REVIEW PAPER
Ife Journal of Science vol. 18, no. 4 (2016)

POLLUTION SOURCES IN THE NIGERIAN ENVIRONMENT AND THEIR HEALTH IMPLICATIONS

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(Received: 3rd August, 2016; Accepted: 3rd October, 2016)

ABSTRACT

In this paper, the various sources of environmental pollution and their implications for health are discussed. All sectors of the environment-air, water, and soil are impacted via a combination of natural and anthropogenic sources. The parameters of major concern in the Nigerian environment are discussed as well as their health impact pathways. Among the natural sources are soil dust, radioactive–containing geologic materials, sea spray and decaying vegetation, while anthropogenic sources include industries, vehicular activities, mining, agricultural practices, municipal waste disposal, radiation exposure, bush burning, domestic practices, even churches and mosques. The most common route of exposure to air pollutants is by inhalation, but direct absorption through the skin or via food and water are also important pathways. Among the health hazards identified are respiratory disease, cardiovascular problems, brain damage, cancer and others. Water is the ultimate environmental sink, hence it receives the most environmental abuse from all sectors. The major source of health impairment from water pollution is through contaminated drinking water and some of the diseases resulting therefrom are cholera, bacterial and amoebic dysentery, typhoid fever, neurological impairment, cancer, brain damage, kidney damage, polio, infectious hepatitis, and schistosomiasis. A few specific examples of incidents of environmental pollution–induced health problems in the country are discussed.

INTRODUCTION

Environmental pollution issues have occupied a pride of place in the advanced countries of the world for quite some time. However, Nigeria has only started devoting the required attention to this very important area within the last two decades. Prior to this time, concern for the environment did not go beyond local municipal sanitation matters. The lack of environmental pollution awareness in Nigeria for so long could be ascribed principally to ignorance on the part of policy makers as well as the general citizenry in whose perceptions, pollution was thought to arise from manufacturing industries alone.

However, the Koko Waste Dump episode of 1988 signalled the beginning of consciousness on environmental protection in Nigeria as it led to the establishment of the Federal Environmental Protection Agency in 1988. This Agency has now mid-wived many environmental sub-agencies of government at the Federal level, and indeed most states of the Federation now have State Environmental Protection Agencies.

Sources of Pollution of the Nigerian Environment

The sources of pollution of the Nigerian environment are not much different from other places only the degree and specifics differ. In general, environmental pollution comes from both natural and anthropogenic sources and they affect all sectors of the environment--soil, water, and air, from which human health is impacted.

Natural Sources

Natural sources of air pollution of the Nigerian environment include soil dust, sea spray, and decaying vegetation. A lot of atmospheric dust arises from storms in arid regions of the Northern part of the country, and such dust travels over long distances. A good example is harmattan dust which is felt in the December/January months of the year all over Nigeria and whose origin has been traced to the Faya Largeau area of the Chad basin (Adepetu *et al.* 1988). As much as 1033 g/m^3 of dust was recorded in Kano and 329 g/m^3 in Ile-Ife during the harmattan period of 1993. Sea spray leaves particles of NaCl in the air after evaporation of the water, as observed in the coastal airshed of Lagos, Nigeria (Oluyemi and Asubiojo, 2001), and confirmed by subsequent source apportionment studies of the Lagos area. As much as two thirds of methane (a greenhouse gas) in air is formed as a result of bacterial metabolism of decaying vegetation as well as of cellulose in the guts of termites and ruminant animals such as cattle. Infact, this source is reported to contribute more to global warming than CO_2 (Fiala, 2009).

Natural pollution of water systems arises when heavy rain washes minerals from land into rivers, some of which are sources of drinking water. Besides, this decreases the Dissolved Oxygen Content and increases the Biological Oxygen Demand, Total Suspended Solids, Total Dissolved Solids of the water, which indirectly affect man who rely on such waters as their source of drinking water. Similarly, trees and marsh plants naturally produce a lot of organic matter from their leaves, stems, and roots. When these plant parts fall off or get washed into a waterbody by storm water, they can lower the Dissolved Oxygen content of the water body. Water hyacyinth is a common source of natural pollution of the environment. Some animals such as ducks and geese live on water. Such animals put manure directly into the water which cause pollution that can contaminate the water with disease-causing organisms.

