AUTOMOTIVE EXHAUSTS EMISSIONS AND ITS IMPLICATIONS FOR ENVIRONMENTAL SUSTAINABILITY

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ABSTRACT

Automotive exhausts' carbon emissions contribute to global climate change, which can have serious consequences on humans and their environment. According to the U.S. Environmental Protection Agency, carbon emissions, in the form of carbon dioxide, make up more than 80 percent of the greenhouse gases emitted in the United States. The burning of fossil fuels releases carbon dioxide and other greenhouse gases. These carbon emissions raise global temperatures by trapping solar energy in the atmosphere. This alters water supplies and weather patterns, changes the growing season for food crops and threatens coastal communities with increasing sea levels.

Keywords: Automotive engine, carbon emissions, fossil fuels, environment, climate change, and pollution.

INTRODUCTION

When a car's engine is running, several different types of gasses and particles are emitted that can have detrimental effects on the environment. Of particular concern to the environment are carbon dioxide, a greenhouse gas; hydrocarbons of more than a dozen volatile organic compounds, some of which are known carcinogens; nitrogen oxides; sulfur oxides; and particulate matter, tiny particles of solids, such as metal and soot. Other emissions that affect human health and create smog include ozone and carbon monoxide. In cities across the globe, the personal automobile is the single greatest polluter, as emissions from more than a billion vehicles on the road add up to a planet-wide problem. Driving a private car is a typical citizen's most air polluting activity. The negative effects of automotive emissions are maximum when you sit in traffic surrounded by cars trucks and buses, their engines idling. Everyone sitting in a traffic jam is getting poisoned.

Vehicle emissions can affect the environment in several ways. Cars emit greenhouse gasses, such as carbon dioxide, which contribute to global warming. Some air pollutants and particulate matter from cars can be deposited on soil and surface waters where they enter the food chain; these substances can affect the reproductive, respiratory, immune and neurological systems of animals. Nitrogen oxides and sulfur oxides are major contributors to acid rain, which changes the pH of waterways and soils and can harm the organisms that rely on these resources.

Global warming is primarily a problem of too much carbon dioxide (CO2) in the atmosphere which acts as a blanket, trapping heat and warming the planet. As we burn fossil fuels like coal, oil and natural gas for energy or cut down and burn forests to create pastures and plantations, carbon accumulates and overloads our atmosphere. Certain waste management and agricultural practices aggravate the problem by releasing other potent global warming gases, such as methane and nitrous oxide. See the pie chart for a breakdown of heat-trapping global warming emissions by economic sector. While people may argue over whether global warming is being caused by humans or that the phenomenon is even happening, they can probably agree that more carbon is being sent into the atmosphere than at any other point in recorded human history. This unprecedented release of carbon is having an effect on the planet, according to scientists (Smith, 2015).

1. AUTOMOTIVE COMBUSTION PROCESS

Gasoline and diesel fuels are mixtures of hydrocarbons (made of hydrogen, oxygen and carbon atoms.) Hydrocarbons are burned by combining with oxygen. Nitrogen and sulphur atoms are also present and combine with oxygen when burned to produce gases. Attempts to reduce exhaust emissions from gasoline and diesel engines have been compromised by limitations of testing, inherent flaws in the design and inadequate maintenance of emission control devices.

Diesel engines pose different emission control problems than gasoline engines. Diesels require more sophisticated and expensive components than the catalytic converters fitted to gasoline engines. Diesel emissions contain nitrogen oxide gases and carbon particles, the smallest of which contribute to lung and heart disease. Increases in airborne fine particulate matter increases the risk for myocardial infarctions, strokes and heart failure. Particle deposition in the lungs activates the sympathetic nervous system and triggers the release of systemic pro-inflammatory responses.

2. AUTOMOTIVE ENGINE COMBUSTION AND EXHAUSTS EMISSIONS

Fuel + Air => Hydrocarbons + Nitrogen Oxides + Carbon Dioxide + Carbon Monoxide + Sulphur Dioxide+ water (Nationalgeographic.com, 2015).

2.1.Hydrocarbon

These emissions are fragments of fuel molecules, only partially burned. Hydrocarbons react in the presence of nitrogen oxides and sunlight to form ground-level ozone, a major component of

smog. Ozone irritates the eyes, nose, throat and damages the lungs. A number of exhaust hydrocarbons are also toxic, some with the potentials to cause cancer (Nationalgeographic.com, 2015)

2.2.Nitrogen Oxides

Under high pressure and temperature conditions in an engine, nitrogen and oxygen atoms react to form nitrogen oxides. Nitrogen dioxide, NO_2, is a brownish toxic gas, an important air pollutant. NO_2 combines with water in the air to form nitric acid - acid rain. A complex chemistry involves NO_2 combining with hydrocarbons to form the photochemical smog that poisons city dwellers (Nationalgeographic.com, 2015).

