AIR POLLUTION IN DEVELOPING ECONOMY - A PERSPECTIVE

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ABSTRACT:

It is shown that air pollution is of two major origins - radioactive and non-radioactive. Pollution as an economic set-back factor, is looked at in its generating prospect, its effects on the environment, side effects on human beings and action to be undertaken to reduce its magnitude. Measures so far taken in developed economy are highlighted. It is concluded that environmental pollution should be accorded priority as any other aspect of our economic development.

1.0 INTRODUCTION

The increasing awareness of environmental effects of the by products of various sources of actions taken in the economic development and its sustenance, in different nations of the world, has prompted the necessity to address the arrest of or mitigate the effect of pollution from source. The growing popularity of the dangers posed to man by pollutants has given rise to the formation of political group campaigners such as the Anti-Nuclear Group, CND - Campaign for Nuclear Disarmament - and the Green Peace. These groups have lobbied successfully governments of developed nations of the world to institute various legislations that will see to the banning or reduction of emission of potent pollutants into the atmosphere. This action has led to international agreement in some areas of pollutant emission. In air pollution, the chronic effects are evident primarily in growth reduction, yield reduction, widespread population structural changes and permanent physical changes to vegetation.

The short term effects of some pollutants may result in loss of several man-hour at governmental or industrial set up and economic waste in medical care finances, due to sicknesses and hospitalization of victims as well as accidents on our roads. Long term effects may be simply quantified as human death, irreversible changes in growth with devastating effects on economy and various deformations to new-born due to genetic defects.

However potent the side effect of some of these pollutants, their sources is such that development cannot totally afford to do without. The refrigerants in common use today, which make life comfortable for us, have been shown to be responsible for the depletion of the stratospheric ozone layer (1) and to be a contributing factor in greenhouse effect. The energy source for generating electricity and for powering our transport system, releases such pollutants that cause acid rain, nausea, chronic heart diseases, intestinal hemorrhage and death to aquatic lives. The depletion of fossil fuel has led man to investigate the substitution of nuclear fuel, only to find that the side effect of this material's use is very dangerous to life on earth and hence greater precautions and safety factors have to be instituted to mitigate these side effects. The production of various items for economic sustenance from our industries generate pollutants which goes to show vividly that we cannot do without generating pollution if we are to keep pace with development and cutting down on the nauseating by-products seem to be the only option.

2.0 RADIOACTIVE POLLUTION OF THE AIR

The radioactive pollution of the air is mainly from the activity of the solar system and the emission generated by man.

2.1 Radioactive Pollution From Space

Viewed from a space capsule the earths atmosphere is a thin film just above the earth. Considering this view it may be imagined how pollutants generated in outer space can pass through the thin film to earth's surface. Carbon-14 is the radioactive pollutant produced in space by cosmic rays' activity (1). This pollutant, which is the most significant, penetrates the earth's atmosphere to reach the earth's surface. Carbon-14, with a half life of 5760 years, is absorbed by plants and so get into the food chain to be absorbed by all mammals. In air it can be inhaled. The cumulative effect of this pollutant is deformation of mammalian genes and cancerous diseases such as lung cancer.

2.2 Radioactive Pollution of Air by Man

The air is radioactively polluted during the atmospheric testing of nuclear bomb, by malfunctioning of nuclear power plants and by the mining of uranium ore. Of the radioactive isotopes released into the atmosphere during these activities, those with a

long half-life of decay are the most dangerous to life on earth because they survive to reach the earth's surface. However emission from mines' site does not have to be of long half-life to be injurious to man.

The pollutants released into the atmosphere, reach the earth's surface as a dry or wet fallout when there is turbulence, due to day-time heating accompanied by rain showers or thunderstorms or tornadoes (2). Where and when these pollutants reach the earth's surface depend on earth's location where the pollutants originate, the speed and direction of wind at the time of atmospheric contamination. Another effect that aids the downward movement of air radioactive pollutants is dust that may be carried from earth into the atmosphere by wind. Radioactive pollutants during the above activities are:

2.2.1 Carbon-14: This is mainly produced by atmospheric nuclear bomb testing. The effects of this contaminant is as explained above.

2.2.2 Strontium-90: This is produced by both atmospheric nuclear bomb testing and nuclear power station malfunction. It has a half-life of 28 years, similar to calcium, when ingested it concentrates in the teeth and bones. It emits B-particles in the bone marrow where new blood cells are produced. The result of this is the leukaemia disease in children.

2.2.3 Cesium-137: This is produced as strontium and it has a half-life of 27 years. Chemically similar to potassium, it concentrates in human's muscular tissues. It may be a contributing factor to the disease called muscular dystrophy.

2.2.4 Iodine-131: Normally called radioactive iodine, it is released due to either human error or plant mal-function at nuclear power plants (3). When absorbed from animal milk or inhaled in large dose, it ends up in the human thyroid system. It is cancerous and may contribute to the disease called hypothyroidism, and

2.2.5 Plutonium Mist: This is plutonium nitrate in a fine spray form. It is produced and emitted at nuclear power stations due to plant mal-function or human error (3,4). This pollutant easily irradiates human in the vicinity and may be eaten in plants after precipitation. It is cancerous to human cells and also leads to genetic deformation in large dosage.

2.3 Mines Radioactive Air Pollution

Radium is an element commonly mined with Uranium ore. Its decay produces a radioactive colourless gas called radon having a half-life of 3.82 days. When radon is taken in large doses by inhaling, it leads to cancer. This radioactive gas is commonly found in air samples of houses built near Uranium mining sites (5)

Effects of radioactive pollutant on man depends on many biological factors and the degree of dosage. In high doses, death result within a short time. Where exposure is only on part of the body, sicknesses such as shock symptoms, nausea, and intestinal hemorrhage may result with eventual recovery. Exposure of the body over a long period of time, to small dose rate results in delayed effects such as life shortening, leukaemia and genetic defects (6).

