Public Health and Physiological Implications of Dust Assaults on the People living in the Dry Belt Zone of Nigeria

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ABSTRACT

Dust storms and harmattan dust are so prevalent in the dry belt region of Nigeria and recently are assuming alarming rate and proportion, destroying lives and property. The sand dunes created by such phenomena bury crops, lands, houses, water, schools, roads and animals, rendering this region almost completely unsuitable for human and animal habitation as well as agricultural activities. This study hence reviews public health and physiological implications of dust assaults on the people living in the dry belt zone of Nigeria. The aim is to explore the adverse effects of dust on public health. The study gathered data using the secondary source. The results of the study reveal among many others the effects of dust assaults on people living in the dry belt zone to include lung cancer, renal failure, infertility, cough, asthma, pneumonia, bronchitis decreased RBC, PCV and Hb concentration, liver cirrhosis, skin diseases, reduced lung oxygen saturation level (SPO_2) and Peak Expiratory Flow (PEF) Rate and generalized impaired resistance to infection in both humans and animals. Consequently, government at all levels, non-governmental organisations, religious groups and all stakeholders in human environment should step up efforts in addressing the issues of public health as a means of having a healthy society.

Keywords: *Dust, assults, dry belt zone, health, Nigeria*

INTRODUCTION

There is no single definition for air pollution. However, air pollution can be defined as the introduction by man, or natural sources, into the environment, toxic substances or pollutants at concentrations high above their normal ambient levels liable to cause hazards to human and animal health, and other living resources, as well as ecological systems, and damage to structure or amenities, and interference with the legitimate use of the environment (Frank, 1974; Seinfeld, 1975, Bowen; 1979). This definition captures the broad and myriad consequences of air pollution to man and his

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environment. Humans and animals are exposed to environmental hazards daily due to air pollution, whether indoor or outdoor. The extent, nature or characteristics of such hazards varies from one locality to another. We cannot find clean air in any part of the world. The air which we breathe is not pure oxygen but is contaminated with dust, smoke and several gases or harmful phosphorus (Sodipo, 2007a). Sub-Saharan Africa and Nigeria in particular, faces several environmental challenges from air pollution and desertification ranging from encroachment of the Sahara desert desiccating wind pattern and dust storms in the north and severe air pollution in overcrowded cities, such as Lagos, Ibadan and Port Harcourt in the south, Kano, Maiduguri and Kaduna in the north, and in the Niger Delta areas, environmental challenges from oil spillage, gas flaring and deforestation. Apart from water, food and soil, air quality is an important factor that determines the sustainability of the environment (Ikamaise *et al*., 2001).

Dust constitutes one of the major air pollutants, especially in the dry belt of Nigeria (McTainsh and Walker, 1982; Middleton, 1985). Dust, according to health fact sheet report series of United States Department of Health and Human Services (DHHS, 2008), consists of a mixture of fine or tiny particles usually formed by disintegration or fracture of solid form materials (DHHS, 2008). The United States Mine Safety and Health Administration (US-MSHA, 2008), defines dust as finely divided solids that may become air borne from the original state without any chemical or physical change other than fragmentation. Dust (also referred to as suspended particulate matter) represents a complex mixture of organic and inorganic substances, solid or liquid substances and mass of inert materials. According to the United Nations Environmental Protection Agency and World Health Organization (UNEP/WHO, 1994) reports on review of methodology of management of particulate matter in ambient air, total suspended particulate matter (TSP) is used to assess air quality.

Dust, together with particulate emissions such as automobile and industrial exhaust fumes and other fugitive and combustion emissions is a paradigm of synergic processes in atmospheric air pollution in the Sahel region. The particulate matters are complex heterogeneous mixture of solid particulates and liquid components such as those from power plants and industries, gas flaring, motor vehicles and natural source elements such as dust.Air borne particulate matter is an example of solid and liquid particulate suspended and dispersed in air (UNEP/WHO, 1994). Air pollutants, especially dusts, permeate all fabric of environment through biogeochemical and anthropogenic routes (Ikamaise, Obioh, Ofoezire and Akeredoulu, 2001). These may constitute serious contaminants or pollutants when present in greater than recommended concentration. The severity of effects and contamination by the pollutants increases with intensity of emissions, sources of strength and atmospheric mixing of the pollutants and some predisposing factors (Obioh, Oluwole and Akeredolu, 1993). The Federal Environmental Protection

Agency of Nigeria (FEPA, 1991) maximum total suspended particulate air quality standard limit is 250µg/m^3. The dry belt zone of Nigeria, generally, which is generally known as the Sahel, is defined as the area that receives between 200mm and 800mm of rainfall per year (IIED, 1989), and occupies about 65% of her total land mass, and is located within the co-ordinates of latitude 10^0 to 14^0N and longitude 3^0 to 14^0 E. Dust constitutes one of the major air pollutants (McTainsh and Walker, 1982; Middleton, 1985; Gadzama, 1991, 1995). In the Sahel region, harmattan dust and hot dry dust storm and desiccating winds, characterized the major part of the year, usually extending from December to June (Rayar, 1996; Middleton, 1985).

