

REVIEW OF THE EFFECT OF CHARCOAL COMBUSTION ON HEALTH AND ENVIRONMENT

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Abstract

In 2014, about 53 million tonnes of wood charcoal were produced worldwide, this number unsurprisingly keeps increasing especially in African countries like Nigeria, this is due to a lack of electricity, high inflation, and expensive cleaner cooking utilities. Household applications of charcoal include; Cooking, Barbeque grilling, Pressing iron, charcoal incense burning, and room warmer. This paper studies the aforementioned ways of charcoal application that produces greenhouse gases and energy through anthropogenic emissions/formation of various pollutants such as heat, carbon monoxide, carbon dioxide, polyaromatic hydrocarbons, nitrogen dioxide, particulate matter, methane, ozone, which affect health and climate at large. By Studying an overview of the mechanism of emission of these pollutants, this review explained more about health and environment concerning greenhouse gases emitted during charcoal combustion, as well as the role of charcoal in the temperature rise, effects of charcoal emitted gases on climate such as Global warming, effects of charcoal emitted gases on health such cancer, seizure, and stroke, effects of charcoal emitted gases on nutrition and coral reef survival. Element such as high temperature, elevated Co₂, and precipitation greatly impact plant growth and nutrient. There is a particularly critical need for action and awareness in sub-Saharan Africa, where population growth has outpaced access to clean cooking.

KEYWORDS: Global warming, environment, coral reefs, nutrition, greenhouse gases, Carbon dioxide, charcoal, heat, emission.

Introduction

In 2014, about 53 million tonnes of wood charcoal were produced worldwide¹. Charcoal is a product of the thermochemical conversion of biomass by pyrolysis and has advantages as fuel when compared to the original feedstock (biomass) such as the higher heating value and easy storage^{2,3}. It has also an advantage in comparison with other renewable fuels: cheaper production. In contrast with mineral coals, charcoal has a relatively low content of sulfur or mercury⁴. In developing countries, charcoal is still an important cooking fuel⁵. Despite the spatial

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¹ FAO, Forest Products Statistics (2014). Global Forest Products Facts and Figures, (2015), <http://dx.doi.org/10.1038/1821553c0>.

² Antal, M.J., Grønli, M. (2003). The art, science, and technology of charcoal production, Ind. Eng. Chem. Res. 42, 1619–1640, <http://dx.doi.org/10.1021/ie0207919>.

³ Johnson, E. (2009). Charcoal versus LPG grilling: a carbon-footprint comparison, Environ. Impact Assess. Rev. 29, 370–378, <http://dx.doi.org/10.1016/j.eiar.2009.02.004>.

⁴ Antal, M.J., Grønli, M. (2003) The art, science, and technology of charcoal production, Ind. Eng. Chem. Res. 42, 1619–1640, <http://dx.doi.org/10.1021/ie0207919>.

⁵ Bonjour, S., Adair-Rohani, H., Wolf, J., Bruce, N.G., Mehta, S., Prüss-Ustün, A., Lahiff, M., Rehfuess, E.A., Mishra, V., Smith, K.R. (2013). Solid fuel use for household cooking: country and regional estimates for 1980–2010, Environ. Health Perspect. 121, 784–790, <http://dx.doi.org/10.1289/ehp.1205987>.

and temporal changes in fuel consumption patterns, charcoal remains a popular cooking fuel in the developed world since it produces food with unique flavour and texture.

Charcoal was estimated the charcoal grilling footprint to be 6.7 kg CO₂ per grill session which is, according to the author, similar to the carbon footprint obtained from driving an average car for approximately 35 km.⁶

In indoor environments, such as restaurants, personal exposure to toxic pollutants from charcoal burning can be significantly high, posing a health risk to the customers and employees. An assessment of the indoor air quality at four different types of restaurants. The authors found the highest CO (15, 100 µg m⁻³) and particulate concentrations (1442 and 1167 µg m⁻³ PM₁₀ and PM_{2.5}, respectively) at the barbecue-style restaurant. Moreover, barbecue cooking can generate considerable amounts of benzene, toluene, methylene chloride, and chloroform.⁷

In the present study, pinic acid was found to be one of the most important compounds in particulate matter emitted from charcoal combustion. It has been described as a secondary organic aerosol product from the ozonolysis of α -pinene^{8,9,10,11}. Its detection in the present study suggests that pinic acid forms in association with charcoal burning through pathways that are not clear and deserve further investigation. Possible mechanisms include the direct emission due to its formation during the combustion of charcoal and/or emission of gaseous precursors which are immediately oxidized to form the terpenic acid in the smoke plume. There is a particularly critical need for action in sub-Saharan Africa, where population growth has outpaced access to clean cooking, and 923 million people lacked access in 2020. Strategies to increase the adoption of clean household energy include policies that provide financial support to purchase cleaner technologies and fuels, improved ventilation or housing design and communication campaigns to encourage clean energy use.¹²

⁶ Johnson, E. (2009). Charcoal versus LPG grilling: a carbon-footprint comparison, *Environ. Impact Assess. Rev.* 29, 370–378, <http://dx.doi.org/10.1016/j.eiar.2009.02.004>.