2.4 Radioactive Pollutants Reduction

Atmospheric nuclear bomb testing has been banned. This move reduces pollution from this source. However the re-entry of spent nuclear powered satellite still poses a problem to all nations. Pollution from nuclear power stations due to mal-function of plants or human error is still on the increase, despite stringent safety guidelines. The population of commercial nuclear stations in the world, less those on order and those nearing completion, is shown in fig. 1 with the per cent per total national need for power.
Except for very bad cases of mal-function like the Chernobyl disaster, the Three Mile Island mishap, Tsuruga nuclear power station leak and the Sellafield plutonium nitrate escape (2,3,4,7,8), a wall of silence is maintained on radioactive pollution of the atmosphere from nuclear plants. The problem here is the international nature of these pollutions, for nations that have no nuclear station(s) will suffer from the pollutants in any event of escape of the latter. In this case, the pollution effect on human, apart from the nation where the pollutants originate may be quantified by equation 1.

$$\text{Radioactive Pollution Effect on nations other than source territory} = f(h,W,C,L,V) \quad \ldots\ldots 1$$

where h = height reached in the atmosphere by escaping nuclear pollutants

W= wind direction and speed during the escape

C= weather condition

L = half-life of escaped radio isotopes

V = vegetation

Equation one indicates that those nations that have no nuclear power plant are not safe should there be any mishap in places having these plants. This has already been proved to be the case by the Chernobyl disaster in the Ukraine. Britain, France, Ireland, Sweden and North African countries felt the

effect of the Chernobyl disaster, for milk was contaminated as well as land and vegetation in these countries. The economic loss to these countries ran into millions of dollars.

There are going to be more nuclear power plants built around the world. Libya, Egypt, Zaire, Ghana and South Africa have either research or full commercial plants already. This is bound to increase in the future. Nigeria should therefore integrate the cost of radioactive pollution management into her economy now, in order not to be taken by surprise when the time comes.

3.0 AIR POLLUTION FROM OTHER SOURCES

Pollution from non-radioactive pollutants may be divided into two regimes: (a) Energy oriented pollutants and (b) Industrial oriented pollutants. The energy oriented pollutants are those that occur mainly due to conversion processes.

In this case fossil fuel are burnt and emission released. Such pollutants from burning fuel are Carbon dioxide, Carbon Monoxide, Unburnt Hydrocarbon, Oxides of Sulphur and Nitrogen, the Halogen groups, Smoke, Soot and particulates. Industrial pollutants, even though may include some or all of the energy oriented pollutants, also have others such as dust emission from cement industries, asbestos particulates from asbestos industry, hydrogen sulphide from die and textile industries and CFCs from refrigerating equipment including all air conditioning equipment.

3.1 Energy Oriented Pollutants

3.1.1 Carbon Dioxide

Combustion processes involving carbon compounds produce carbon dioxide and water which may be chemically represented as shown in equation 2,

$$C_nH_y + (n+y/4)Air \quad {}_nCO_2 + y/2H_20 + 3.76\,(n + y/4)\,N_2 \quad \ldots\ldots 2$$

Carbon dioxide is released and emitted into the atmosphere during the above process. It was a good thing to produce carbon dioxide before, as this serves as part of plants source of food intake. However in cities and areas of high industrial set-up, the large amount of CO_2 emitted cannot all be taken up by plants. The remaining CO_2 is therefore left in the earth's atmosphere. Another source of carbon dioxide generation is commercial and non-commercial flights as well as stand-by electricity generators. The amount of carbon dioxide emitted during cruising in these engines, is very high and this emittance is also left in the atmosphere to swell the amount already available.

The effect of carbon dioxide emission in our atmosphere is just being realised. Carbon dioxide has the capability to retain heat, hence its abundant presence in the atmosphere makes it able to retain more of the sun's heat as well as trapping combustion generated heat. This process known as greenhouse effect (9), increases the earth's temperature heating up seas and oceans of the world. With the seas and oceans warmed up, polar ice-caps and glaciers in general will melt. As more water is released by this process the seas and oceans' levels will rise destroying everything along their path. Cities below and at sea level will be flooded. This has already been happening. The Commonwealth of nations, formerly Soviets Union, due to ice-caps melting effect, has lost a research station in the Antarctic (9). It is useful to note at this point that this new development knows no national boundaries, developing or developed economy.

Way of reducing the emission of carbon dioxide, which now contributes more than 50% to the greenhouse effect (10), are:

(a) changes in agricultural and deforestation procedures,

(b) conversion of carbon dioxide in flue gases into other compounds by absorption, and

(c) the use of alternative energy.

As for the emission of this pollutant from vehicular exhaust the use of solar and electric vehicles and electric trains are proposed for use in cities and towns.

3.1.2 Carbon Monoxide

Carbon Monoxide is a by-product in flue gases due to incomplete combustion of fossil fuels and other carbonaceous materials. It is a common exhaust pollutant in vehicles both in urban and rural areas. When air-craft is idling on the runway, the emission of carbon monoxide has been shown to be very high. The formation of carbon monoxide, CO, may be shown as in equation 3,

$$C + 1/2O_2 \quad CO \quad \ldots\ldots\ldots\ldots 3$$

The magnitude of carbon monoxide produced during the approach and idling condition of a turbofan aircraft engine is shown in figure 2 after Lister et al (11). The figure indicates that carbon monoxide produced during idling is quite high. CO is also produced as a by-product in flue gases of integrated steel mills (12) and wood-fire common in most villages up and down the country.