2.3.Carbon Monoxide (CO)

Carbon monoxide is a colorless, odorless, poisonous gas, a product of incomplete combustion of hydrocarbon-based fuels. Carbon monoxide consists of a single carbon atom and a single oxygen atom linked together (CO), the product of incomplete combustion of fuel. Most CO is produced when air-to-fuel ratios are too low in the engine during vehicle starting, when cars are not tuned properly, and at higher altitudes, where thin air reduces the amount of oxygen available for combustion. Two-thirds of the carbon monoxide emissions come from transportation sources, with the largest contribution coming from cars. In urban areas, the passenger vehicle contribution to carbon monoxide pollution can exceed 90% (Nationalgeographic.com, 2015).

2.4.Carbon Dioxide.

U.S. Environmental Protection Agency (EPA) originally viewed carbon dioxide as a product of "perfect" combustion, but now views CO2 as a pollution concern. Carbon dioxide is a greenhouse gas that traps the earth's heat and contributes to Climate Change. This is discussed in section 3.

2.5.Particle Pollution and Human Disease

The U.S. Environmental Protection Agency (EPA) defines fine-particle air pollution, PM10, particulate matter 10 micrometers or less in diameter. Suspended particles in the air create aerosols that are important to the behavior of whole atmosphere and play a role in determining human disease. Human air pollution now dominates aerosol production over cities with negative health effects. Thick aerosols are obvious as haze and contain a complex system of particles with adherent toxic gases such as sulphur dioxide. Air pollution is associated with increased hospital admissions for cardiovascular diseases with increases in acute morbidity and mortality (EPA, 2015).

2.6.Evaporative Emissions

Hydrocarbon pollutants also escape into the air through fuel evaporation - evaporation causes significant hydrocarbon pollution from cars on hot days when ozone levels are highest. Evaporative emissions occur several ways:

2.6.1. Diurnal: Gasoline evaporation increases as the temperature rises during the day, heating the fuel tank and venting gasoline vapors.

2.6.2. Running Loses: The hot engine and exhaust system can vaporize gasoline when the car is running.

2.6.3. Sitting Evaporation: The engine remains hot for a period of time after the car is turned off, and gasoline evaporation continues when the car is parked.

2.6.4. Adding Fuel: Gasoline vapors are always present in fuel tanks. These vapors are forced out when the tank is filled with liquid fuel.

2.7.Benzene

This is the main toxin in the hydrocarbon fraction of the exhaust. Benzene and other less known hydrocarbons are produced in petroleum refining, and are widely used as solvents and as materials in the production of various industrial products and pesticides. Benzene also is found in gasoline and in cigarette smoke. Other environmental sources of benzene include gasoline (filling) stations, underground storage tanks that leak, wastewater from industries that use benzene, chemical spills, and groundwater next to landfills containing benzene. Exposure to benzene can cause cancer, especially leukemias and lymphomas. Benzene has a suppressive effect on bone marrow and it impairs blood cell maturation and amplification.

2.8.Hydrogen

Ultimately cars might burn hydrogen in fuel cells, but despite working prototypes, a hydrogen economy is a distant fantasy. There are many problems to be solved before hydrogen can replace fossil fuels as a portable energy source.

3. EFFECTS OF CARBON DIOXIDE EMISSIONS

Carbon dioxide (CO_2) is the primary greenhouse gas emitted through human activities. In 2013, CO_2 accounted for about 82% of all U.S. greenhouse gas emissions from human activities (EPA, 2015). Carbon dioxide is naturally present in the atmosphere as part of the Earth's carbon cycle (the natural circulation of carbon among the atmosphere, oceans, soil, plants, and animals). Human activities are altering the carbon cycle both by adding more CO_2 to the atmosphere and by influencing the ability of natural sinks, like forests, to remove CO_2 from the atmosphere.

While CO_2 emissions come from a variety of natural sources, human related emissions are responsible for the increase that has occurred in the atmosphere since the industrial revolution (NRC, 2010).