The dust particles are mechanically produced by the breakup of larger solid particles (US-EPA, 1996), and may include windblown dust from the Sahara desert, dust from agricultural processes, uncovered soils, unpaved roads or mineral operations, among others (Moses, 2007). As soon as the dust has been raised by wind and lifted up in the atmosphere, the coarse particles begin to be removed from the atmosphere by gravitational forces. Relatively big particles with radii of more than 100µm will have atmospheric residence time of the order of minutes to hours, while particles of radii of 1µm or less, might remain in the atmosphere for up to weeks and transported several thousands of kilometers from the site of origin (Christer,1998). The annual dust storm frequency as well as the magnitude in the Sahel region is on the increase at an alarming rate (Gadzama,1991; Rayar , 1996).

The zone is generally characterized by scanty rainfall and vegetation cover, summering heat, incessant dust storms and harmattan, droughts and desertification, desiccating wind pattern and sandy soil textures that are prone to droughts and alarming desertification and soil degradation and deterioration, brought by both natural and human forces. The open and flat topography of the region allows an uninterrupted incursion of dust particles into the region and this persist for the greater part each year (Dajab 2006; Gadzama, 1991, 1995; Rayar, 1996). In Nigeria, particularly in the north, the Harmattan, , dry dust-laden atmosphere, occurs from November to June each year as experienced in some other parts of West Africa (Dajab 2006; He, Breuning-Madsen and Awadzi, 2007; Gadzama,1995; Rayar 1996). The Harmattan is known to rise in the Sahara desert and is carried southwest by winds from that area (Harris, 1967). Harmattan dust is the product of an Aeolian system of continental scale which originates in the southern Sahara and across West Africa and the Atlantic (McTainsh, 1980).

Storm activities in the Bilma and FayaLargeau area in the Chad Basin were reported to raise large amounts of dust into the atmosphere, which is then carried southwest by the predominant winds (Alfeti and Resch, 2000). On the other hand, fugitive dust and automobile emissions result from the complex interplay between wind and anthropogenic activities that generates dust or particulate matter (PM) which is suspended in the atmosphere. Anthropogenic activities generate dust which emanates primarily from soil that has been disturbed by wind or human activities, such as earthmoving and vehicular traffic on both paved and unpaved surfaces. Generally, the entity air particulate or dust is a mixture of particles in which differentiation exists only in source, size, composition, and properties (USEPA, 2004a, IDEQ, 2008). This region is generally scantily industrialized, but heavily populated and extensively utilized for agricultural activities. This heavy dependence on agriculture related activities lead to land degradation and desertification, as a result of deforestation and denudation. This further exacerbates the environmental problems. Anthropogenic activities, such as extensive and indiscriminate land clearing, tree felling, bush burning, removal of vegetations, accentuate soil erosion, cause excessive flooding (Bababe, 1988). Air pollution may come from human (anthropogenic), industrial as well as natural sources. Human and Industrial sources of air pollution usually result from activities aimed at improving the quality of life of people. These activities may be industrial, transportation or commercial activities.

Industrial activities implicated in environmental contamination, include oil refining, metal smelting, food and wood processing, metal recycling, mining, battery making, plumbing, dye fabrication, welding, brass and pottery work, News Print and so on (DHSS, 1980; Ward, 1988; Akeredolu, 1989; Oyedele *et al.*,1995). Natural sources of air pollution may result from sand or dust storms, harmattan winds, hurricanes or as direct consequences of soil or wind erosion. The particles are mechanically produced by the breakup of larger solid particles (US-EPA, 1996). This may result from disintegration, or fragmentation of solid form material, windblown dust from agricultural processes, uncovered soils, unpaved roads or mineral operations, among others (DHHS 2008; Moses, 2007).

The mobilization of soil dust, comprising mineral dust and product of chemical or organic processes, depends on a variety of factors, which can be divided into two categories: firstly, mobilization resulting from the surface and presence of wind being strong enough to lift the soil particles into the air. The amount of dust mobilized at a given location over any given period will therefore depend on the frequency, intensity and duration of wind events in which the magnitude of the surface velocity exceeds a certain threshold value at that location (Akeredolu, 1989). Secondly, the degree of dust mobilization occurring at a given location as a result of particular combination of climatic factors will depend on the susceptibility deflation of the soil at that location (Moses, 2007). The particular mix and concentrations of air pollutants may vary considerably from location to location, and from day to day. Particles suspended in the atmosphere may have long atmospheric resident times; these may be transported by vertical and horizontal wind currents, frequently to a great distance (McCartney, 1976). The incidences of harmattan dust and dust storms in the dry belt of Nigeria have become a recurring phenomenon and recently are assuming alarming rate and proportion, destroying lives and properties (Moses, 2007; Rayar, 1996).