⁷ Lee, S.C., Li, W.M., Yin Chan, L. (2001). Indoor air quality at restaurants with different styles of cooking in metropolitan Hong Kong, *Sci. Total Environ.* 279, 181–193, [http://dx.doi.org/10.1016/S0048-9697\(01\)00765-3](http://dx.doi.org/10.1016/S0048-9697(01)00765-3).

⁸ Ma, Y., Willcox, T.R., Russell, A.T., Marston, G. (2007). Pinic and pinonic acid formation in the reaction of ozone with α -pinene, *Chem. Commun.* 1328–1330. <http://dx.doi.org/10.1039/B617130C>.

⁹ Christoffersen, T.S., Hjorth, J., Horie, O., Jensen, N.R., Kotzias, D., Molander, L.L., Neeb, P., Ruppert, L., Winterhalter, R., Virkkula, A., Wirtz, K., Larsen, B.R. (1998). cis-Pinic acid, a possible precursor for organic aerosol formation from ozonolysis of α -pinene, *Atmos. Environ.* 32, 1657–1661, [http://dx.doi.org/10.1016/S1352-2310\(97\)00448-2](http://dx.doi.org/10.1016/S1352-2310(97)00448-2).

¹⁰ Warnke, J., Bandur, R., Hoffmann, T. (2006). Capillary-HPLC-ESI-MS/MS method for the determination of acidic products from the oxidation of monoterpenes in atmospheric aerosol samples, *Anal. Bioanal. Chem.* 385, 34–45, <http://dx.doi.org/10.1007/s00216-006-0340-6>.

¹¹ Yu, J., Griffin, R.J., Cocker, D.R., Flagan, R.C., Seinfeld, J.H., Blanchard, P. (1999). Observation of gaseous and particulate products of monoterpene oxidation in forest atmospheres, *Geophys. Res. Lett.* 26, 1145–1148, <http://dx.doi.org/10.1029/1999GL900169>

¹² IEA, IRENA, UNSD, World Bank, WHO (2022). Tracking SDG 7: The Energy Progress Report. World Bank, Washington DC. © World Bank. License: Creative Commons Attribution Non Commercial 3.0 IGO (CC BY-NC 3.0 IGO). Available from <https://trackingsdg7.esmap.org/downloads>

Household Application of Charcoal

Charcoal can be used in variety of household applications, such as cooking, barbeque grilling, pressing iron, charcoal incense burner, and even as a room warmer.

While charcoal has various household applications, it also has a number of disadvantages that should be considered. One of the biggest drawbacks of using charcoal is that it produces harmful smoke and carbon monoxide, which can lead to respiratory problems and even death if inhaled in large quantities. Additionally, charcoal can be messy and difficult to handle, often leaving behind black residue that can stain clothing and surfaces. Another issue with using charcoal is that it can be expensive and requires a constant supply, which can be a burden on household budgets. Finally, burning charcoal contributes to deforestation and environmental degradation, as the trees used to make the charcoal are often harvested unsustainably. Overall, while charcoal has some useful household applications, it's important to weigh the disadvantages before deciding to use it regularly.

Overview of Interrelationship Between Charcoal Combustion With Climate and Health