U.S. Carbon Dioxide Emissions, By Source

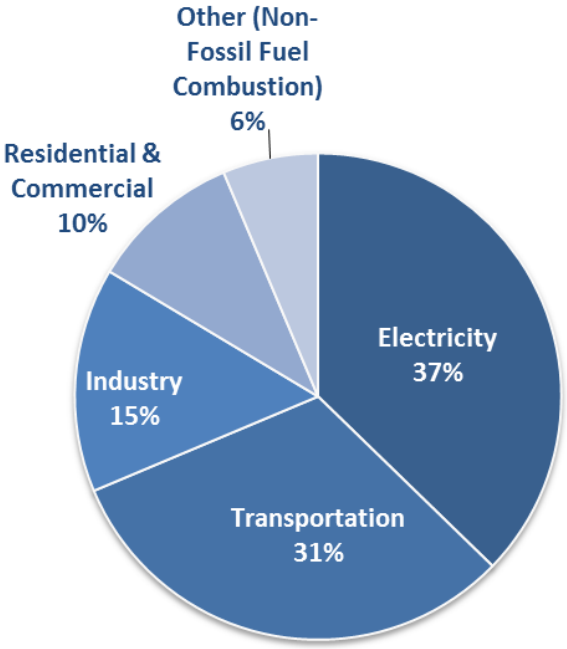

Figure 1. All emission estimates from the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2013*. Source: Environmental Protection Agency (2015).

The report in figure 1 above shows that the combustion of fossil fuels such as gasoline and diesel to transport people and goods is the second largest source of CO_2 emissions, accounting for about 31% of total U.S. CO_2 emissions and 26% of total U.S. greenhouse gas emissions in 2013. This category includes transportation sources such as highway vehicles, air travel, marine transportation, and rail.

The main human activity that emits CO_2 is the combustion of fossil fuels (coal, natural gas, and oil) for energy and transportation, although certain industrial processes and land-use changes also emit CO_2. Between 1990 and 2013, the increase in CO_2 emissions corresponded with increased energy use by an expanding economy and population, and an overall growth in emissions from electricity generation. Transportation emissions also contributed to the 7% increase, largely due to an increase in miles traveled by motor vehicles. The concentrations of unburned and partially-burned hydrocarbons (HC), carbon monoxide (CO) and oxides of Nitrogen (NOx) in the exhaust stream were measured during HCCI and SI operations (Noraz al-Khairi, Naveenchandran, & Rashid A Aziz, 2011).

According to Singer, Charles Joseph; Raper, Richard (2013), since the diesel engine uses less fuel than the petrol engine per unit distance, the diesel produces less carbon dioxide (CO_2) per

unit distance. The electronic injection can "sense" engine revolutions, load, and even boost the temperature, and continuously alter the timing to match the given situation. In the petrol engine, air and fuel are mixed for the entire compression stroke, ensuring complete mixing even at higher engine speeds (Ricardo, 2011).

4. AIR POLLUTION

Smog hanging over cities is the most familiar and obvious form of air pollution. But there are different kinds of pollution some visible, some invisible that contribute to global warming. Generally any substance that people introduce into the atmosphere that has damaging effects on living things and the environment is considered air pollution.

Carbon dioxide, a greenhouse gas, is the main pollutant that is warming Earth. Though living things emit carbon dioxide when they breathe, carbon dioxide is widely considered to be a pollutant when associated with cars, planes, power plants, and other human activities that involve the burning of fossil fuels such as gasoline and natural gas. In the past 150 years, such activities have pumped enough carbon dioxide into the atmosphere to raise its levels higher than they have been for hundreds of thousands of years (Science News, 2015)

The products of combustion coming out of the exhaust system are more noticeable with diesel engines, particularly if any of the injection equipment components are out of tune. It is questionable which are the more harmful: the relatively invisible exhaust gases from the petrol engine, which include nitrogen dioxide or the visible smoky diesel, exhaust gases.

5. NOISE POLLUTION

Diesel engines tend to become noisy and to vibrate on their mountings as the operating load is reduced. The combustion process is quieter in the petrol engine and it runs smoother than the diesel engine. There is no noisy injection equipment used on the petrol engine, unlike that necessary on the diesel engine. The distinctive noise of a diesel engine is variably called diesel clatter, diesel nailing, or diesel knock. According to Manbw.com (2015), Diesel clatter is caused largely by the diesel combustion process; the sudden ignition of the diesel fuel when injected into the combustion chamber causes a pressure wave.