This pollutant, when present in air, causes headache. In smog CO attacks human cerebral function and impairs its activity. At a concentration greater than 0.3 in air, when breath in, it increases hemoglobin affinity for and decreased tissue unloading of oxygen. It also increases the deposition of fats in blood vessel walls (13). This emission, in our community, manifest itself in our road vehicles today but more

dangerous is its occurrence and killing prowess in the use of wood as a source of fuel in space heating in homes.

The emission of CO is controlled by proper combustion procedures such as proper mixture control during transient operating conditions at cold start and rapid acceleration or deceleration in vehicular engines (14). The best way of control in engines is by the use of the 3-way catalyst. Good ventilation or excess supply of air during the combustion of wood will help in reducing the magnitude of this emission.

3.1.3 Unburnt Hydrocarbon

Unburnt hydrocarbon, UHC, is another noxious emission that pollutes atmospheric air.
This pollutant is also a by-product of the combustion of hydrocarbon fuel and occurs largely due to insufficient supply of oxygen during combustion. It is generated in large proportion from both spark ignition and diesel engines as well as aircraft engines. In the spark ignition and diesel engines, UHC is brought about by flame quenching along the walls, flame blowout in over-lean combustion zone and flame blowout under conditions of excessively rich mixtures. It has been shown by Khan et al (15) that unburnt hydrocarbon's emission in diesel engines is also increased at advance injection timing and an increase in fueling at a given injection timing. The emission of UHC from aircraft combustor has been shown (16) to be low for mixtures richer than a specific equivalence ratio while at idling condition (11) high proportion of UHC is produced.

The effect of this pollutant is to combine with other pollutants to form particulates in air. It is also a precursor in the formation of smoke and soot (17), both of which result in atmospheric turbidity. It contributes to the greenhouse effect and damages both plants and animals.

Destruction of this pollutant may be effected by increasing combustion efficiency in engines. However the most common methods of controlling UHC emission are by sorption and controlled combustion. In vehicles or for that matter engines, UHC is better controlled by burning lean or applying catalyst to the exhaust. In developed economy exhaust level of this pollutant is fixed and any one who violates this, faces severe penalty.

3.1.4 Sulphur Oxides

Oxides of sulphur, SO_x, are pollutants that are produced not only by energy means but also by natural means and industrial processes such as mercaptants from paper pulp mills.

In rural areas, sulphur dioxide is produced by the oxidation of hydrogen sulphide, H_2S, and by biological decay. In the combustion of fossil fuel, such as wood, coal and other fuels with sulphur compounds, the sulphur content of these fuels reacts with oxygen to produce sulphur dioxide, SO_2, and sulphur trioxide, SO_3. The SO_2 is produced during combustion as

$$S + O_2 \longrightarrow SO_2 \quad \ldots\ldots\ldots\ldots 4$$

(The sulphur in the above reaction is from the fuel)

Two main ways of SO_3 formation in combustion system (18) are:
(a) oxidation of SO_2 to SO_3 on combustion-well-surface as

$$SO_2 + \tfrac{1}{2}O_2 \longrightarrow SO_3 \quad \ldots\ldots\ldots\ldots 5$$

and (b) formation of SO_3 through atomic oxygen within the flame itself as shown in equation 6,

$$SO_2 + O + M \longrightarrow SO_3 + M \quad \ldots\ldots 6$$

In air the SO pollutant, in the presence of water vapour and ammonia, reacts to form ammonium sulphate solid particulate. SO can also absorb energy from sunlight to get to its excited state where it can undergo chemical reaction (19) with water vapour to form sulfuric acid mist. This process is shown in equation 7 to 13 below.

$$SO_2 + h\nu \xrightarrow[\text{(sun energy)}]{} SO_2' \quad \ldots\ldots\ldots 7$$

$$SO_2' \longrightarrow SO_2'' \ (+ M \rightarrow SO_2) \quad \ldots\ldots 8$$

$$SO_2' + M \longrightarrow SO_2 + M \quad \ldots\ldots\ldots 9$$

$$SO_2' + O_2 \xrightarrow[\text{(from air)}]{} SO_4 \quad \ldots\ldots\ldots 10$$

$$SO_4 + SO_2 \longrightarrow 2SO_3 \quad \ldots\ldots\ldots 11$$

$$SO_4 + O_2 \longrightarrow SO_3 + O_3 \quad \ldots\ldots\ldots 12$$

$$SO_3 + H_2O \longrightarrow H_2SO_4 \quad \ldots\ldots\ldots 13$$

(where M in equations 8 & 9 may be nitrogen, oxygen or sulphur dioxide)

The damages that SO_x emissions have caused are enormous. In human beings SO increases mortality rate. It causes an increase in flow resistance during respiration and this become intense in the presence of aerosol (20) in air.

Smog containing SO_2 has been reported to have killed 4,000 people in London (21) in December 1952. For the same reason 750 people died again in London in 1962. The deaths in Meuse Valley, Belgium, in 1930, of 60 people, Pennsylvania of 18 people, New York in 1963 of 405 people and again in 1966 of 168 people are all linked with SO_2 air pollution (11). The data given above is a perspective of what is likely

to happen in any of our growing industrial cities today if good care is not taken now.

SO_2 emission from power stations and other industrial set-ups has been shown to be carried from the country of origin to other neighboring countries (22). As shown in the chemical equations above the SO_2 , when it showers or rains, fall to earth as acid rain. In this form, it has denuded large vegetation. Aquatic life has been extinguished in some cases. Areas that suffer this havoc, due to its light reflectance and heat absorption, has altered weather condition. In urban areas this pollutant has deteriorated buildings and damaged materials.