CHARACTERISTICS OF ARID AND SEMI ARID ZONES OF NIGERIA

All the regions that are situated above 10^0N according to Dajab (2006); Gadzama (1995); Rayar (1996) are bathed by simmering heat experience, endless occurrence of incessant droughts, harmattan and dust storm of monumental proportions, which are brought about by an alarming rate of desertification, and thereby putting tremendous pressure on the already crippled agriculture and economy, resulting in a continued declined in the living standard of the people. This region is characterized by arid and semi arid climate pattern, which consist of vegetation zones of Northern Guinea, Sudan and Sahel Savannas. The arid and semi arid zones of Africa are a mixture of varying magnitude of deserts and dry lands, coupled with difficult and fragile environment that is fast becoming inhabitable (Gadzama, 1991, 1995; Rayar, 1996). The zone is generally characterized by short rainfall, receives between 200mm and 800mm of rainfall per year (IIED, 1989), scanty vegetation cover, summering heat, incessant dust storms and harmattan, droughts and desertification, desiccating wind pattern and sandy soil textures that are prone to droughts and alarming desertification and soil degradation and deterioration, brought by both natural and human forces. Nonetheless, a short cold spell usually known as harmattan cold blows from December to February. The temperature during this period is relatively lower; thus enabling the cultivation of wheat and other vegetable crops under irrigation. The open and flat topography of the region allows an uninterrupted incursion of dust particles into the region and this persists for the greater part each year. The scanty vegetation dictated by insufficient rainfall and anthropogenic activities and demand for wood for construction, building, fuel and other uses, removal of trees, shrubs, herbaceous plants and grass cover from the fragile land of the Sahel continue to accelerate the degradation of the soil to desert like condition, predisposes the soil to various destructive forces of nature, thus leading to its degradation of varying magnitude, thereby reducing sustainable agricultural production and ensuring the perpetuation of drought syndrome (Dajab, 2006; Gadzama, 1995; Rayar, 1996). Together with seemingly limited and erratic distributions of rainfall lingering each year, the ravaging effect of drought and desertification becomes exceedingly intensive and warrants systematic monitoring of the climatic pattern and changes so as to institute deliberate and appropriate measures to stop this ugly trend. It is presently estimated that Nigeria has lost some 351,000 square km to desertification representing 38% of its total landmass which corresponds to the eight desert–threatened front line States of Sudano-Sahelian West Africa (Table 1). Maiduguri, the capital of Borno State for example, is located in the semi arid region of the dry belt zone of Nigeria, and it has a close proximity to the Sahara desert. The open and flat topography of the region allows an uninterrupted incursion of dust particles into Maiduguri and its environs. Suspended particulate matter or dust is prevalent in this region and mostly accrues from dust storms from the harmattan winds, which blows across the Sahara desert (Gadzama, 1991, 1995; Rayar, 1996).

Table 1: Sudano-Sahelian West Africa

Country	Population (millions-1983)	Total Land (Area 000/sq, kms)	Total Dry lands (000/sq.km)	As % of total
Benin	3.8	113	50.7	45
Burkina Faso	6.7	274	243.9	89
Cameroun	9.6	474	123.6	26
Cape Verde	0.3	4	3.5	87
Chad	4.7	1,284	1,1686	91
Gambia	0.7	11	9.6	90
Ghana	12.5	239	66.8	28
Guinea	5.8	246	2.5	1
Guinea-Bissau	0.9	36	1.1	3
Mali	7.3	1,240	1,202.5	97
Mauritania	1.6	1,031	1,031.0	100
Niger	6.1	1,267	1,267.0	100
Nigeria	93.6	924	351.0	38
Senegal	6.2	196	171.1	87
Togo	2.8	57	14.0	25
Total	168.8	7,397	5,706.9	77.1

Source: United Nation Sudano-Sahelian Office (UNSO) (1989)

Maiduguri dust storm in particular, which occurred on 30th May, 1988, is of grave concern to every inhabitant of this region and indeed, the entire nation (Rayar, 1996).This unsurpassed sand storm lasted for about 30 minutes, thereby causing total darkness at about 3.30pm. It has been estimated that the magnitude of dust accumulations in an enclosed house hold yard during this storm was 45 tons per hectare (45t/ ha) (Rayar, 1996). The extent of deaths, and damage or injury to human and animal health as well as damage to the environment by this single unsurpassed episode of dust storm has not yet been officially documented, but surely the consequences must be grievous.

Similar episode of almost exact magnitude occurred on 30th May, 2012, exactly 24 years after. This dust storm also occurred the same time, at 3.30 pm, and lasted for the same duration of time, that is, about 30 minutes. This is of particular interest for researchers and all concern citizens of Nigeria and calls for keen and systematic scientific observation and continuous monitoring of such a natural phenomenon. It can be inferred that such a horrible dust phenomenon will probably occur again in the next 24 years, that is, on 30th May, 2036, around 3.00pm local time, and will last for about 30 minutes. Similar episodes of dust storm of less magnitude occur on daily basis, especially between the months of January and June (Gadzama, 1995; Rayar, 1996).