Naturally-occurring radionuclide materials (NORM) occur widely in different parts of the world, Nigeria inclusive. These materials contain ^{14}C, ^{40}K, ^{87}Rb and nuclides of ^{232}Th and ^{238}U decay series, and the human population in these areas are continually exposed to radiation from these radionuclides. Radiation exposure also occurs in home environment, particularly those built on granitic ground (Mokobia *et al.,* 2006). We are even exposed to some radiation (from ^{40}K, ^{14}C, and ^{226}Ra) from our own bodies. Of these three, ^{40}K provides us the largest internal dose of radiation as the potassium is distributed throughout our bone structures. Infact, from time to time one of these radionuclides turns up in clay used to make pottery and unknowingly the consumer can find himself with a lovely set of radioactive dishes!

Anthropogenic Sources of Air Pollution

Anthropogenic sources of atmospheric pollution fall into 2 broad categories--point sources or fugitive sources. Point sources are discrete, stationary, identifiable sources of emissions which are typically located in industrial settings. They are characterized by the release of general air pollutants typically associated with fossil fuel combustion and by-products of industrial processes e.g. NO_x, SO_2, CO, particulate matter (PM), and Hazardous Air Pollutants (HAP) including VOCs and metals. On the other hand, fugitive sources are not confined to specific points or stacks. Common sources of these are soil erosion, rock crushing, building and road construction, road surface re-suspension. They have the potential for much greater ground level impacts per unit emission than stationary sources since they are emitted and dispersed close to the ground. The two main types of fugitive emissions are VOCs and particulate matter (PM), along with CO.

More specifically, the major anthropogenic sources of air pollution are industry, vehicular emissions, solid waste dumps, incineration, bush burning and other agricultural practices. A considerable amount of pollutants are also emitted into the air from domestic sources.

a. Industry

Industrial activities are the greatest sources of man-made pollution of the atmosphere. This is particularly so in countries like Nigeria where most of the operating industries were set-up when there were no pollution abatement regulations in place.

The greatest contributors of particulate dust are cement and metal-smelting industries. For example, as much as 56,100 g/m^3 of particulate dust have been measured in a cement factory vicinity and 12,320 g/m^3 in a metal smelting factory premises (Adejumo *et al.,* 2004). These particulates are hosts to many heavy metals which are very toxic. However, with environmental protection now being enforced by the various national and state environmental protection agencies, these are now being minimized. Other air pollutants commonly emitted from manufacturing industries are sulphur dioxide and nitrogen oxides (both from fuel combustion), carbon monoxide from incomplete combustion of fuel, Volatile Organic Carbon (VOC) compounds from the use of industrial solvents.

Oil exploration and production activities are also major culprits of atmospheric pollution in Nigeria. Volatile organic compounds (VOCs) are emitted into the environment from product volatilization and fugitive emissions (from equipment failures/wears, leakages from fittings, flanges, valves, valve seals, compressor vents, e.t.c.). Pollutants are emitted from combustion

systems (flares, power generating utilities and heaters) and process emissions (separators, water treatment systems, e.t.c.). Associated gas containing SO_2, NO_x, CO, CO_2, hydrocarbons, soot and particulate matter in the oil fields are flared into the environment. Some of these pollutants like NO_x and SO_2 have been implicated as primary precursors to the formation of acid rain. Indeed, one of our previous studies showed considerable acidity of rainwater (pH 3.35 – 6.8) in the Niger Delta area (Oluwole *et al.*, 1996). About 168 billion cubic meters of natural gas is flared worldwide out of which 23 billion cubic meters (or 13%) comes from Nigeria and this is one of the major contributors to global warming.

Sources of water pollution may be divided into two categories: Point-source pollution, in which contaminants are discharged from a discrete location, and non-point sources or diffuse pollution referring to all other discharges that deliver contaminants to water bodies. Industrial water pollution belongs essentially to the first category. Industries that use large amounts of water for processing have the potential to pollute waterways through discharge of their wastes into streams and rivers, or by runoff and seepage into nearby water sources. Only a few of the industries in Nigeria have standard wastewater treatment facilities; many of them discharge their raw surface runoff and liquid effluents directly into public drains which end up in surface streams and rivers. Some which have waste treatment facilities still end up discharging into the same receptors. The industrial effluent discharges contain biodegradable and non-biodegradable organic wastes such as pesticide residues, solvents and cleaning fluids, dissolved residues from fruit and vegetables, and lignin from pulp and paper, bacterial and viral pathogens etc. Inorganic wastes include brine salts and heavy metals. Even shallow aquifers are polluted by the effluents which contain high organic matter, oil and grease, high particulate loading and non-biodegradable heavy metals, with concomitant health problems.