In small amount, 98% of SO_2 in inspired air may be removed by the nasal mucosa. The removal or reduction of SO_x in generating plants may be effected by the addition of limestone to combustion system. However, its precipitation from air when it rains has also been suggested (22) to be effected by the addition of magnesium hydroxide powder of approximately 3im in size. When it rains the SO_2 reacts with magnesium hydroxide to give solid magnesium sulphate. Exhaust emission of SO_2 is not significant but this can also be reduced using the above procedure. Areas of major concern in the country today are petrochemical plants, steel manufacturing complexes, major cities with high population of electricity generating sets and vehicular exhaust.

3.1.5 Nitrogen Oxides

Nitrogen oxides, NO_x , are pollutants emitted during fuel combustion. Two sources of nitrogen during combustion exist. These sources are, nitrogen available in combustion air which goes on to form thermal NO_x and nitrogen available in the combustion fuel. The formation of NO_x is brought about by the reaction of the available nitrogen with oxygen during combustion. It has been shown (16) that the higher the combustion temperature the greater the chances of NO_x formation. The formation of NO_2 is known to be preceded by nitric oxide, NO, formation. It has been shown (23, 24) that flame gases contain NO_2 . In its simplest form, the formation of NO_x may be represented as

$$N + \frac{1}{2}O_2 \longrightarrow NO \xrightarrow{(O)} NO_2 \quad \ldots\ldots 14$$

$$N + O_2 \longrightarrow NO_2 \quad \ldots\ldots\ldots\ldots\ldots 15$$

No emission quickly undergoes oxidation to give NO_2 which is more stable. In the presence of SO_2 and light in air, nitrosyl bisulfate, $NOHSO_4$, an intermediate in the formation of sulfuric acid, is produced. Other particulates of ammonium sulphates in air are also produced in this way when ammonia is present. The most significant reaction undergone by NO_2 in air is its photochemical conversion to peroxy-acetynitrate, PAN. PAN is an odourless, tasteless gas that damages the life of plants and attacks human strength with similar vigour. A by-product in the production of PAN is Ozone which attacks and kill selected tissues of plants e.g. tobacco leaves.

NO_x emission can be controlled by improved combustor design such as using air staging techniques, recycle of flues gases and by overfiring or by sorption. Other methods of NO_x reduction include the injection of ammonia or urea based chemicals into combustion flues gases and the application of selective catalytic reduction system into internal combustion engines. In developed economy of the world, the level of emission of NO_x is pegged and stiff penalties exist for those overshooting this limit.

3.1.6 Lead Emission

The emission of lead pollutant is mainly from the exhaust of spark ignition engines. Lead is added to gasoline as tetral-ethyl or methyl lead, to prevent knocking in engines. This pollutant forms fine spray in air and could be inhaled to form heavy metal in the blood stream. Investigation has confirmed the presence of lead (25) in roadside dust and inside buildings adjacent to roads.

Lead emission results in brain retardation in urban city children and adolescence that live close to the roadside. Its cumulative effect in human adults is heavy metal poisoning. In engines it disables pollution control catalyst. Lead fumes in smelting industries also pollutes air and contaminates surrounding human dwellings.

As a result of the dangers posed by lead pollutant its addition to gasoline has now been banned in the European Union, EU, member countries. Engines that run on leaded petrol in the EU countries are now being converted (26) to run on lead-free-petrol. Due to the large volume of this type of engines in the EU countries, they are now being replaced and exported to third world countries including Nigeria, where no laws exist against the use of leaded-petrol engines. Other developed countries of the world, outside the EU, also have stringent emission control regulations. A developing economy should make an early decision to go unleaded to minimise future cost of this problem. Legislation also ought to be in place restricting smelters from undue emissions.

3.1.7 Soot and Smoke

Soot and smoke pollutants occur mainly from

incomplete combustion of fossil fuels during energy generation processes. It has been shown (17) that the precursor of soot formation in flame are unsaturated hydrocarbons such as acetylene and aromatic hydrocarbons. Calcote (27) has investigated the ionic mechanism of soot formation in flames. He concluded that chemical additives or electric fields affects soot formation in flames.

Soot and smoke formed from the combustion of wood has been reported to be responsible for chronic lung diseases, enlarge liver and heart failure prevailent among the people of New Guinea that live on high lands (13). In cities, exhaust gases from hand-set generators and vehicles react with building materials over some length of time to reduce their strength. It also disfigures the buildings with a deposit of black soot which is often cleaned off at high costs

Improved combustion efficiency and good combustor design are ways by which these pollutants may be reduced. Application of catalyst reduces the engines emission of these pollutants. In Nigeria today, these pollutants' exhaust are common site from various forms of vehicles and apart from sustaining our development, the country must take positive account of this pollution expenses in computing the yearly budget. Many must have died in the villages as a result of inhaling these pollutants from wood combustion but no data is yet available.

3.2 Industrial Oriented Air Pollutants

3.2.1 Halogen Pollutant

Members of the halogen family are fluorine, chlorine, bromine, iodine and astatine. Of this member, fluorine, chlorine and iodine are currently air pollutants of concern. The air pollution of these elements and their compounds are partly due to combustion of waste containing halogenated compounds such as Polyvinylchloride, PVC, and Polytetrafluoroèthylene, PTFE (28). During the incineration of these wastes both fluorine and chlorine are emitted as pollutants. Also the industrial production of aluminum, phosphate fertilizer, glass, ceramics and steel release into the atmosphere fluoride pollutants.

