is to avert mass mortality in the near future.

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