The sand dunes created by such phenomena bury crops lands, houses water, schools, roads, animals, and rendering this region almost completely unsuitable for human and animal habitation and agricultural activities. Famine, diseases, poverty and hunger are amongst myriads of consequences of this catastrophe. This presents continuous prevalence of hostile and inhospitable environment to crop and animal production as well as human habitation (Gadzama, 1995; Rayar, 1996). Incidences of disease out breaks resulting directly or indirectly from such catastrophe are common in this region. Adverse health effects of dust or particulate matter (PM) are greatly associated with its size and weight (USEPA, 2004b; Nku *et al*., 2005). When such pollutants are inhaled, the coarse particles (2.5-10µm) are deposited in the upper respiratory tract and bronchi, whereas the fine particles (<2.5µm) may reach terminal bronchioles and alveoli and remain there and, contributing to respiratory illness. The adverse effects of these dust particle deposits include acute respiratory morbidity, pneumonia, asthma,lung damage,decreased lung functions andincreased mortality and premature death in sensitive individuals (USEPA, 2004b). Man breathes between $10cm^3$ and $25cm^3$ of air daily and any toxins present are also inhaled (Radojevic and Bashkin, 2006). Of main concern are the small size dust particles ranging from 0.1-3.0µm unit density sphere.

These usually have high percentage passing rate through selector device and are normally deposited in the respiratory system upon inhalation, and present 60%-80% extraction efficiency into biological system (Patterson and Schroeder, 1971). Due to the complexity and varying sizes of dust and other particulate matters, a number of terms are used to describe them (Patterson and Schroeder, 1971; OSHA, 2008). Suspended particles vary in size, composition and origin. It is convenient to classify particles by their aerodynamic properties because these govern the transport and removal of the particles from the air and subsequent deposition in the respiratory system (OSHA, 2008; Patterson and Schroeder, 1971).The transport and removal of dust and other particulates in the respiratory system are also governed by their deposition rate within the respiratory system and are associated with the chemical composition and sources of particles (OSHA, 2008; Patterson and Schroeder, 1971). The aerodynamic diameter is the size of a unit-density sphere with the same aerodynamic characteristic. Dust, therefore, in general can be differentiated or classified on the basis of composition, or with respect to size (OSHA, 2008). Dust can be classified by size into three primary categories: Respirable dusts, Inhalable dusts, and Total dusts (OSHA, 2008).

Respirable Dust: This refers to those dust particles that are small (< 2.5µm) enough to penetrate the nose and upper respiratory systems and deep into the lungs. Particles that penetrate deep into the respiratory systems are generally trapped by body's natural clearance mechanism of cilia and mucus, and are more likely to be retained. The United States Mine Safety and Health Administration (US-MSHA, 2008) defines respirable dust as the fraction of air borne dust that passes a size selecting device, having the following characteristics (Table 2).

Table 2: Aerodynamic diameter and percent (%) passing selector of respirable dust

Aerodynamic diameter (µm)	Percent passing selector (%)
2.0	90
2.5	75
3.5	50
5.0	25
10.0	0

Source: US-MSHA (2008)

Inhalable dust: The United States Environmental Protection Agency (US-EPA, 1996) describes inhalable dust as those dust particles, which enter the body, but is trapped in nose, throat, and upper respiratory tract. The median aerodynamic diameter of this dust is about 10 µm.

Total Dust: This includes all dust or air borne particles, regardless of their size or composition

Composition of Dust

Dust represents a complex mixture of organic and inorganic substances, solid or liquid substances and mass of inert materials. Dust composition can be chemical, mineralogical or organic in composition or source, among which may be hydrocarbons, nitrogenous compounds, sulphur compounds or other metals.

(i) Fibrogenic dust: This consists of fibrogenic materials, such as free crystalline silica or asbestos, which are biologically toxic.

(ii) Nuisance (or inert) gas: This consists of mass of inert materials such as clay, silt etc, and usually consists of dusts that contain less than 1% quartz (OSHA, 2008).

Extensive researches have been conducted on composition and elemental contents of dusts in the Sahel region of Nigeria (McTainsh, 1980; Adepetu, Asubiojo, Iskander and Bauer, 1987; Adedokun, Emofurieta and Adedeji, 1989; Ayodele and Gimba, 2002; Dimari, Hatis, Waziri and Maitera, 2008) and in neighboring West African country (Oduro-Afriyie and Anderson, 1996; Breuning-Madsen and Awadzi, 2005; Ogugbuaja and Barsisa, 2001; Moses 2007) on annual basis with elemental enrichment factors**.** Some of these elements include Copper (Cu), Iron (Fe), Lead (Pb), Cadmium (Cd), Aluminum (Al), Nickel (Ni), Selenium (S), Zinc (Zn), Arsenic (Ar) Cobalt (Co). Also found were silt, clay, organic matters or hydrocarbons in varying proportions. These elements or the organic matters when absorbed in high proportion are toxic to the body systems (Rob, 1996).