b. Mining

In the solid minerals sector, the three processes of exploration, mining and processing all generate health–impairing pollutants of all forms. Site clearing involves the use of fuel-operating machines which emit noxious fumes of SO_2 NO_x CO into the atmosphere in addition to particulate matter; the metals and industrial minerals that mining produces can find their ways into the environment as pollutants. In addition, there are associated by-products of processing such as Sulphur, Arsenic, Mercury and other heavy metals which are all injurious to human health. Coal mining produces methane, a potent greenhouse gas, with a global warming potential 21 times greater than that of CO_2 on a 100 year time line. The more direct effect comes from Mercury emissions from coal burning which are concentrated as they work their way up the food chain and get converted to methylmercury, a toxic compound, also causing pollution of groundwater. Exposure to radioactivity is very common in the workplace particularly in areas of high natural background radioactivity. As indicated above, Naturally-Occurring Radioactive Materials (NORM) is very common in geologic materials. In the process of carrying out geologic-related activities, man is exposed to anomalously high concentrations of radioactivity, either directly from air in the work environment, or through food or water which have been contaminated from the mine tailings. This pathway to radiation exposure is referred to as Technologically Enhanced Natural Radiation (TENR) – i.e. exposure to truly natural sources of radiation which would not occur without or which are increased by some technological activity not expressly designed to produce radiation. This occurs in mining and processing of mineral ores, processing materials from mine wastes, production of fertilizers and oil/gas drilling and abstraction (Makweba and Holm, 1993; Benes, 1999). During exploration and extraction processes, various operational practices contribute to or induce NORM occurrence, namely remote sensing methods of mapping and explosives associated with seismic exploration, drilling equipment and activities, and down-the-hole geophysical logging methods. In some instances, radioactive marker bullets are employed as an aid in relative depth determinations. The gamma ray log is used to locate the bullets after casing has been set.

c. Vehicular Emissions

Atmospheric pollutants from motor vehicles are

of 2 types -- exhaust and non-exhaust emissions. Emissions from the exhaust are products of fuel combustion such as NO_x, SO_2, CO, CO_2, VOCs and some quantities of particulate matter containing toxic heavy metals (V, Cd, As and also Pb in cases of leaded gasoline). On the other hand, non-exhaust emissions from motor vehicles include particles from brake wear (Cu, Sb), tyre wear, road surface abrasion and re-suspension in the wake of passing traffic (Thorpe and Harrison, 2008).

d. Solid Waste Dumps

The problem of solid waste disposal is a major environmental issue in Nigeria, particularly in the urban centres. A common practice of solving this problem is disposal at designated sites. However this is also an indirect source of atmospheric pollution by way of bio-degradation of organic waste producing methane, a greenhouse gas and other gaseous toxins. Closely related to this is incineration of solid waste which generates CO_2, CO, and VOCs into the atmosphere. Studies have also shown heavy pollution of adjoining soil, rivers and groundwater in the neighbourhood of solid waste dumps, a case of creating one pollution problem while trying to solve another.

e. Agricultural Practices

Agricultural practices contribute to atmospheric pollution by way of bush burning and pesticide use. Nigeria ranks among the top 13 countries in the volume of biomass burning worldwide (Isichei *et al.*, 1995). Bush burning leads to emission of gaseous pollutants such as CO, CO_2, NO_x, SO_2, VOCs and particulates.

The common pesticides in use in Nigeria are synthetic hydrocarbons such as dichlorodiphenyl trichloroethane (DDT), Aldrin and Dieldrin. These are all toxic volatile liquids which are non-biodegradable as a result of which they have been banned in the developed countries. In a study of Organochlorine Pesticide Residues (OCPs) in some cocoa-producing areas of Ondo State, it was found that the levels of OCPs and PCBs exceeded the international standards for these non-biodegradable toxic compounds in some of the surface waters and in most of the river sediments and soil samples (Okoya, Torto, Ogunfowokan, and Asubiojo, 2013a,b).

Also in common use are Copper fungicides in cocoa plantations. In a study of fungicide residues on the physico-chemical characteristics of soils in cocoa-producing soils of Ondo State, it was found that copper-based fungicides predispose the soils to Nitrogen, Phosphorous and Potassium (N,P,K) deficiencies and Copper toxicity in the soils (Akinnifesi, Asubiojo, and Amusan, 2006). Of course, this will be passed on to man through the food chain.