Engine designers can reduce diesel clatter through: indirect injection; pilot or pre-injection; injection timing; injection rate; compression ratio; turbo boost; and exhaust gas recirculation (EGR). Common rail diesel injection systems permit multiple injection events as an aid to noise reduction. Diesel fuels with a higher cetane rating modify the combustion process and reduce diesel clatter. CN (Cetane number) can be raised by distilling higher quality crude oil, by catalyzing a higher quality product or by using a cetane improving additive (Fiat.com, 2015)

A combination of improved mechanical technology such as multi-stage injectors which fire a short "pilot charge" of fuel into the cylinder to initiate combustion before delivering the main fuel charge, higher injection pressures that have improved the atomisation of fuel into smaller droplets, and electronic control (which can adjust the timing and length of the injection process

to optimise it for all speeds and temperatures), have partially mitigated these problems in the latest generation of common-rail designs, while improving engine efficiency (Anyebe, 2009).

6. AUTOMOTIVE EMISSION AND ENVIRONMENTAL SUSTAINABILITY

According to Science News (2015), the combustion of fossil fuels releases carbon dioxide (a major "greenhouse gas") into the atmosphere, and most climate scientists believe that the buildup of those gases is the primary cause of the global warming that has occurred in recent decades. Because the effects of carbon dioxide (CO2) result in more than just rising temperatures, scientists prefer the phrase "climate change," which helps convey that other changes are taking place as well.

University of Hawaii at Manoa (2013) future warming from fossil fuel burning could be more intense and longer-lasting than previously thought. This prediction emerges from a study that includes insights from episodes of climate change in the geologic past to inform projections of human-made future climate change.
According to University of Hawaii at Manoa (2013) humans keep adding large amounts of greenhouse gases to the atmosphere, among them carbon dioxide (CO_2), the most important human-made greenhouse gas. Over the past 250 years, human activities such as fossil fuel burning have raised the atmospheric CO_2 concentration by more than 40% over its preindustrial level of 280 ppm (parts per million). In May 2013, the CO_2 concentration in Earth's atmosphere surpassed a milestone of 400 ppm for the first time in human history, a level that many scientists consider dangerous territory in terms of its impact on Earth's climate (Zeebe, 2013)

A global cooling calamity as depicted in the movie 'The Day After Tomorrow,' though, is very unlikely to be the result of climate change. The globe is likely to become warmer in the near future, and probably a lot warmer in the distant future. In the study by Zeebe (2013) Professor of Oceanography in the School of Ocean and Earth Science and Technology at the University of Hawai'i at Mānoa, has examined humankind's long-term legacy of fossil fuel burning. The study suggests that amplified and prolonged warming due to unabated fossil fuel burning raises the probability that large ice sheets such as the Greenland ice sheet will melt, leading to significant sea level rise.

6.1.**Air Pollution and Human Health**

Scientific experts now believe the nation faces an epidemic of illnesses that are exacerbated by air pollution. These illnesses include cardiovascular disease, asthma, chronic obstructive pulmonary disease, lung cancer, and diabetes.

The American Academy of Pediatrics has concluded that levels of ozone and particulate matter are high enough in many parts of the U.S. to threaten children's health. Cardiovascular disease, hypertension, diabetes and cancer are all illnesses disproportionately borne by the elderly. Chemicals in vehicle exhaust are harmful to asthmatics. EHHI (2015) Exhaust can adversely affect lung function and may promote allergic reactions and airway constriction. All vehicles, especially diesel engines, emit very fine particles that deeply penetrate lungs and inflame the

circulatory system, damaging cells and causing respiratory problems. Even short-term exposure to vehicle exhaust may harm asthmatics. Asthmatic children are particularly sensitive to air pollution. New England states have some of the highest asthma rates in the country. Inhalation of vehicle emissions, even for short periods, may be harmful to asthmatics.

6.2.**Scarcity of Water Supplies**

In Cairoli (2015) Carbon dioxide persists in the atmosphere for 50 to 200 years, so emissions released now will continue to warm the climate in the future. The EPA predicts that climate change will cause the demand for water to increase while the supply of water shrinks. Water is not only essential to human health but also to manufacturing processes and the production of energy and food. Climate change is expected to increase rainfall in some areas, thereby causing an increase in the sediment and pollutants washed into drinking water supplies. Rising sea levels will cause saltwater to infiltrate some freshwater systems, increasing the need for desalination and drinking water treatment.

