SOOT AND CARCINOGENESIS IN RIVERS STATE

Abstract

Soot is the product of incomplete combustion of hydrocarbons. It is a fine black powdery substance also known as Black Carbon that arises from the burning of substances such as oils, woods, chars, tyres, and other hydrocarbon compounds. This processes leads to the release of various components within the soot particles which have been linked to various diseases. Soot is formed through complex chemical processes and are dispersed by air. The sticky nature of soot allow it to stick to exhaust pipes of power generating set and automobiles. It has also been identified as a major pollutant around the world, with the highest amount being emitted by developing countries. Africa ranks high among the highest emitters of soot and in world, especially with the spike in the activities of artisanal refining of crude oil and gas flaring in the South-South Nigeria, particularly the Niger-Delta. Heavy metals such as Cadmium, Chromium, Lead, Iron, Nickel, and Arsenic have been found to be present in soot and are linked to various types of cancers like the cancers of the lungs, liver, skin, throat, and disease such as diabetes. Many respiratory conditions treated in hospitals within Rivers State has been linked to soot and its component. Further studies predicts that the cases could worsen if the emissions continues. This study is focused on black soot and its carcinogenesis in Rivers State.

***Keywords**: carcinogen, soot**,** polycyclic aromatic compounds, lead*

1.0 INTRODUCTION

Soot is the product of incomplete combustion of hydrocarbons (organic compounds consisting of hydrogen and carbon only) (Silberberg, M. 2004; Hamid, *et al*., 2015). Soot is also known as lampblack and is defined as a smooth black or brown powdery substance which possesses slightly sticky properties arising from partial burning of hydrocarbons (energyeducation, 2022).The production of soot follows a complex process which involves condensation of vaporized organic substances (Chylek and Pinnick, 2003). It is appropriate to restrict soot to the by-product of gaseous phase of combustion process of hydrocarbons, although it can be extended also to cover the residues of a number of polycyclic aromatic compounds (PAH) such as coal, petroleum coke, charred wood, cenospheres and other related compounds that may be dispersed by air in the course of pyrolysis (Chylek and Pinnick, 2003).

The sticky nature of soot allows it to glue to exhaust pipes of power generating sets and automobiles, as well as other engine and sources where they are formed (U.S.E.P.A, 2022). When defined in terms of pollution, soot is said to be a type of pollution caused by particles referred to as PM 2.5, which are particulate matter with 2.5 micrometers or less in size. For clarity sake, soot is different from carbon black (CB), although both are being used interchangeably. The study conducted by Long et al. (2013) shows soot and carbon black are distinct from each other both in their physical and chemical makeup (Long *et al*., 2013). Carbon Blacks are intentionally manufactured in a regulated environment and process in the plastic, painting and printing industries for commercial consumptions (Watson and Valberg, 2001; Long *et al*., 2013). Soot (Black carbon) on the other hand is an unwanted byproduct of incomplete combustion of hydrocarbons (Watson and Valberg, 2001; Long *et al*., 2013).

Recently, soot spike has become a subject of great concern in Nigeria, particularly, Rivers State, which is located in the Southern part of the country (Ann, 2021). The report of Ann (2021) revealed that the spike in soot was as a result of increased illegal oil bunkering activities and gas flaring within the state (Ann, 2021). This outcome was from an investigation conducted by a team of 20 experts from various disciplines and various fields, including a consultant physician and dermatologist at the University of Port Harcourt Teaching Hospital, Dr. Dasetima Altraide. Concerns were raised following an investigative report from a technical study team in April 2019 on soot which showed records of over 22,000 persons who were treated for soot related cases at Health Facilities in Rivers State with conditions such as adverse respiratory, skin, and reproductive cases all traced to black soot (Ann, 2021). Further investigation showed that soot components such as heavy metals concentrations leads to several diseases including cancerous and non-cancerous disease and those in Rivers State are likely to suffer from these diseases in the future if nothing is done to curb the situation (Ann, 2021). Black soot in Port Harcourt was first noticed in the year 2016, November precisely, which was reported by the Punch Newspaper and other media arm like Sweet Crude report (Odogwu, 2017; Sweet Crude, 2017).