Fluoride pollutant is phytotoxic and injurious to plants and animals. A vivid example of the toxicity of fluoride pollution is displayed by the devastation it caused in Brazil (29), to both crops and plants at the vicinity of an aluminum smelting plant. Parts per billion concentration of fluoride in air is enough to cause severe damage to sensitive plants and the ingestion of forage containing excessive concentration of fluoride results in fluorosis. Fluorosis is a crippling bone disease in cattle (30).

Chlorine is converted, in the presence of water vapour, into hydrochloric acid and its effect on both plant and animal is similar to acid rain from SO_2 . In the presence of free carbon and oxygen, chlorine will react to give phosgene, COCl, a colourless poisonous gas used in chemical warfare. It is deadly to man in all its ramifications.

Iodine is emitted by nuclear power stations in its radioactive form as pollutant. It passes through plant and cattle to man. It is cancerous. Absorption with good filtering and good management will eliminate or reduce this pollutant.

It should be noted that of the five industrial materials mentioned above as sources of these pollutants, Nigeria is fully engaged in four and aluminum smelting and production is on its way. A strong legislation against emission from these industries should now be put in place and enforced to forestall future disaster.

3.2.2 Particulates

Particulates air pollution are from various sources and of sizes ranging from 52.5mm to 15mm. These particulates result in various disasters starting from precursor to various diseases to extermination of life in an ecological set-up. However only two sources of these particulates will be considered in the present discussion. These particulate sources are those of Asbestos and Cement Industries

3.2.2.1 Asbestos Particulate Emission

Asbestos particle emission results at asbestos materials' manufacturing factories or as a result of decay of these materials most especially from asbestos ceilings in old and disused buildings. In the factories it may be seen as dusty clouds but in buildings it is not easily seen during decay.

The effect of inhaling asbestos particles or its dust is the disease called asbestosis, a bad coughing disease, which has a success rate of treatment of less than 35%. The asbestos particle cannot be digested and get locked up along the lining walls of human breathing tracks and lung. The death of most people that worked in asbestos factories in Britain, USA and India have been traced to this pollutant. It has also been claimed (8) that cigarette smoke accentuates and aggravates asbestosis in bronchial mucosa.

To control the emission of this pollutant, stringent safe guards have been introduced in asbestos factories in Europe and America. In the early eighties the use of asbestos product was banned in workshops in the EU member states (31). High volume electrostatic precipitators and X-ray diffraction techniques are now being used to monitor and control asbestos emission (32) at background sites and vicinity of asbestos works. The question to be answered is does the Nige-

rian government have any law against this form of pollutant and if so, has it ever been enforced? This author's visit to an asbestos' work in a part of the country shows no such safe guard is in place. Another question to be asked is whether the government has in place any legislation against the use of asbestos in buildings? To this the answer is simply no.

3.2.2.2. Cement Particulate Emission

Cement production is now a well established part of Nigeria's industrial set-up. However a rigorous statutory control on the pollutant this industry may generate has not been in place or if it is, it has not been rigorously enforced. The pollutant commonly emitted from this industry is particulate in form of dust. During the processing of cement, dust containing fluorine ion is released into the atmosphere.
Fluoride, as stated before, attacks and damages vegetation. The ability of vegetation to accumulate fluoride ion and thus result in fluoride ion intoxication and death of grazing animals has also been established (33). Cement particulate also has the ability to turn fertile or farm land into desert waste, polluting drinkable water and contaminating surrounding air. Inhalation of such contaminated air leads to an assortment of lung diseases including cancer. Experience of the devastating effect of this contaminant has been reported in Wamako, Local Government area of Sokoto State (34) and also in Gboko, Benue State. The people in these areas who sojourn in the precinct of the cement factories recently brought their problems into the open. They reported of death to human beings, their animals and premature death to crops. Animals were said to give birth to deformed youngs and the whole population suffer from various unknown illnesses.

In this industry, the particulate emission standard is the first thing that should have been inbuilt into the plan and enforced from day one of its operation. Any thing above 200 part per million (200ppm) particulate emission will ruin vegetation several kilometers away from the industry, whereas emissions of less than 100ppm will witness green grasses growing few meters from the industry (35). More of this industry will come into being in the development of this country and one cannot always affordably displace people, hence due account must be given to pollutants from this industry now. In future adequate safe guard must be taken before giving permission to the building of this industry.

3.2.3 Air Pollutants From Iron & Steel Industry

This industry, which at various times has being referred to as the core of the nation's technological take-off, has had a lot of human and material resources invested in its development already. What is not certain is the implementation and enforcement of legislations preventing the pollution of the environment from this industry. As with the cement industry, the atmosphere is polluted by the emission of fluoride particulates that associate with the mined iron ore. The devastating effect of this pollutant is as pointed out for the cement industry. Another pollutant from this industry is the emission of cyanides which is poisonous to both man and animal. Soot and smoke are other pollutants that result from the operation of this industry and need to be controlled by stringent legislation.

3.2.4 CFCs Air Pollution And Greenhouse Effect

In Nigeria, air conditioning machines, house hold refrigeration, and industrial refrigeration are widely in use. All these air conditioners and refrigerating systems use one of a family of refrigerants known as CFC.

Apart from the above, CFC is also applied in aerosol propellants and plastic foam blowing. CFC, which is simply an organic compound containing carbon, chlorine, fluorine and in most cases hydrogen, has the characteristics of being chemically and thermally stable, non-flammable, non-toxic and thermodynamically suitable for use in refrigeration systems. CFCs have an internationally recognised system of numbering these compounds which start with letter 'R' followed by numerical numbers depending on the chemical component of the CFC. Table 1 shows (36) this international way of referring to each of these refrigerants and their chemical composition.