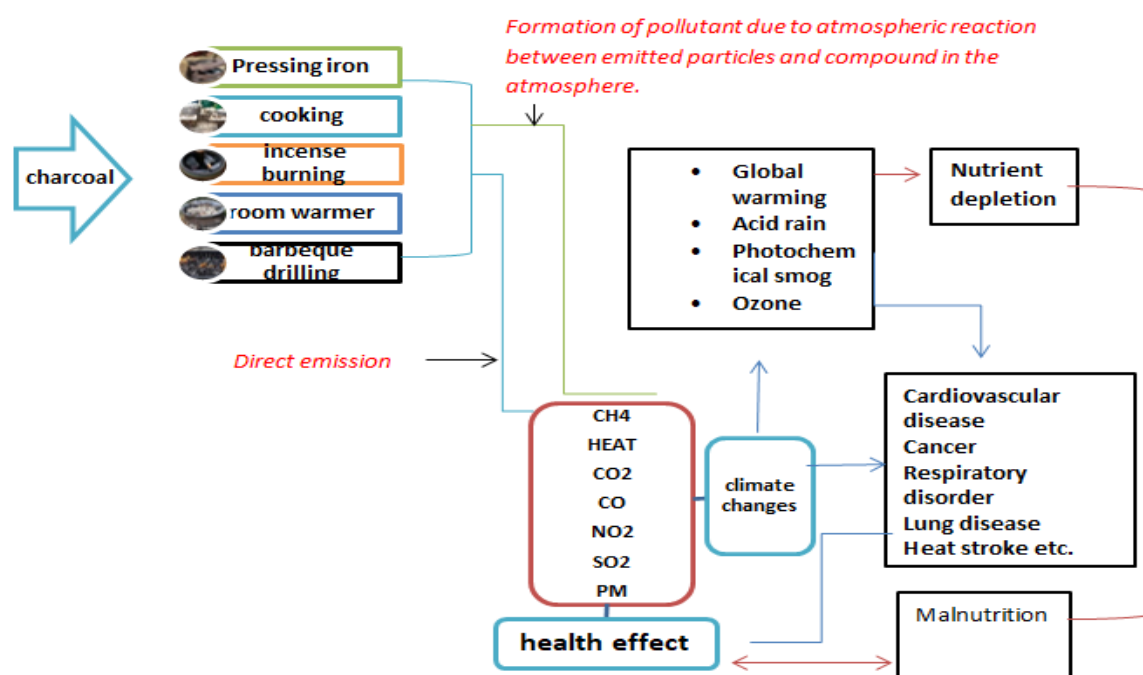


Figure 1: Interrelation between charcoal, climate and health¹³

Figure 2 show the overview interrelation between charcoal applications in household which leads to the emission of toxic compound /pollutant. Below are summary points explaining the figure above

¹³ Ibrahim, A.G. (2023) Interrelation of charcoal with climate and health and mechanism of emission figure, Google drive Folder. http://drive.google.com/drive/folders/1sKVRdMiH_Ib0hhPYX_VaGR2XNFjnOPtM

1. Application of charcoal for various house processes using heat.
2. Combustion of this charcoal to ash. (see figure 2)
3. Emission of the pollutant during the process of charcoal combustion (carbon, heat, Carbon dioxide, particulate matter), this directly affect the population health through continuous inhalation.
4. Reaction of these emitted substances to atmospheric compounds; these in turn negatively affect the environment and health.

Anthropogenic Emissions/Formation During Household Charcoal Application

During the charcoal application, toxic compounds and heat are largely released to the surrounding. These compounds may include polyaromatic hydrocarbons, carbon dioxide, carbon, particulate matter. Furthermore the emission of this particles and compounds to the atmosphere would also lead to subsequent formation of other toxic compound by the reaction of this emitted substances and the free roaming particles, substances and compounds in the air i.e. the formation of nitrogen oxide, methane, carbon monoxide, sulfuric oxide, ozone and so on

Mechanism of Emission

The combustion process starts when the charcoal is exposed to a source of heat, such as a flame or spark. The heat breaks down the chemical bonds in the charcoal, releasing volatile gases and forming a layer of glowing embers. As oxygen is introduced to the embers, it reacts with the carbon in the charcoal to produce carbon dioxide, which is released into the air, and carbon monoxide, which can be toxic in high concentrations.

The combustion of charcoal is a process that involves burning the carbon-based material in the presence of oxygen. Charcoal is created by heating wood in the absence of air, which removes the moisture and other volatile compounds, leaving behind a carbon-rich material. When charcoal is burned, it combines with oxygen to produce carbon dioxide and water vapor, along with heat and light energy.

The rate of combustion and the resulting ash formation can be influenced by a variety of factors, including the temperature of the fire, the amount of oxygen available, and the moisture content of the charcoal. In general, a hotter fire with more oxygen will result in more complete combustion and less ash formation, while a cooler fire with less oxygen will result in incomplete combustion and more ash formation.

Overall, the combustion of charcoal to ash is a complex process that involves the chemical reaction of carbon with oxygen, releasing energy and creating various byproducts. The resulting ash can be used for a variety of purposes, including as a fertilizer or a component of building materials.