2.0 Composition of Soot

The makeup of soot is largely determined by the material being burned (C.A.P., 2022). The formation process has been considered a very complex one as it involves a change in the state of matter in which different molecules undergoes both physical and chemical transformation within a very short time (Omidvarborna *et al*. 2015). The solid particulate matter component of soot is in a powdery form known as amorphous carbon while the gaseous form contains PAHs called mutagens (Rundel, 2001).Mutagens are physical or chemical agents with ability to alter genetic materials like the DNA permanently in organism; a situation known as mutation (Rundel, 2001). Mutations result into the development of entirely new variety or specie of an organism or a part in an organism wherever it occurs. The International Agency for Research on Cancer (IARC), have classified PAHs, a component of soot as a carcinogen to humans (IARC, 2022). Soot content causes a range of both environmental and health effects.

Other sources of soot include cooking, oil lamps, furnaces, house fires, smoking plants, and local burnings (Kamboures *et al*., 2013). The sizes of soot particles range from about 10nm to 1 mm (Niessner, 2014; China *et al*., 2013; Wang *et al*., 2014). According to the study by Watson and Valberg, soot consists of about 60% elemental carbon (Watson *et al*. 2001). In diesel emitted soot, the elemental components are made up of hydrogen, oxygen, sulphur, trace metals, and carbon as the main element (Fernandes and Brooks, 2003; Vedal *et al*. 2013). The chemical composition of soot changes with time and this has been attributed to the heterogeneous oxidation reactions in the environment (Zielinska *et al*., 2010; Ivleva *et al*., 2013; Brown *et al*., 2015). Developed nations were thought to be the biggest emitters of soot, however, developing countries are those being implicated at the moment as the main source of soot emission (Victor *et al*., 2015). The United States of America alone according to study, emits up to 6.1% of the global soot, while India and China accounts for about 25 to 30% (Wang et al. 2014; Subramanian, M. 2014). Latin America, Asia, and Africa, emits the biggest quantity (Wang *et al*., 2014; Anenberg *et al*., 2012).

3.0 Formation of Soot

Understanding the formation of soot offers the chance of the ability to combat its emission from various sources such as forests fires, engines, and cook stoves, as well as to be able to regulate its production during industrial processes (Sandia, 2018). Soot is formed from the incomplete combustion of hydrocarbon substances and fuels such as natural gas, oil, and wood. In its last form, soot is a solid similar to graphite, with an initial formation from gaseous hydrocarbons (Sandia, 2018). Evidences from experiment shows that soot transits from gas to liquid before finally becoming a solid (Sciencedaily, 2022). The particles of soot are formed when gaseous molecules like crude oil are heated to a very high temperature. A study by Omidvarborna et al. (2015) revealed that the chemistry behind the formation of soot is yet to be unknown, but few agreements have been established which are; soot formation begins with the some precursors, followed by nucleation of heavy molecules which forms particles. The next step is the growth of surface particles proceeded by the adsorption of molecules in the gas phase, followed by coagulation through particle collision, and lastly molecule oxidation and soot particles which reduces soot formation (Omidvarborna *et al*., 2015).

4.0 Carcinogens

Carcinogens are substances capable of promoting the formation of cancer, especially due to their ability to alter the DNA or genes, or to disrupt the metabolic processes (Stephanie, 2020). Carcinogens were thought to be mainly radioactive substances, however, there are carcinogenic substances highly related to radiations such as alpha and gamma rays. Other non-radioactive carcinogens are substances such as asbestos, certain dioxins, tobaccos, alcohols, crispy brown foods, formaldehyde, engine exhausts soot, herbicides and so on (Stephanie, B. 2020). Carcinogen therefore could be a substance in the air, a product used by people, or chemical in foods and drinks and can arise from both natural and synthetic substances (Ames *et al*., 2000).

Carcinogens that cause cancer are known as genotoxic while the non-cancer causing carcinogens are called non-genotoxic carcinogens. The cancer causing carcinogens (genotoxic) cause irreversible changes in the genes by binding to the DNA (Kolle, 2012). Carcinogen have been implicated as the cause of the most common cancers (lung, colon, breast, and stomach cancers) and are responsible for about 41% worldwide cancer cases. They are also responsible for some other types of cancers not mentioned in this study say Bernstein et al. (2008) in their research (Bernstein *et al*. 2008).