Table 1: CFCs - International mode of referring to it, its use and pollution potential.

CFC Numbering	CHEMICAL COMPOSITION	CHEMICAL FORMULA	ABILITY TO DEPLETE OZONE LAYER%	AREA OF USE
R11	Trichloroflorumethane	$CCl1_3F$	100	Propelant Plastic blowing, refrigerants.
R12	Dichlorodifluromethane	CCl_2F_2	100	Propelant, Plastic foam blowing, refrigerant.
R13	Monochlorotrifluoromethane	$CClF_3$	-	Refrigerant
R113	Trichlorotetrifluoroethane	$C2Cl_3F_4$	80	Plastic foam blowing, Solvent for electronics industry
R114	Dichlorotetrafluoroethane	$C_2Cl_2F_4$	80	Propelant for aerosols, Platisc foam blowing.
R502	Azeotrope of R22 & R115	-	33	Refrigerants.
R22	Chlorodiflouromethane	$CHClF_2$	5	Refrigerants.
R134a	Tetraflouroethane	$C_2H_2F_3$	0	Poor operating efficiency as Refrigerant.
R717	Ammonia	NH_3	0	Manufacture of fertilizers, Propelant, Refrigerant.

From the characteristics of CFCs above it becomes imperative that CFCs find use in refrigerating systems. The other areas where CFCs are in use are not wide spread in Nigeria and the only region of importance is in plastic foam blowing industry. Now the problem with CFCs start when it is released into the atmosphere as a result of leaks in a sealed system, during maintenance of CFC's equipment and during the blowing of plastic foam. The stability of CFCs enables it to stay for a long time unaffected in the surrounding air before being carried to the upper layers of earth's atmosphere - the stratosphere.

The stratosphere, a distance of approximately 14 kilometers above the earth's surface, is a layer of ozone gas. This gas prevents ultraviolet radiation of the sun as well as other sun rays of wave lengths shorter than 0.3im from reaching living organisms on earth. Ultraviolet rays and its likes burn, causing skin cancer, cataracts and irritation to humans and great damage to vegetation.

When the CFC reach the stratosphere and is exposed to the sun's ultraviolet rays, it becomes unstable and breaks down releasing the chlorine radical. The chlorine radical reacts with ozone removing one atom of oxygen. The chlorine atom acts as a catalyst (36) and can cause the breakdown of thousands of ozone molecules. The potential by which various CFCs destroy ozone layer and allows ultraviolet sun rays to reach the earth is shown in table 1 with R11 and R12 being the highest. The table also shows that the higher the proportion of chlorine in the CFC compound the higher its tendency of causing damage to the ozone layer. For this same reason R22 has 5% capability of destroy-

capability, on exposing these to ultraviolet ray in the stratosphere.

Beside causing ultraviolet rays to reach the earth's surface, CFCs, in its stable state, and methane are known to absorb infra-red radiation and retain heat that is generated on earth. This process helps in maintaining earth's temperature above that of polar cap of -6°C . This process by which heat radiation is prevented from escaping is known as greenhouse effect, as stated in section 3.1.1. In a large release and accumulation of CFCs and methane, in conjunction with CO_2 , heat retention on earth increases in magnitude and global warming occurs as temperature increases. This will lead to the warming up of polar-ice cap and the release of large amount of water into the oceans and seas giving rise to the process inscribed in section 3.1.1. CFCs and methane are known to contribute about 40% to the increase in temperature on earth i.e. the greenhouse effect.

A way of protecting the stratosphere ozone layer will be for us not to employ chlorine based CFCs as refrigerant or for blowing plastic. However the choice here is very limited as both R11 and R12 are widely in use world wide. The developed economy of Europe, USA and Canada have set a target date to replace these ozone damaging CFCs with others such as R22 and R134a. The problem here is the developing world's reaction time to development in developed economy. It is strongly suggested that the government takes a cue from changes in developed economy on this issue to avoid becoming a dumping ground for R11 and R12 machine compatible equipment.

4.0 CONCLUSIONS

4.1 Various sources of air pollution, its adverse effects on vegetation and man and ways by which these may be controlled have been stated. Issues dealt with must be a matter of great concern to any developing economy since environmental care takes little place in the scramble for development. It is of significance therefore that environmental care must be viewed with priority and put at par with economic development.

4.2 Nigeria should react in time to machineries phased out by developed economy due to its environmental hazard to avoid becoming a dumping ground for such machineries. She should also be import conscious to avoid the type of experience of KOKO incident.

4.3 It causes millions of US-dollars to clean up polluted areas once contamination had taken place apart from work force economic waste. Legislations to protect the environment from industrial exhaust contaminants must be put in place and with existing ones, enforced to prevent calamitous economic waste in future.