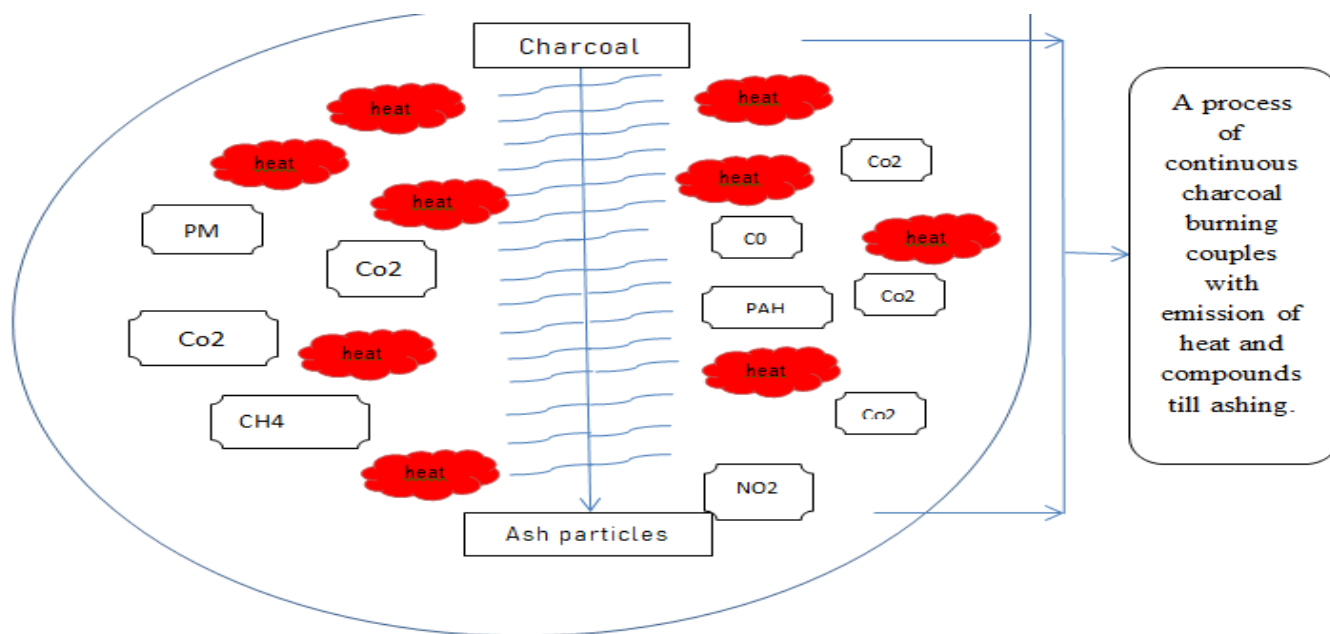


FIGURE 2: COMBUSTION AND EMISSION PROCESS OF CHARCOAL (Ibrahim, 2023)

✓ Heat

High ambient temperatures result in increased hospital admissions¹⁴ and deaths¹⁵, particularly in the elderly, the very young and those with chronic health conditions^{16,17}. Increasingly, and with greater confidence, extreme heat events and subsequent health impacts are being attributed to anthropogenic climate change, and these exposures are predicted to rise in frequency and magnitude as the world continues to warm in response to greenhouse gas emissions^{18,19}. For example, the 2003 European heatwave caused an estimated 70,000 excess deaths²⁰ (with much of this toll now robustly ascribed to climate change²¹). In the UK, it is estimated that approximately

¹⁴ Kovats, R.S., Hajat, S., Wilkinson, P. Contrasting patterns of mortality and hospital admissions during hot weather and heat waves in Greater London, UK. *Occup Environ Med* 2004;61:893e8

¹⁵ Gasparrini, A., Guo, Y., Hashizume, M., Lavigne, E., Zanobetti, A., Schwartz, J., Tobias, A., Tong S, Rocklöv J, Forsberg B, Leone M. Mortality risk attributable to high and low ambient temperature: a multicountry observational study. *The Lancet* 2015;386(9991):369e75

¹⁶ Semenza, J.C., Rubin C.H., Falter, K.H., Selanikio, J.D., Flanders, W.D., Howe, H.L., Wilhelm, J.L. (1996) Heat-related deaths during the July 1995 heat wave in Chicago. *N Engl J Med*;335(2):84e90.

¹⁷ Hajat S, Kovats RS, Lachowycz K. Heat-related and cold-related deaths in England and Wales: who is at risk? *Occup Environ Med* 2007;64:93e100.

¹⁸ Intergovernmental Panel on Climate Change. Fifth assessment report (AR5). 2014. Available from: <https://www.ipcc.ch/report/ar5/>. [Accessed 20 March 2018].

¹⁹ Robine J.M., Cheung, S.L.K., Le Roy, S., Van Oyen, H., Griffiths, C., Michel, J.P., Herrmann, F.R., Death toll exceeded 70,000 in Europe during the summer of 2003. *Comptes Rendus Biol* 2008;331(2):171e8.

²⁰ Robine J.M., Cheung, S.L.K., Le Roy, S., Van Oyen, H., Griffiths, C., Michel, J.P., Herrmann, F.R., Death toll exceeded 70,000 in Europe during the summer of 2003. *Comptes Rendus Biol* 2008;331(2):171e8.

²¹ Mitchell Daniel, Heaviside Clare, Vardoulakis Sotiris, Huntingford Chris, Masato Giacomo, Guilloid Benoit P, Frumhoff Peter, Bowery Andy, Wallom David, Allen Myles. Attributing human mortality during extreme heat waves

2000 heat-related deaths occur annually; it is predicted to rise to 7000 by 2050 as a result of more frequent and severe heatwaves and the ageing population.²²

Nitrogen dioxide (NO₂)

The current WHO guideline value of 10 µg/m³ (annual mean) was set to protect the public from the health effects of gaseous nitrogen dioxide (NO₂). NO₂ is the main source of nitrate aerosols, which form an important fraction of particulate matter (pm_{2.5}) and in the presence of ultraviolet light of ozone. The major sources of anthropogenic emissions of NO₂ are combustion processes (heating, power generation, and engines in vehicles and ships). Epidemiological studies have shown that symptoms of bronchitis in asthmatic children increase in association with long-term exposure to NO₂. Reduced lung function growth is also linked to NO₂ at concentrations currently measured (or observed) in cities in Europe and North America.

✓ **Ozone (O₃)**

Ozone at ground level – not to be confused with the ozone layer in the upper atmosphere – is one of the major constituents of photochemical smog. It is formed by the reaction with sunlight (photochemical reaction) of pollutants such as nitrogen oxides (NO_x) from a vehicle and industry emissions and volatile organic compounds (VOCs) emitted by vehicles, solvents, and industry. As a result, the highest levels of ozone pollution occur during periods of sunny weather²³. Excessive ozone in the air can have a marked effect on human health. It can lead to breathing problems, trigger asthma, reduce lung function and cause lung diseases.