IMPACTS OF DUST ON NORMAL PHYSIOLOGY

Dust assaults on animals and humans have resulted in several diseases which impacted adversely on normal body physiology. Prolonged dust deposition in the respiratory

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tract causes acute respiratory morbidity,chronic bronchitis, pneumonia,lung damage,decreased lung functions(Noor *et al*, 2000; Glvosky *et al*., 1997; Nku *et al*., 2005). Such particulate matters or dust irritate the respiratory systems to cause respiratory illness. It increases both the incident and severity of chronic respiratory diseases and provides reaction sites for other pollutants or microbes, resulting in breaching or damage to the lung and facilitates acid formation (Ogugbuaja and Barsisa, 1991). This decreases effective gaseous exchange at the alveoli and can cause further decrease in oxygen supply to the tissues or cells of the body. The depositions of the particles in the lung are governed by particle characteristics, anatomy of the respiratory tract, tidal volume and breathing pattern (Lippman, 1994).

The small size dust particles ranging from 0.1-3.0μm unit density sphere have high a percentage passing rate through selector device and are normally deposited in the respiratory system upon inhalation, and present 60%-80% extraction efficiency into biological system (Patterson and Schroeder, 1971). Once the dust are inhaled and deposited in the lung most particles are removed by the various clearance mechanisms, such as mucociallary activities (Schlesinger, 1990). Clearance from the pulmonary region may occur through the actions of alveolar macrophages or other alternatives mechanisms (Schlesinger, 1990). The rate of effectiveness of clearances also depends on the amount of particles inhaled or deposited and particulate characteristics (Pepeiko, 1987). Clearance mechanism may be adversely affected by the inhaled toxicants so that the clearance may take longer periods and extends particle retention in the respiratory system. This may provide reaction sites for other pollutants, resulting in breaching of the wall of alveolar lumen and adjacent interstitial tissue causing damage to the lung.

Nku *et al*. (2005) report reduced lung oxygen saturation level (SPO_2) and peak expiratory flow Rate (PEF) in street sweepers, leading to lower respiratory function indices (FVC, FEV, and PEFR). Prolonged dust exposure has been reported to decrease total Red Blood Cells (RBC), Packed Cell Volume (PCV) and Haemoglobin (Hb) concentration (Moses (2007). The Hb content of the blood determines the oxygen carrying-capacity of the circulatory system. In the alveoli, high oxygen concentrations are usually maintained through the acts of breathing. Oxygen diffuses from the alveoli into the plasma in the capillary where the oxygen binds with the haemoglobin. Oxygen binds with haemoglobin in the blood to form oxyhaemoglobin and is transported as such to the cells of the body. Decreased Hb concentration as well as decreased RBC and PCV will impair oxygen transport and result in tissue hypoxia as a result of decreased oxygen supply to the tissues or cells of the body. In such individuals therefore, they can easily succumb to any form of respiratory illness or stress. Thus, cough and asthma have been reported in individuals exposed to suspended dust particulate matters for a long period of time (Cohen, Bowers and Lepow, 1973; Lovejoy and Linden, 1991; Baraski, 1993; Sullivan, 1993). Dust has also been reported to cause some damages to vital organs and structures in the body and alters their function or physiology (Cohen *et al*., 1973; Lovejoy and Linden, 1991; Baraski, 1993; Sullivan, 1993; Aukernman, 1996). This can be by direct physical or chemical damage transported through haematogenous routes. Physical breaches and direct injury to the skin and mucous membrane will destroy their normal physiology and damage to some vital organs can be a threat to life. Toxicokinetics of dust in goats following intra tracheal infusion of buffered dust was studied by Moses (2007). The dust elements were readily absorbed into the body system with highest concentrations found in the liver, lung, kidney and myocardium, 2-3 hours after infusion (Moses, 2007).

Biological systems possess mechanism for absorption, transportation and excretion of elements. However, this function may be compromised in disease conditions or droughts such as those caused by dust assaults. Damage to major detoxifying agents and excretory agents such as the liver and kidney will affect their physiology, resulting in increased level of toxic substances in the body; this is of great potential danger to the body. Cadium for example, apart from being carcinogenic, its long time exposure has been associated with renal dysfunction and lung diseases (Jerome, 1996; Aukernman, 1996). Other metals such as selenium and nickel also cause kidney damage and decreased glomerular filtration rate (GFR), liver damage and impaired hepatic function (Jerome, 1996; Aukernman, 1996).
Consequently, clinical renal failure (CRF) and end stage renal diseases (ERDs) are highly prevalent in this region (Arogundade *et al*., 2006). Therefore, the distribution and elimination of toxic substances in the body will be impaired. Possible relation between some forms of cancers and congenital malformation and dust storms has been suggested, but the situation has not been systematically studied.

Apart from adverse effects on human and animal physiology, the dust has equally been reported to affect plants physiology, resulting in disruption in photosynthesis, retardation in growth and death in plants (Seinfeld, 1975, Gwaski, 2001). The dust pollutants probably enter the plants through the stomata during respiration to cause the observed effects. Incessant dust assaults, together with other harsh extreme environmental conditions of the Sahel region had led to some physiological and anatomical adjustments in the native animals and humans. Borno white goats, which are ecotypes of Sahel goats, were reported to have high respiratory rate when compare to their counterparts, the West African Dwarf goats (WAD) in the humid region of Nigeria (Akinwole*et al*., 1999).