Besides, decay of agricultural wastes lead to emission of methane and other greenhouse gases (Obioh *et al.*, 1994). Also, as mentioned above, cattle farming contributes to air pollution in 2 ways, feeding on vegetation which normally absorbs CO_2 from the atmosphere, thus indirectly increasing CO_2 and producing CH_4 a very potent greenhouse gas. A 1988 estimate of methane emissions from ruminant and non-ruminant sources in Nigeria was 950 Gg (Obioh *et al.,* 2004) and Methane is believed to be a greater contributor to global warming than Carbon dioxide.

f. Power Generation

Ordinarily, normal power generation, be it from coal, oil, gas or water is accompanied by emission of gaseous pollutants into the atmosphere. Some potential health-related consequences of power generation, transmission and distribution include: impact on air quality from ozone production through Corona effect, injury and death from electrocution due to possible failure of suspension line, health effects from electromagnetic fields, audible noise generated by corona effect around live (energised) conductors. Besides, every home in the urban areas have one or more private electric power generators which continuously emit fumes of Carbon, Nitrogen and Sulphur oxides into the atmosphere.

Surface runoff carrying facility effluents, waste streams, fuel and oil from construction and power generation plant operational sites impact nearby surface water quality. The construction of transit and permanent residential camps engender solid waste and domestic sewage discharge which also impact the surface water quality or the shallow aquifer. Leaks and spills from the facility also potentially impact the surface water quality and

shallow aquifer. Excavation could introduce suspended solids into the shallow aquifer as well. For private power generation which is very prevalent, run-off of spent fuel into adjoining drains is a source of water pollution.

Besides air and water pollution from this source, private power generators are a major source of noise pollution with their serious health consequences.

g. Domestic Practices

Wood burning for domestic cooking is still very prevalent in Nigeria and other less-developed countries, particularly in the rural areas. This practice results in the production of smoke which contains toxic polycyclic aromatic hydrocarbons (PAH), carbon monoxide, sulphur dioxide, aldehydes and particulate matter. The World Health Organization (WHO) estimates that 2.5 billion people are adversely affected by pollution from this source. Of course, the use of kerosene and cooking gas also produces sulphur and carbon oxides which are major indoor air pollutants particularly in poorly-ventilated homes.

Domestic practices account for a large part of water pollution being experienced in Nigeria. This comes in form of treated and untreated sewage which are discharged into municipal rivers which consequently house several pathogens thereby causing diseases, improper discharge/treatment of solid waste which cause pollution of surface waters and underground water as highlighted above

The various sources discussed above are not exhaustive. Other sources, some of which have been alluded to indirectly are sewage disposal, accidental and deliberate oil spillage, leakage from sewer lines, leakage from landfills, etc.

Health Implications of Environmental Pollution

Environmental pollution affects all sectors of the environment--human health, ecosystems, physical materials, and global climate, but only the human health effects will be highlighted here with only cursory reference to the other sectors.

The most common route of exposure to air pollutants is by inhalation, but direct absorption through the skin or via food and water are also important pathways. Because they are strongly oxidizing agents, sulphates, SO_2, NO_x, and O_3 act as irritants that damage delicate tissues in the eyes and respiratory passages. Fine suspended particulates are irritants, capable of penetrating deep into the lungs and carrying metals (some of which are very toxic) and toxins on their surfaces. Inflammatory responses set in motion by these irritants impair lung function and trigger cardiovascular problems as the heart tries to compensate for lack of oxygen by pumping faster and harder. Carbon monoxide replaces oxygen in the bloodstream forming carboxyhaemoglobin which can impair vision, alertness, and other mental and physical capacities. It has particularly severe health effects for people with heart and lung problem. Lead also binds to haemoglobin and reduces oxygen–carrying capacity at high levels. By virtue of its chemical nature, ozone, a form of oxygen with 3 oxygen atoms instead of two, reacts with practically every material with which it comes in contact. This reactivity causes health problems because it tends to break down biological tissues and cells.

Greenhouse gases, most of which come from fossil fuel burning cause indirect health problems in addition to other problems in the ecosysystems. It is likely to affect the distribution patterns of infectious diseases as such disease vectors move to new areas. Chlorofluorocarbons which are products of the petrochemical industry, have been shown to cause destruction of the ozone layer which causes skin cancer in addition to other problems in the ecosystem.

The World Health Organization (WHO) estimates that some 7 million people die prematurely every year from air pollution–related illnesses (WHO, 2014). These include a variety of respiratory problems, irritation and distress, acute or chronic inflammatory changes in lung tissues, acute asthma attacks, exacerbations of bronchitis, cancer and even death. For a cement factory or quarry the main hazard is respirable dust from the various operations. This has been identified as a skin, eye and respiratory tract irritant.