✓ **Particulate matter (PM)**

PM is a common proxy indicator for air pollution. It affects more people than any other pollutant. The major components of PM are sulfate, nitrates, ammonia, sodium chloride, black carbon, mineral dust, and water. It consists of a complex mixture of solid and liquid particles of organic and inorganic substances suspended in the air. While particles with a diameter of 10 microns or less, (≤ PM₁₀) can penetrate and lodge deep inside the lungs, the even more health-damaging particles are those with a diameter of 2.5 microns or less, (≤ PM_{2.5}). PM_{2.5} can penetrate the lung barrier and enter the blood system. Chronic exposure to particles contributes to the risk of developing cardiovascular and respiratory diseases, as well as lung cancer²⁴.

Air quality measurements are typically reported in terms of daily or annual mean concentrations of PM₁₀ particles per cubic meter of air volume (m³). Routine air quality measurements typically describe such PM concentrations in terms of micrograms per cubic meter (µg/m³). When

to anthropogenic climate change. *Environ Res Lett* 2016;11(7):8. 074006, <https://doi.org/10.1088/1748-9326/11/7/074006>.

²² Hajat, S., Vardoulakis, S., Heaviside, C., *et al.* Climate change effects on human health: projections of temperature-related mortality for the UK during the 2020s, 2050s and 2080s. *J Epidemiol Community Health* 2014. <https://doi.org/10.1136/jech-2013-202449>. Published Online First: 03 February.

²³ IEA, IRENA, UNSD, World Bank, WHO (2022). Tracking SDG 7: The Energy Progress Report. World Bank, Washington DC. © World Bank. License: Creative Commons Attribution Non Commercial 3.0 IGO (CC BY-NC 3.0 IGO). Available from <https://trackingsdg7.esmap.org/downloads>

²⁴ IEA, IRENA, UNSD, World Bank, WHO (2022). Tracking SDG 7: The Energy Progress Report. World Bank, Washington DC. © World Bank. License: Creative Commons Attribution Non Commercial 3.0 IGO (CC BY-NC 3.0 IGO). Available from <https://trackingsdg7.esmap.org/downloads>

sufficiently sensitive measurement tools are available, concentrations of fine particles (PM_{2.5} or smaller), are also reported.

There is a close, quantitative relationship between exposure to high concentrations of small particulates (PM₁₀ and PM_{2.5}) and increased mortality or morbidity, both daily and over time. Conversely, when concentrations of small and fine particulates are reduced, related mortality will also go down – presuming other factors remain the same. This allows policy-makers to project the population health improvements that could be expected if particulate air pollution is reduced. Small particulate pollution has health impacts even at very low concentrations – indeed no threshold has been identified below and no damage to health is observed. Therefore, the WHO Global guideline limits aimed to achieve the lowest concentrations of PM possible.

✓ **Carbon Dioxide**

Breathing too many CO₂ results in high levels of CO₂ in the blood (hypercapnia) associated with a decrease in blood pH (increased acidity) resulting in a condition known as acidosis. The decreases in blood and tissue pH produce effects on the respiratory, cardiovascular, and central nervous systems (CNS)²⁵. Changes in pH act directly and indirectly on those systems producing effects such as tremors, headache, hyperventilation, visual impairment, and CNS impairment. In terms of worker safety, the US Occupational Safety and Health Administration has set a permissible exposure limit (PEL) for CO₂ of 5,000 parts per million (ppm) (or 0.5%) over an 8-hour workday²⁶. They report that exposure to levels of CO₂ above this can cause problems with concentration, an increased heart rate, breathing issues, headaches, and dizziness.

✓ **Methane (CH₄)**

Methane is a component of natural gas, mainly used as a fuel source and chemical feedstock in industries. It is usually harmless, however, at high concentrations; it may reduce the oxygen percentage in the air, causing suffocation. It is also extremely flammable and can cause an explosion when its concentration reaches 5% to 15% in the air.²⁷

Effect of Charcoal Emitted Substance on Climate, Health, and Environment

Global warming

Global warming and the associated climate changes are predictable. They are enhanced by the burning of fossil fuels and the emission of huge amounts of CO₂ gas which resulted in the greenhouse effect. It is expected that the average global temperature will increase by 2–5 °C in the next decades.

²⁵ Eckenhooff, R.G., Longnecker, D.E., (1995). The therapeutic gases. Effects of carbon dioxide. In: Goodman and Gilman's The Pharmacological Basis of Therapeutics, 9th Ed (Hardman JG, ed). McGraw Hill, 355-356.

²⁶ OSHA (Occupational Safety and Health Administration). (2012). Sampling and Analytical Methods: Carbon Dioxide in Workplace Atmospheres. Available: <http://www.osha.gov/dts/sltc/methods/inorganic/id172/id172.html> [accessed 23 December 2014].