There seems to be compensatory physiological adaptation to increase respiratory efficiency that might have been compromised due to dust assaults and also as a means to achieving evaporative cooling effects. Thus, during the hot dry season, the adult goats breathe more air per kg body weight than others at rest (Akinwole*et al*., 1999). Other physiological peculiarity observed in the Sahel native animals and humans of the dry belt region is the development of thick nasal hairs as first line of defense against dust entry into the body. Hence they have more developed mucocilliary mechanisms which effectively filter the incoming dusty air than their counter parts elsewhere.

EFFECTS OF DUST ON PUBLIC HEALTH

It is common knowledge that exposure to dusty air causes short but reversible effects like irritation of the nose, throats, eyes among others, but in-depth study of prolonged exposure of dust on humans and animals as well as ecosystem in general indicate more grievious consequences on health and ecosystem. Suspended particulate matter, or dust, in the atmosphere, may have series of deleterious effects on humans, animals, as well as the ecosystem in general. Dust pollution leads to at least 500,000 premature deaths and chronic bronchitis per year in West Africa (Aukernman, 1996). This leads to loss in productivity, heavy economic loss and hundreds of work hours are lost every day due to sicknesses associated with dust exposure (Aukernman, 1996).

Exposure to dust has long been associated with the prevalence of varying degrees of airway obstruction and respiratory illness in both humans and animals (Noor *et al*., 2000). High incidence of cough, chronic bronchitis, sneezing and eye irritation, coupled with infection of the throat, acute respiratory morbidity, pneumonia, asthma,lung damage,decreased lung functions and increased mortality and premature death in sensitive individuals (USEPA, 2004b; Nku *et al*.,2005), has also been reported to be direct or indirect consequences of dust pollution in the environment. Recent studies have linked exposure to dust generated from heavy goods vehicles and busy traffic with respiratory problems (Carlos, 1999; Nku *et al*., 2005).

In addition to inhalation, excessive dust deposition in the eyes, throat, ears and on the skin, may cause unpleasant body response and irritations. This may cause injury to the skin or mucous membrane by chemical or mechanical actions, resulting in unpleasant body odours (Noor *et al.*, 2000; IDEC, 2008). Some constituents of the dust pollutants affect body systems or organs; others act indirectly. Cadmium, for example, is known to be harmful to the kidney; mercury (Hg) impairs the central nervous system (CNS), while benzene is carcinogenic (Ikamaise *et al*., 2001). Other components of the dust that may be injurious to both humans and animals include some heavy metals or chemicals from germicides, fungicides and herbicides, employed in agricultural activities, trace metals and macronutrients such as Potassium (K), Magnesium (Mg), Calcium (Ca), strong acids, or alkalis, halogens, acid compounds, which may be constituents of pesticides (Noor *et al*., 2000; USEPA, 2004b; IDEC, 2008).

These chemicals may damage the general ecosystem as well and change the composition of the ecosystem in this particular environment. The effect of inhaled aerosols or dust on health depends on the site of deposition in the respiratory tract which is also determined by particle size, its composition, biological reactivity and the amount of the substances inhaled (Seinfeld, 1975). The nose is the specialized

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structure of the head that serves as both an organ of smell and respiration. The air breathed into the nose is warmed, humidified, and filtered by the richly vascular mucous membrane and mucocilliary apparatus. In animals, which is often termed nuzzles, in addition to being the site of respiratory passages; it also lodges some of the end organs of the sense of touch. resence of pathogens in the nasal region can be influenced by several factors or predisposing factors some of which include:

Inflammation of Respiratory Tract: In most cases, the direct cause of the inflammation of the respiratory tract is the infection of the lining of the respiratory mucous membrane with micro organisms. Parasites or micro-organisms may lodge in upper part of the nasal cavity and causes signs of cold or purulent running nose (Blood *et al*., 1983).

Exposure to draughts: In most cases, pathogens are able to produce their effect in the body when the general vitality of the body or local vitality of the membrane itself is lowered through some predisposing cause. Among such are exposures to draughts, cold, underlining disease condition, hunger, extreme weather conditions, and so on.

Age: Extreme age limits such as the very young and the very old are important factors that influence the presence of pathogens in the respiratory system. These groups have lower resistance to draughts and diseases, and therefore are susceptible to such respiratory diseases like pneumonia, asthma, whooping cough, tuberculosis, and so on (Blood *et al*., 1983). Humans and animals are usually exposed to air pollutants, through inhalation, contact with skin or ingestion. The associated health problems may vary. These may include cough, sneezing, asthma, bronchitis, pneumonia, lung cancer, renal failure, infertility, decreased RBC, PCV and Hb concentration, liver cirrhosis, skin diseases, reduced lung oxygen saturation level (SPO^2) and Peak Expiratory Flow (PEF) rate and generalized impaired resistance to infection (Cohen *et al*., 1973; Lovejoy and Lindon, 1991; Baraski, 1993; Sullivan, 1993). The effects of inhaled aerosol or dust on health depend on the site of deposition in the respiratory tract and subsequent absorption and distribution into tissues which also depends on both particle size and chemical composition (Patterson and Schroeder, 1971; Seinfeld, 1975).