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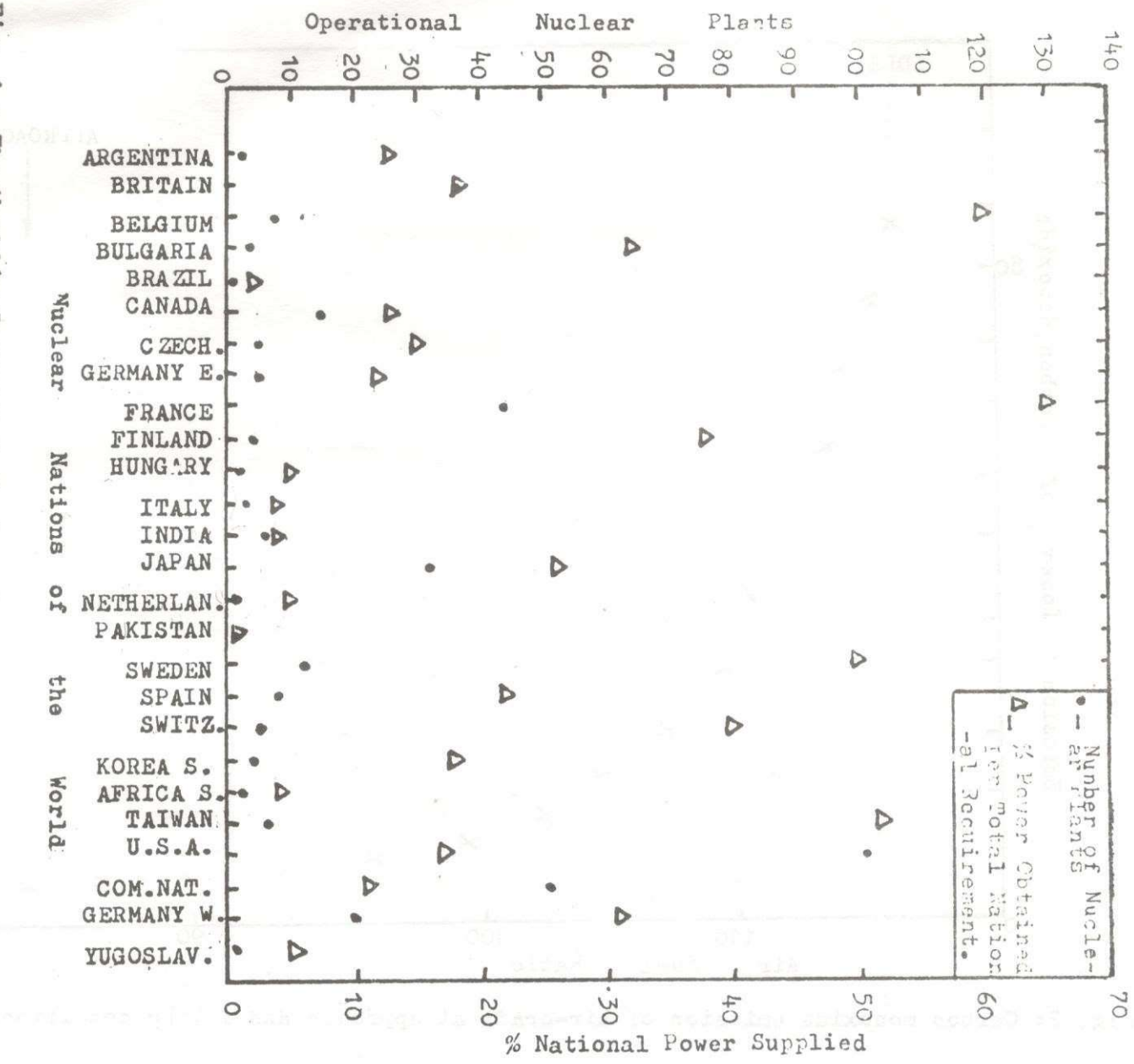


Fig. 1 : The World's Commercial Nuclear Plants.