²⁷ Jo, J. Y., Kwon, Y. S., Lee, J. W., Park, J. S., Rho, B. H., & Choi, W. il. (2013). Acute respiratory distress due to methane inhalation. *Tuberculosis and Respiratory Diseases*, 74(3), 120–123.
<https://doi.org/10.4046/trd.2013.74.3.120>

As a result, the earth will exhibit marked climatic changes characterized by extremer weather events in the coming decades. There will be rise in temperature, increased volume of rainfall, even summertime, droughts, more frequent ferocious tornadoes, and hurricanes. The epidemiological disease cycle includes host, pathogen, and in certain cases intermediate host/vector²⁸.

Direct health effect

As greenhouse gases affect climate they also initially affect the individual who is exposed to them. Continuous inhalation and exposure of greenhouse gases/air pollutants that have been released into the atmosphere as a consequence of household exercises, pose threat to health directly.

Cancer: A 2013 assessment by WHO's International Agency for Research on Cancer (IARC) concluded that outdoor air pollution is carcinogenic to humans, with the particulate matter component of air pollution most closely associated with increased cancer incidence, especially lung cancer. An association also has been observed between outdoor air pollution and an increase in cancer of the urinary tract/bladder.²⁹

Cardiovascular disorder: The latest burden estimates reflect the very significant role air pollution plays in cardiovascular illness and death. More and more, evidence demonstrating the linkages between ambient air pollution and cardiovascular disease risk is becoming available, including studies from highly polluted areas.³⁰

Each year, 3.2 million people die prematurely from illnesses attributable to household air pollution caused by the incomplete combustion of solid fuels and kerosene used for cooking. Particulate matter and other pollutants in household air pollution inflame the airways and lungs, impairing immune response and reduce the oxygen-carrying capacity of the blood.

Among these 3.2 million deaths from household air pollution exposure:

- 32% are from **ischaemic heart disease**: 12% of all deaths due to ischaemic heart disease, accounting for over a million premature deaths annually, can be attributed to exposure to household air pollution;
- 23% are from **stroke**: approximately 12% of all deaths due to stroke can be attributed to the daily exposure to household air pollution arising from using solid fuels and kerosene at home;

²⁸El-Sayed, A., & Kamel, M. (2020). Climatic changes and their role in emergence and re emergence of diseases. In *Environmental Science and Pollution Research* (Vol. 27, Issue 18, pp. 22336–22352). Springer. <https://doi.org/10.1007/s11356-020-08896-w>

²⁹ *PRESS RELEASE N° 221 IARC: Outdoor air pollution a leading environmental cause of cancer deaths.* (2013). <http://www.iarc.fr/en/publications/books/sp161/index.php>

³⁰ Puthumana, J.S., Ngaage, L.M., Borrelli, M.R., Rada, E.M., Caffrey, J., Rasko, Y. (2021): Risk factors for cooking-related burn injuries in children, WHO Global Burn Registry. *Bull World Health Organ.* Jun 1;99(6):439-445. <https://doi.org/10.2471%2FBLT.20.279786>

- 21% are due to **lower respiratory infection**: exposure to household air pollution almost doubles the risk for childhood LRI and is responsible for 44% of all pneumonia deaths in children less than 5 years old. Household air pollution is a risk for acute lower respiratory infections in adults and contributes to 22% of all adult deaths due to pneumonia;
- 19% are from **chronic obstructive pulmonary disease (COPD)**: 23% of all deaths from chronic obstructive pulmonary disease (COPD) in adults in low- and middle-income countries are due to exposure to household air pollution; and
- 6% are from **lung cancer**: approximately 11% of lung cancer deaths in adults are attributable to exposure to carcinogens from household air pollution caused by using kerosene or solid fuels like wood, charcoal, or coal for household energy needs.³¹

Household air pollution accounted for the loss of an estimated 86 million healthy life years in 2019, with the largest burden falling on women living in low- and middle-income countries. Almost half of all deaths due to lower respiratory infection among children under 5 years of age are caused by inhaling particulate matter (soot) from household air pollution. There is also evidence of links between household air pollution and low birth weight, tuberculosis, cataract, nasopharyngeal and laryngeal cancers.³²

Indirect Health Effects: Climate changes and infectious disease

The level of compounds emitted and formed during various house charcoal applications directly affects the atmospheric temperature and climate at large. Various studies have shown that climate change influences infectious diseases. Reaching back to the effect of temperature on the development and growth of parasites bacteria, viruses, and fungi. many studies have shown that temperature has a direct impact on the quick development of insects and vectors. Diseases may include; malaria, dengue virus, yellow fever, etc. The most common category of infectious disease affected by climate change may include the following;

Insect And Insect Borne Diseases: Global warming influences both vector host dimensions in a way that controls their spatiotemporal expansion and the emergence of diseases in a complex but balanced way.^{33 34}

Water-borne and foodborne diseases: These are serious public health concerns worldwide. Waterborne and foodborne outbreaks are closely associated with climatic changes and

³¹ Puthumana, J.S., Ngaage, L.M., Borrelli, M.R., Rada, E.M., Caffrey, J., Rasko, Y. (2021): Risk factors for cooking-related burn injuries in children, WHO Global Burn Registry. Bull World Health Organ. Jun 1;99(6):439-445. <https://doi.org/10.2471%2FBLT.20.279786>