Most of the traditional air pollutants primarily affect the respiratory and cardiovascular systems (OECD, 1984). Of main concerns are the small size particles ranging from 0.1µm – 3.0µm. These particles are normally deposited directly into the respiratory system upon inhalation and present 60% - 80% extraction efficiency into the biological system (Patterson and Schroeder, 1971). The severity of effect however depends on the level of exposure, age and the state of health of the individual and other predisposing agents at the time of exposure (Seinfeld, 1975; OECD, 1984). Particulate matter irritates the respiratory system and can contribute to acute respiratory illness. It may increase both the incident and severity of chronic respiratory diseases and may provide reaction sites for other pollutants and facilitates acid formation (Ogugbuaja and Barsisa, 1991). Excessive dust deposition in the eyes, throat, ear, and on the skin, may cause direct or indirect injury or unpleasant body or skin responses. Direct injury to the skin or mucous membrane, by chemical from dusts or by mechanical action, results in unpleasant body odours (Noor *et al*., 2000). Adverse health effects, such as thyroid enlargement, lung cancer or pneumoconiosis have long been associated with prolonged exposure to dust particles (Ogugbuaja and Barsisa, 1991). In addition, there are other pollution synergies with dusts which together constitute serious health hazards when inhaled in excess.

These pollutions synergy include toxic gases released under various conditions of environmental pollutions associated with increase in urbanization and industrialization, increased human and vehicular traffic, air pollution resulting from increased leakages in storage areas, industrial accident; slurry tanks used to store animal wastes and so on. The major harmful gases released are carbon dixodie (CO_2), carbon monoxide (CO), nitrogenoxide (NO), methane (CH_4), suphoxides (SO_x), ammonia (NH_3), hydrogen sulphide (H_2S). Some of the toxic effects of these gases include apnoea, progressive dysponea, lachrymation, excessive salivation, grunting, anorexia, emaciation, dehydration, bronchitis, infarction, kidney failure and necrosis of skeletal muscles (Cohen *et al*., 1973; Lovejoy and Linden, 1991; Baraski, 1993; Sullivan, 1993). Sulphurdioxide (SO_2) aggravates respiratory diseases; Nitrogen dioxide (NO_2) and Nitric oxide (NO) both interfere with normal function of the respiratory system. NO_2 causes lung cancer; it is a deep lung irritant capable of producing pulmonary oedema. The type I cells of the alvieoli appear to be the cells chiefly affected on acute exposure (Katzung, 2004). Pollutants fall on soil by acid rain which tends to lower the pH of the soil rendering it infertile. Carbon monoxide reduces the haemoglobin capacity to carry and circulate oxygen. These effects manifests as slow reflexes and drowsiness to eventual deaths at very high doses (Noor *et al*., 2000; OECD, 1984).

Nitrate can also be obtained from oxides of nitrogen (NO_2). These are not toxic, but on conversion to nitrite (NO_2^-) within the body are toxic (Sodipo, 2007b). The highest level of nitrite originates in our saliva where bacteria in the mouth change nitrates to nitrite (Nelzlich, 1991). Nitrates easily enter the blood stream and causes methaemoglobinaemia. The Nitrates oxidise the Fe^{2+} ion in the heamoglobin to Fe^{3+} state, which is unable to carry oxygen leading to cyanosis, stupor and cerebral anoxia (Lawrence *et al*., 1997). Sulphaemoglobin, a sulphide oxidation product of Hb, produced *in vivo* is irreversible and is an indirect poison as it can neither transpire O_2 or CO_2 (Sodipo, 2007b). Heavy metals bio-accumulate over time and toxicity occurs when they accumulate faster than they are metabolized or excreted (Rob, 1996). Biological systems possess mechanism for absorption transportation and excretion of toxic elements. However, at high doses following prolonged exposure, the rate of deposition and subsequent absorption may exceed the rate of elimination, leading to toxicity and damage to organs like the lung, liver, kidney, spleen and other target organs. Cadmium, for example, apart from being carcinogenic, long time exposure to it has been associated with renal and biliary dysfunction and lung diseases (Jerome, 1996, Sodipo, 2010). Over 50% of the total burden of cadmium is in the liver and kidney because the metal strongly binds to a specific metal binding protein called metalothionein which is synthesized in both liver and kidney. At the same time cadmium is not easily eliminated from the body as its half life is over 10years (Sodipo, 2010). Other metals, such as selenium and nickel also have been reported to cause kidney and liver damage (Rob, 1996; Jerome, 1996). Many elements are classified as essential or toxic.