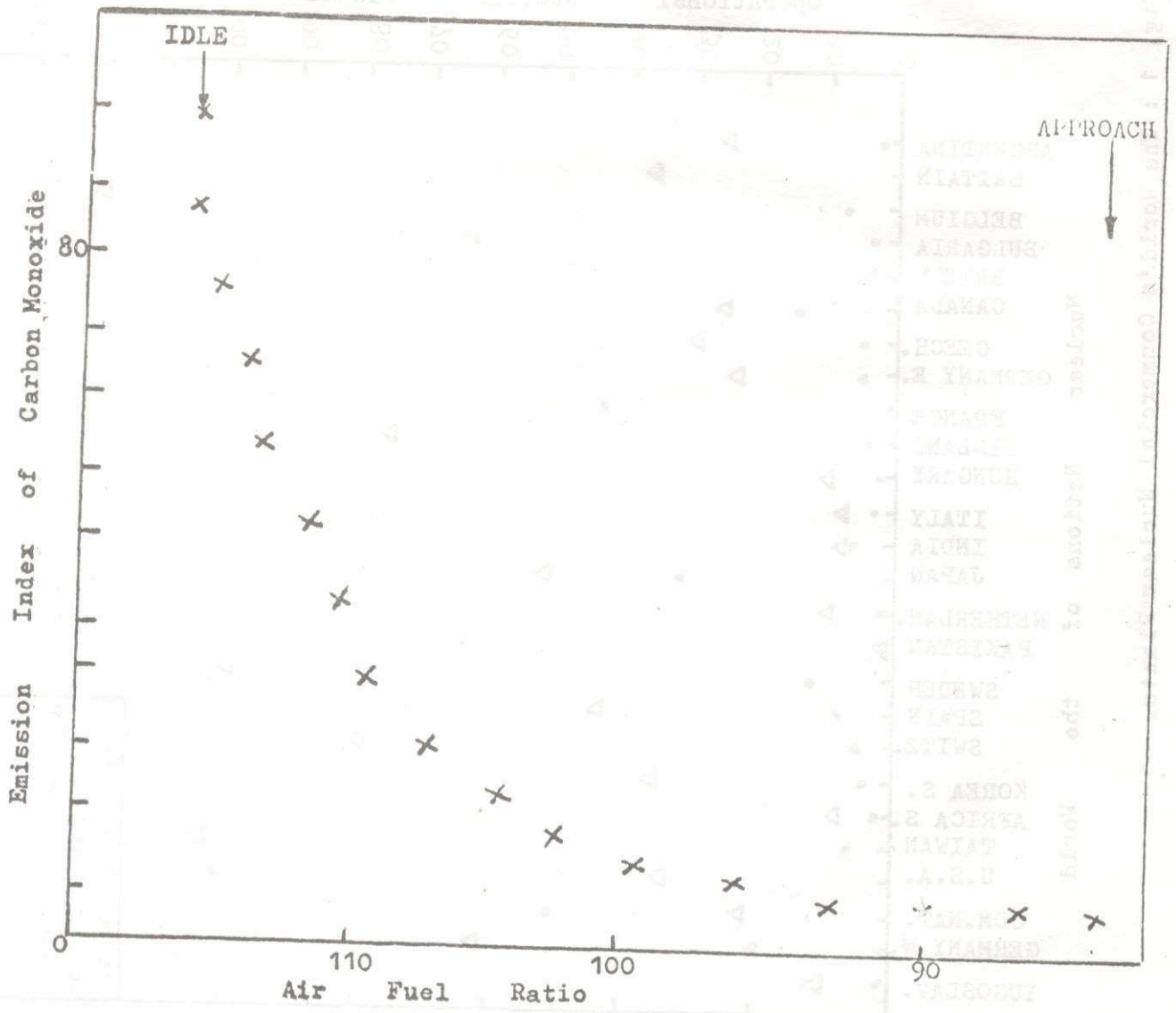


Fig. 2: Carbon monoxide emission of air-craft at approach and idling condition.

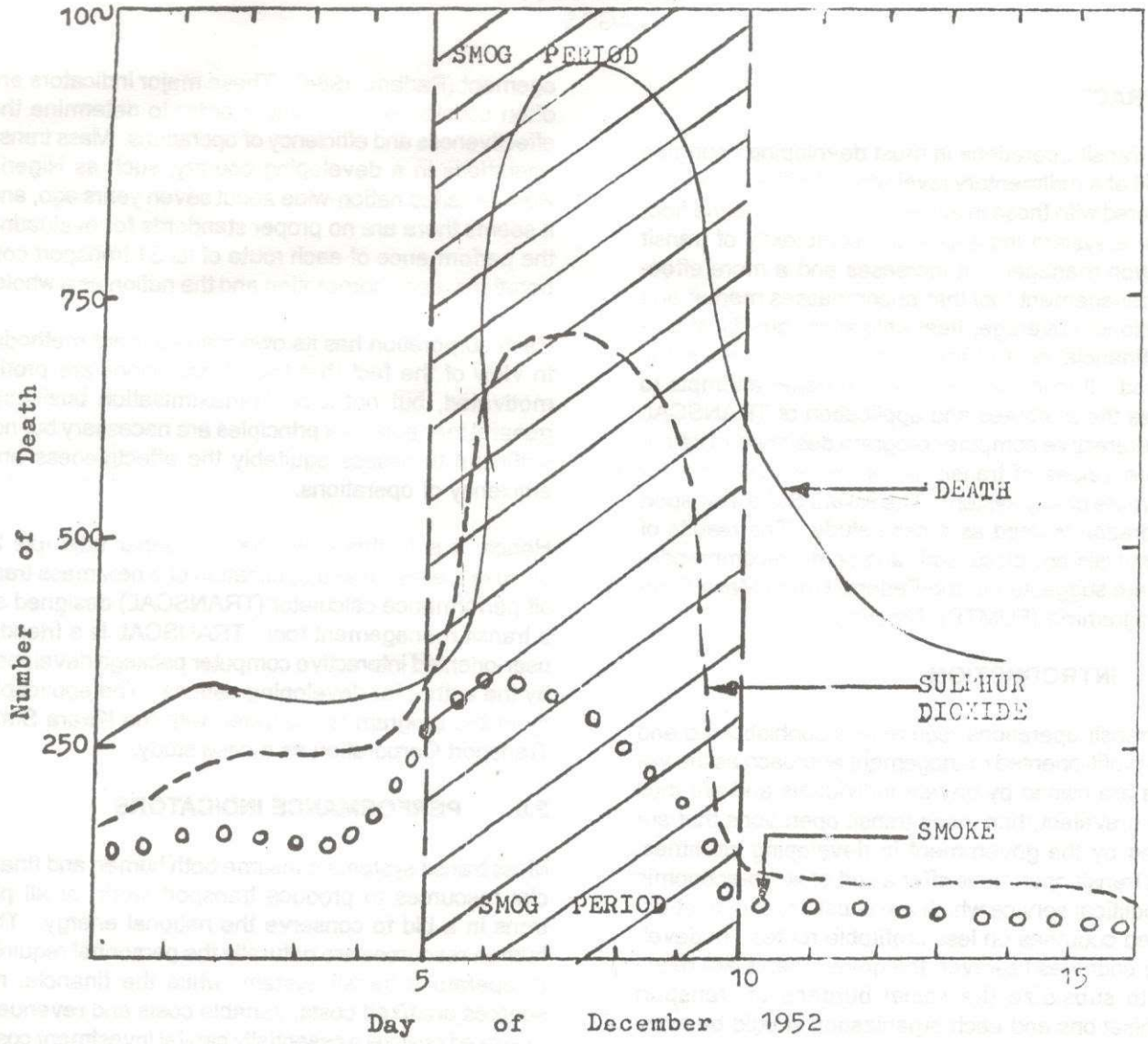


Fig. 3: Sulphur dioxide pollutant and death in London county in Dec. 1952. (after Frenkiel)