³² Puthumana, J.S., Ngaage, L.M., Borrelli, M.R., Rada, E.M., Caffrey, J., Rasko, Y. (2021): Risk factors for cooking-related burn injuries in children, WHO Global Burn Registry. Bull World Health Organ. Jun 1;99(6):439-445. <https://doi.org/10.2471%2FBLT.20.279786>

³³ Morgan, J., Dejong, R., Snyder, S., Mkoji, G., Loker E., (2001). Schistosoma mansoni and Biomphalaria: past history and future trends.Parasitology 123:211–228

³⁴ Renn, O., Klinke, A., Van Asselt, M. (2011). Coping with complexity, uncertainty and ambiguity in risk governance: a synthesis. Ambio 40: 231–246

disturbances in the ecosystem. They are more common in the summertime and increase with rising temperatures and humidity.³⁵

Rodent And Rodent Related Diseases: a large number of zoonotic disease agents either directly such as leptospirosis, Sin Nombre virus, and Hantaan virus which spread via dust contaminated with dried rodent urine^{36,37} or indirectly as plague (*Yersinia pestis*). Global warming influences the change in rodent distribution maps and their population worldwide.³⁸

Climate and Malnutrition

Nutrient Depletion on Plant

Elevated CO₂ (Carbon-dioxide) in the atmosphere has direct and indirect impacts on soil properties and processes via forced alterations in soil water and temperature, in addition to the competing of nutrients.³⁹ Investigations on plant response to the elevation of CO₂ may not be representative of the conditions of actual fields in some plant species. There was a drawback in the effectiveness of the experiments of raised CO₂ and temperature for determining their impacts on photosynthesis and other processes of the ecosystem. They attributed this to incorporating short-term sudden variations in elevated CO₂ or temperature in the laboratory or field experiments. These changes rarely generated quantifiable variations in net primary productivity (NPP), Carbon (C) in the ecosystem, or other properties linked to longstanding responses to continuing Carbon-Carbon⁴⁰. They studied the influence of elevated CO₂ on native grass and cultivated ecosystems and found that understanding the link between CC and plant nutrition may be best accomplished firstly by understanding this interaction in both range and grazing areas.⁴¹

Nitrogen is an essential nutrient that influences plant development and physiology. It is also a key component of amino acids, protein, nucleic acids, and chlorophyll, helping to regulate C absorption and metabolism. It is indicated that elevated CO₂ reduces leaf N content, in general, due to the

³⁵ Greer, A., Ng, V., Fisman, D. (2008). Climate change and infectious diseases in North America: the road ahead. *Cmaj* 178:715–722

³⁶ Hansen, A., Cameron, S., Liu, Q., Sun, Y., Weinstein, P., Williams, C., Han, G.S., Bi, P. (2015). Transmission of haemorrhagic fever with renal syndrome in China and the role of climate factors: a review. *Int J Infect Dis* 33:212–218

³⁷ Pijnacker, R., Goris, M.G., Te Wierik, M.J., Broens, E.M., van der Giessen, J.W., de Rosa, M., Wagenaar, J.A., Hartskeerl, R.A., Notermans, D.W., Maassen, K. (2016). Marked increase in leptospirosis infections in humans and dogs in the Netherlands, 2014. *Eurosurveillance* 21

³⁸ Moore, S., Shrestha, S., Tomlinson, K.W., Vuong H. (2012). Predicting the effect of climate change on African trypanosomiasis: integrating epidemiology with parasite and vector biology. *J R Soc Interface*, 9:817–830

³⁹ Dotaniya, M.L., Rajendiran, S., Meena, B.P., Meena, A.L., Dotaniya, C.K., Jat, R.L., Saha, J.K. (2016). Elevated Carbon Dioxide (CO₂) and Temperature vis-a-vis Carbon Sequestration Potential of Global Terrestrial Ecosystem. In *Conservation Agriculture*; Bisht, J.K., Ed.; Springer: Singapore,

⁴⁰ Hatfield, J.L., Prueger, J.H. (2011). Agroecology: Implications for Plant Response to Climate Change. In *Crop Adaptation to Climate Change*, 1st ed.; Yadav, S.S., Redden, R.J., Hatfield, J.L., Lotze-Campen, H., Hall, A.E., Eds.; JohnWiley & Sons, Ltd.: Hoboken, NJ, USA

⁴¹ Hatfield, J.L., Prueger, J.H. (2011). Agroecology: Implications for Plant Response to Climate Change. In *Crop Adaptation to Climate Change*, 1st ed.; Yadav, S.S., Redden, R.J., Hatfield, J.L., Lotze-Campen, H., Hall, A.E., Eds.; JohnWiley & Sons, Ltd.: Hoboken, NJ, USA

diluting effect. Moreover, the decreased transpiration rate by elevated CO₂ might cause a decrease in mass flow, reducing N absorption with the mass flow. Furthermore, the N concentration in plants may be connected to endogenous abscisic acid concentrations, which are influenced by variations in root development. Furthermore, low leaf N might enhance cytokinin levels under elevated CO₂, encouraging stomatal opening. It is noteworthy that N can impact the accumulation of endogenous abscisic acid and the responses of the stomata to endogenous abscisic acid, thereby influencing the stomatal response to the stress of drought under elevated O₂ growth conditions.⁴²