5.0 Routes of Soot Exposure

Exposure to soot may take place via inhalation, ingestion, or absorption via the skin. (cancer.gov, 2022). People are exposed to soot from sources such as exhaust fumes from both petrol and diesel engines, smoke from kerosene stoves, firewood burnt in a poorly ventilated area, smokes from smelting companies and those from incomplete burning or usage of fossil fuels (Geraldine, 2018). People who are constantly exposed to either of these sources of soot are at high risk of developing the complications that come with soot, especially those related to respiratory difficulties like “pneumoconiosis”, which arises from prolonged exposure to soot (Geraldine, 2018). “Pneumoconiosis” is the general term which is assigned to lung complications resulting from mineral dust inhalation. Prolonged exposure to soot affects the lungs as soot lines the walls of the aveoli, preventing the normal ability of the lungs to exchange gases. Geraldine (2018) reported that “pneumoconiosis” makes patients susceptible to other respiration complications like pneumonia, asthma, and so on (Geraldine, 2018).

6.0 Soot Carcinogens and Associated Medical Complications

The fine particles of soot are believed to contain a number of carcinogens including some heavy metals like arsenic, cadmium, and chromium (cancer.gov, 2022). The Black Carbon in soot, which is its main component, is responsible for conditions such as premature mortality and disability in humans (Goto, 2014). Heterogeneous oxidation reactions which occurs in the environment causes changes in soot chemical makeup (Browne *et al*., 2015; Zeilinska *et al*., 2010). According to the research conducted by Cassee et al. (2013), vehicle exhausts emits about 50% of particulate matters within the urban areas and these particulate matters can find their way into the lungs where they cause hazards, especially the smaller fractions within the sizes of 2.5 and 0.1nm (Cassee *et al*. 2013, Valavandis *et al*. 2013). The components of soot which has been identified in health conditions apart from Arsenic, and Chromium are Nickel, Lead, and Mercury, and the compounds of these metals. The International Agency for Research on Cancer (IARC) has classified these metals and their compounds as the first group carcinogens (IARC, 2012). Ingestion and inhalation of these compounds have led to health complications such as cancers of the liver and lungs as well as those of the nose and kidney (IARC, 2012). Lead and Mercury are Lead have been categorized under the group 2A, 2B, or 3 carcinogens based on the metallic state of their compounds. A study by Owoade et al. (2019) in Lagos state Nigeria during two seasons (rainy and dry seasons) revealed that 6 metals; Cromium, Manganese,, Iron, Zinc Copper, and lead were high in concentrations during the dry seasons (Owoade *et al*., 2019). These components of soot have been linked to high rate of diseases such as leukemia, and cancers of the liver and esophagus, alongside lung and skin cancers among the residents of Port Harcourt (Ana *et al*., 2010; Yakubu, 2018). Iron, a macronutrient needed by the body for blood building and others is also a component of soot and in excess leads to diseases like Alzhemer and Parkinson's disease. It has also been linked to type 2 diabetes in high concentration in the body (Killilea *et al*., 2003). Cadmium, has no known nutritional benefit to humans. Being a component of soot leads to health complications such as renal failures, liver diseases, skeletal and reproductive dysfunctions and has been classified as a group 1 carcinogen by the IARC (Ihesinachi, et al. 2019). Prolonged exposure to soot components such as Lead, Cadmium, and Arsenic have also been linked to many types of cancers (Jerup, 2003).

Conclusion

Finally, it is worthy to note that soot is a black fine particle arises from the incomplete combustion of hydrocarbons. These hydrocarbons released during the combustion are made of poisonous components, which are detrimental to the health of people within ht environments where they are released. Two major activities have been implicated in the spike of soot in Rivers State, Port Harcourt and they are the activities of illegal oil bunkery from artisanal refining, and gas flaring. These activities have resulted to the release of soot with its components comprising of heavy metals such as Cadmium, Lead, Iron, Cromium oxide, Arsenic, and Nickel which have been linked to disease like cancers of the liver, lungs, skin, esophagus, and other serious health difficulties relating to the kidney.

Recommendation

Seminars and other modes of awareness should be carried out through the various media outlets within Port Harcourt and the affected environs on the negative impacts of soot to health. Consumption of antioxidant rich foods should also be advised, as they will go to greater lengths to combat oxidative stresses. The use of face masks are also encouraged during the day in areas with high soot concentrations. Change of sleeping position has proven to yield positive outcomes in cases of preventing soot inhalation while asleep. The government at the national and state levels should take decisive actions such as heavy sanctions in cases of gas flaring and proper harnessing and upgrading of the local refineries to modern types.

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