6.3.**Change in Weather condition**

Vehicle emissions contribute to air pollution generated from the combustion of fossil fuels from many other sources, including the burning of coal and oil in power plants, incinerators, home heating oil, and construction equipment. The combustion of gas and diesel fuels produce greenhouse gases that are contributing to local, regional and global climatic changes. A recent study published in Science analyzed more than 900 scientific articles listed with the keywords "global climate change." Not one disagreed with the consensus view that humans are contributing to global warming.

Global warming has the potential to result in more wildfires, droughts and tropical storms, according to NASA. Catastrophic weather events caused $1 billion in damage in the United States during 2012. Storms like 2012's Hurricane Sandy and 2013's Typhoon Haiyan are becoming more frequent, and the devastation they cause takes local communities years to remedy, often with the help of international aid. The destruction of infrastructure causes several human health issues, including disease transmitted when water and sewer systems are not working properly. The storms themselves and the damage to infrastructure they cause often result in a tremendous loss of human life.

6.4.**Shortage in Food Supply**

Changing weather affects the agricultural industry and the human food supply. Carbon emissions contribute to increasing temperatures and decreasing precipitation, changing the growing conditions for food crops in many areas. According to the U.S. Global Change Research Program, carbon emissions are causing warming in California's Central Valley that is projected to significantly reduce the yields of tomatoes, wheat, rice, maize and sunflowers in this region. Major changes in crop yield will cause food prices to rise around the world. In addition, climate change influenced by carbon emissions forces animals, many of which are hunted as food, to migrate to higher altitudes or northern habitats as the climate warms.

6.5.Geographical Changes

It takes only a small change in temperature to have enormous environmental effects; temperatures at the end of the last ice age were only cooler than today's temperatures by 2.5 to 5 degrees Celsius (5 to 9 degrees Fahrenheit), but parts of the United States were covered by thousands of feet of ice, according to NASA. The Intergovernmental Panel on Climate Change estimated that carbon emissions will cause global temperatures to rise by approximately 1.5 BY

7. STRATEGIES TO REDUCING CARBON DIOXIDE EMISSIONS

On a larger scale, governments are taking measures to limit emissions of carbon dioxide and other greenhouse gases. One way is through the Kyoto Protocol, an agreement between countries that they will cut back on carbon dioxide emissions. Another method is to put taxes on carbon emissions or higher taxes on gasoline, so that people and companies will have greater incentives to conserve energy and pollute less (Science News, 2015)
However the measures, the most effective way to reduce carbon dioxide (CO_2) emissions is to reduce fossil fuel consumption. Many strategies for reducing CO_2 emissions from energy are cross-cutting and apply to homes, businesses, industry, and transportation. Hence, EPA is taking common sense regulatory actions to reduce greenhouse gas emissions from world's largest sources, including power plants and motor vehicles.

Strategy	Examples of How Emissions Can be Reduced
Energy Efficiency	Improving the insulation of buildings, traveling in more fuel-efficient vehicles, and using more efficient electrical appliances are all ways to reduce energy consumption, and thus CO_2 emissions.
Energy Conservation	Reducing personal energy use by turning off lights and electronics when not in use reduces electricity demand. Reducing distance traveled in vehicles reduces petroleum consumption. Both are ways to reduce energy CO_2 emissions through conservation.
Fuel Switching	Producing more energy from renewable sources and using fuels with lower carbon contents are ways to reduce carbon emissions.
Carbon Capture and Sequestration	Carbon dioxide capture and sequestration is a set of technologies that can potentially greatly reduce CO_2 emissions from new and existing coal- and gas-fired power plants, industrial processes, and other stationary sources of CO_2.

8. CONCLUSION

Combustion from fossil fuel engines such as those which burn gasoline and diesel fuel is causing irreparable damage to the environment. Carbon monoxide is not the only carbon by-product given off in exhaust fumes. Carbon dioxide is also a problem and it is the number one cause of the breakdown in the ozone layer which is leading to global warming. However, global warming is a catch all phrase that encompasses a great number of problems both to the earth on which we live and to the creatures that dwell on it.

Climate change is not just a national concern. Worldwide, CO2 emissions are projected to increase substantially, primarily as a result of increased in technological development. Therefore, future decisions about whether and how to limit greenhouse gas emissions will affect us all

9. RECOMMENDATIONS

There should be reduction in combustion of all kinds. Also, use of vehicles with new energy sources such as ethanol, biofuels, propane and natural gas should be encouraged as they can contribute to reduce air pollution, though their benefit is limited if vehicle use continues at current intensities.

The problem with all alternative fuels however, is that the manufacture of fuels requires energy, distribution with a manufacturing infrastructure that consume energy, often derived from burning fossil fuels.

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