High temperatures: this result in an increase in CO₂ efflux from the soil. Global warming is lowering the SOC stock (carbon stock expressed as Mg ha⁻¹ or kg m⁻²) by boosting the rate of decomposition and, as a result, the residence time of C in the soil. As a result, soils are expected to be the main source of CO₂ emissions in the future⁴³. The increasing temperature modifies the factor of plant nutrients and different nutrient cycles in nature⁴⁴. The rising temperature also influences physiological processes such as photosynthesis and respiration. The net impact of CC will vary owing to specific conditions. Therefore, in areas with cold spring and summer periods, where the growing season is short, higher temperatures may improve the crop yields. However, a warmer climate will reduce yields when the temperature increases.

Precipitation levels: The considerable variations in precipitation directly influence the yield, especially in semi-arid and arid climates. Soil water is an essential resource in agriculture. Nutrient absorption is connected to soil water availability, which may be affected by climate change and changing precipitation patterns⁴⁵. Additionally, nutrient leaching will also be forced by increased precipitation. It is known that intensive rainfall increases soil erosion, which is likely to be higher under CC. An increase of 1% in precipitation is projected to result in a 1.5 to 2% increase in erosion. Intensive rain and transforming from snowing to raining will moreover increase the erosion rate. Plant cover reduces soil erosion rates by weakening rain power (in addition to stabilizing soils by root and reducing sediment transportation by crop residue). Thus, variations in plant biomass can increase those impacts of soil erosion and nutrient leaching.

Coral Reefs Deterioration: Climate change is currently the strongest driver affecting coral dynamics⁴⁶. Sea level rise, high ocean temperatures, ocean acidification, and the synergistic effects that climate drivers have with one another and with non-climate drivers are currently causing widespread negative effects on PICT corals. For example, calcification rates are affected by both

⁴² Rajput, V.D., Chen, Y., Ayup, M. (2015). Effects of high salinity on physiological and anatomical indices in the early stages of *Populus euphratica* growth. *Russ. J. Plant Physiol.*, 62, 229–236.

⁴³ Shahzad, K., Sintim, H., Ahmad, F., Abid, M., Nasim, W. (2022). Importance of Carbon Sequestration in the Context of Climate Change. In *Building Climate Resilience in Agriculture*; Jatoi, W.N., Mubeen, M., Ahmad, A., Cheema, M.A., Lin, Z., Hashmi, M.Z., Eds.; Springer: Cham, Switzerland.

⁴⁴ Dotaniya, M.L., Rajendiran, S., Meena, B.P., Meena, A.L., Dotaniya, C.K., Jat, R.L., Saha, J.K. (2016). Elevated Carbon Dioxide (CO₂) and Temperature vis-a-vis Carbon Sequestration Potential of Global Terrestrial Ecosystem. In *Conservation Agriculture*; Bisht, J.K., Ed.; Springer: Singapore,

⁴⁵ Khan, S., Anwar, S., Sun, M., Shafiq, F., Khalilzadeh, R., Gao, Z.-Q. (2021). Characterizing Differences in Soil Water Content and Wheat Yield in Response to Tillage and Precipitation in the Dry, Normal, and Wet Years at the Loess Plateau. *Int. J. Plant Prod.*, 15, 655–668

⁴⁶ Aronson, R.B., Precht, W.F. (2016). Physical and Biological Drivers of Coral-Reef Dynamics. *Coral Reefs World* 6, 261-275.

ocean pH and temperature. Current maximum calcification rates are just 2-3 °C below the maximum temperature corals can withstand before thermal bleaching.⁴⁷

When corals bleach, calcification is further suppressed because photosynthetic products from the zooxanthellae are essential for the calcification process⁴⁸. The factors affecting Coral Reefs include; increase in Ocean Temperatures, Ocean acidification and Sea level rise and cyclones.

Conclusion

Current impacts of elevated and increasing levels in greenhouse gases, heat and ambient CO₂ in indoor environments, mostly due to activation of the autonomic nervous system, include inflammation, respiratory diseases, headaches, fatigue, increased heart rate, increased blood pressure, and other symptoms. Recently charcoal has been Nigerian major fuel sources for different household applications, due to the expensive price of gas and minimal or average electricity supply. Climate and health has been interlinked i.e. at any given stage, any element that affect climate would directly or indirectly affect the health of individuals and as well as the availability and quality of their food, water and environment. This review aim to educate the Nigerian population, on the increase application of charcoal and heat, and how the consequence of their action might affect their health and climate.

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⁴⁷ Evenhuis, C., Lenton, A., Cantin, N.E., Lough, J.M. (2015). Modelling coral calcification accounting for the impacts of coral bleaching and ocean acidification. *Biogeosciences* 12, 2607-2630.

⁴⁸ Evenhuis, C., Lenton, A., Cantin, N.E., Lough, J.M. (2015). Modelling coral calcification accounting for the impacts of coral bleaching and ocean acidification. *Biogeosciences* 12, 2607-2630