These classifications are further complicated since trace elements which are considered toxic at relatively small doses may be essential and indispensable for normal body function at lower physiological amounts (Schwartz, 1977). For example, arsenic levels above safe limits of 0.01mg/L (ppm), causes skin lesions, cancer and neurological diseases, while fluoride level above 1.5mg/L (ppm) causes bone diseases and mottled teeth in humans (UNEP/WHO, 1994). Metals such as Aluminum (Al), Iron (Fe), Cobalt (Co), Nickel (Ni), Chromium (Cr) and Cadmium (Cd) were found by some researchers to be constituents of dust samples in Maiduguri and environs (Ogugbuaja and Barsisa, 2001; Moses, 2007). This is a typical representative of Sahelian dusts in Nigeria. Such elements were earlier reported to catalyze free radicals formation and activate the formation of reactive oxygen species (Drehar *et al*., 1997; Vallyathan and Shi, 1997; Smith *et al*., 2000).

Free radicals are reported to react with and impede normal body metabolic functions (Drehar*et al*., 1997). Also organic constituents of the dust were reported to undergo oxidation and reduction processes resulting in interference with normal body metabolic functions. Exposure to naphthalene for example has been reported to cause anaemia characterized by marked reduction in Packed Cell Volume (PCV) and Red Blood Cell counts (RBC) in individuals exhibiting genetic susceptibility to this condition (Stanley, 2005; Smith *et al*., 2000).

The deposition of the particles in the lung is governed by particle characteristics, anatomy of the respiratory tract, tidal volume and breathing pattern (Lippman, 1994). These usually have high percentage passing rate through selector device and present 60%-80% extraction efficiency into biological system (Patterson and Schroeder, 1971). Once the dust is inhaled and deposited in the lung most particles are removed by the various clearance mechanisms, such as mucocialliary activities (Schlesinger, 1990). Clearance from the pulmonary region may occur through the actions of alveolar macrophages or other alternative mechanisms (Schlesinger, 1990). The rate of effectiveness of clearances also depends on the amount of particles inhaled or deposited and particulate characteristics (Pepeiko, 1987). Clearance mechanism may be adversely affected by the inhaled toxicants, extending retention in the respiratory system. This may provide reaction sites for other pollutants, leading to breaching of the wall of alveolar lumen and adjacent interstitial tissues, thus causing damage to the lung. Similar mechanisms in ther target organs also occur following heavy doses of dusts containing similar metals such as aluminum (Al), Iron (Fe), cobalt (Co), Nickel (Ni) and chromium (Cr) (Ogugbuaja and Barsisa, 1991; Gwaski, 2001; Moses, 2007). These types of metals were reported to catalyze free radical formation and activate the formation of reactive oxygen species (Drehar*et al*., 1997; Vallyyathan and Shi, 1997; Smith *et al*., *et al*., 2000). Free radicals react with and impede normal body metabolic functions and physiology causing severe pain and damage to body organs (Drehar*et al*., 1997). The long roster of diseases caused by dust is generally mediated by physical, chemical or biological means which directly or indirectly affects humans and animals.

Animals are part of man's biological environment. The incorporation of domesticated animals into human habitations increases the risk of many infectious diseases which are contracted through dust. Animals tend to be more physically active than humans, therefore environmental toxicants found in the air, both indoor and outdoor, will be delivered to animals at higher internal doses than humans. Animals have lower breathing zones, due to their feeding habits when compared to humans and are therefore more vulnerable to environmental hazards than humans. They feed in the field close to the ground, so chemicals and heavy pollutants like mercury and lead will concentrate in their breathing zone. The care and breeding of animals, frequent butchering for meat and other purposes, consumption of milk and meat of diseased or infected animals, offer unlimited opportunities for transmission of zoonotic diseases to man and vice versa.

Thus, the animal diseases are ultimately transferred to man as end target. Direct contact with infected or sick animal products or faeces carried in the dusts as a result of contamination during processing and deliveries are some of the common modes of transmission of the zoonotic diseases. Zoonosis, according to the joint Expert Committee on Zoonosis (FAO/WHO, 1967) is defined as those diseases and infections which are naturally transmitted between vertebrate animals and man. Transmission of such diseases is directly or indirectly influenced by dusts and other pollution synergies.

CONCLUSION

In the dry belt zone of Nigeria, the main air pollutants are derived from the incessant perennial harmattan dust and dust storms. This is further exacerbated by alarming desertification and soil degradation and deterioration, brought by both natural and human forces leading to loss of lives and property. This piece of work examined public health and physiological implications of dust assault on the people living in the dry belt zone of Nigeria. The observations so far have revealed that dust assault has serious public health implication as it is capable of causing several health problems such as lung cancer, renal failure, infertility, cough, asthma, pneumonia, bronchitis among so many others. Based on these and much more, it was concluded that dust assault has serious negative impact on public health. Consequently, government at all levels, non-governmental organisations, religious groups and all stakeholders in human environment should step up efforts in addressing the issues of public health as a means of having a healthy society.

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