In a study on cement workers in Nigeria, Erhabor and Fatusi (2004) evaluated pulmonary symptoms such as cough, sputum, breathlessness, wheeze,

chest pain and determined the ventilatory functions of workers and controls for comparison. Ventilatory functions usually monitored include Peak Expiratory Flow Rate (PEFR) and Forced Vital Capacity (FVC). Statistical analysis of their data showed that the cement factory workers had higher incidence of chronic non-specific lung diseases, and significantly lower lung functions than the control subjects ($P<0.05$). Among the factory workers, those that were directly exposed to cement dust especially in the mill and packing plant had higher incidence of respiratory symptoms than office workers. The results were supported by the finding that a strong correlation existed between the FVC and PEFR of the factory workers and the Total suspended particulate concentrations at the factory site.

In order to investigate the effect of vehicular emissions on human health in Nigeria, we determined the concentrations of Lead, Bromine, Zinc and some other vehicle traffic-related elements in roadside air particulates, soil and human blood in Lagos and lle-lfe (Ogunsola *et al,* 1993 a,b,c). Lead, Bromine and Zinc were highly enriched in ambient air and roadside dust in both cities, with the enrichments being higher in Lagos and the elemental concentrations being positively correlated with traffic density. Concentrations of the traffic-related trace elements also decreased with soil depth. In addition, the mean concentration of Lead was significantly higher in the blood of Lagos traffic wardens (18.1 6.4g/dl) than lle-lfe traffic wardens (10.2 2.7g/dl), in correspondence with the traffic densities in the 2 areas. There was no significant difference in the blood Lead levels of Ile-Ife traffic wardens and control subjects. However, the results for the Lagos traffic wardens gave cause for concern because of the toxicity of Lead. In fact, studies have shown that there may be a loss of up to 2 Intelligence Quotient (IQ) points for a rise in blood level of 10-20g/dl in young children (Baghurst *et al.*, 1992 a, b). The results of this study prompted us to recommend to government the stoppage of importation of leaded gasoline to Nigeria.

Here in Nigeria, the first report of a major pollution–related health issue was of widespread, acute lead poisoning in Zamfara State in which at least 400 children were reportedly killed (Human Rights Watch, 2010). Considered the worst outbreak of lead poisoning in modern history, more than 3,500 affected children required urgent, life-saving treatment. There were high rates of infertility and miscarriage among adults. A more recent case of Lead poisoning in Niger State was reported by the World Health Organisation (WHO, May 15, 2015). A total of 46 cases were reported, some of them involving deaths. The common symptoms reported were "fever, pallor, abdominal pain, vomiting, concussion and altered level consciousness". Blood samples of the hospitalized cases showed high levels of serum Lead (171.5-224) ug Pb/dl).

Water is the ultimate environmental sink, hence it receives the most environmental abuse from all sectors. Among the most important waterborne diseases are typhoid, cholera, bacterial and amoebic dysentery, enteritis, polio, infectious hepatitis, and schistosomiasis. Malaria, yellow fever, and filariasis are transmitted by insects that have aquatic larvae. About 25 million deaths each year result from these annually worldwide, a large number of these coming from Nigeria where malaria is the leading cause of death. Toxins and other pollutants produced in water effluents are consumed by fish and eventually by man, affecting the heart and kidneys. Other health problems are poor blood circulation, skin lesions, vomiting and damage to the central nervous system

Fossil fuels, even though essentially composed of hydrocarbons contain significant amounts of heavy metals. Effluents from the processes invariably contain high levels of these trace metals which are toxic even at ppm levels. Some of them are toxic because of their interaction with Sulphur–containing biochemicals such as enzymes and proteins. They have been linked to severe birth defects, a damaged or suppressed immune system, cancer, fertility problems and developmental changes in children. Key examples of very toxic trace metals are Pb and Hg. Even moderate exposure to Pb adversely affects neuropsychological developments in children leading to decrease in Intelligence Quotient (Baghurst *et al.*, 1992; 1995). High levels of exposure affect haemoglobin synthesis, cause kidney problems and chronic damage to the

nervous system among other health problems, even in adults. Mercury has no known function in human biochemistry but causes damage to the brain and the central nervous system. The first two major incidents of Hg poisoning were recorded in a Japanese city - Minimata in 1932 and 1952, with the second incident of consumption of mercury–polluted fish leading to more than 500 fatalities.

CONCLUSION

The various sources of pollution of the Nigerian environment were discussed. Among the natural sources identified were harmattan dust, sea spray and decaying vegetation while anthropogenic sources identified include industry, mining, vehicular emissions, solid waste disposal, agricultural practices, power generation and domestic practices.

The human health implications of these sources were discussed with specific references to some of our previous studies in this area as well as some health-impairing pollution incidents in the country.

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