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A review of some ozone depleting substances and hydrofluorocarbons in tropical areas of developing countries (Cameroon-Africa)

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Summary

Hydrofluorocarbons (HFCs) are greenhouse gases (GHGs) commonly used by federal agencies in a wide variety of applications, including refrigeration, air-conditioning (AC), building insulation, fire extinguishing systems, and aerosols. HFCs have high global warming potential (GWP), raising concern about their impacts as they become increasingly used as replacements for ozone-depleting substances (ODS), and as economic growth spurs demand for new equipment, especially in the refrigeration/AC sector. Information about ongoing domestic efforts and tools to address HFCs, sector, is provided below. To help agencies monitor progress, the amendment also requires contractors to keep track of and report on the amounts of HFCs added or removed during routine maintenance, service, repair, and disposal of all government equipment, appliances, and supplies.

Key words: Hydrofluorocarbons (HFCs), greenhouse gases (GHGs), global warming potential (GWP), Developing countries

Introduction

Hydrofluorocarbons (HFCs) are man-made organic compounds that contain fluorine and hydrogen atoms, and are the most common type of organofluorine compounds. Most are gases at room temperature and pressure. They are frequently used in air conditioning and as refrigerants; R-134a (1,1,1,2-tetrafluoroethane) is one of the most commonly used HFC refrigerants. In order to aid the recovery of the stratospheric ozone layer, HFCs were adopted to replace the more potent chlorofluorocarbons (CFCs), which were phased out from use by the Montreal Protocol, and hydrochlorofluorocarbons (HCFCs) which are presently being phased out. HFCs replaced older chlorofluorocarbons such as R-12 and hydrochlorofluorocarbons such as R-21. HFCs are also used in insulating foams, aerosol propellants, as solvents and for fire protection.They may not harm the ozone layer as much as the compounds they replace, but they still contribute to global warming --- with some like trifluoromethane having 11,700 times the warming potential of carbon dioxide. Their atmospheric concentrations and contribution to anthropogenic greenhouse gas emissions are rapidly increasing, causing international concern about their radiative forcing. Hydrofluorocarbons (HFCs) are greenhouse gases (GHGs) commonly used by federal agencies in a wide variety of applications, including refrigeration, air-conditioning (AC), building insulation, fire extinguishing systems, and aerosols. HFCs have high global warming potential (GWP), raising concern about their impacts as they become increasingly used as replacements for ozone-depleting substances (ODS), and as economic growth spurs demand for new equipment, especially in the refrigeration/AC sector.Fluorocarbons with few C–F bonds behave similarly to the parent hydrocarbons, but their reactivity can be altered significantly. For example, both uracil and 5-fluorouracil are colourless, high-melting crystalline solids, but the latter is a potent anti-cancer drug. The use of the C-F bond in pharmaceuticals is predicated on this altered reactivity.[4] Several drugs and agrochemicals contain only one fluorine center or one trifluoromethyl group.

SCIENTIFIC APPRECIATION

1. Environmental regulation

Unlike other greenhouse gases in the Paris Agreement, hydrofluorocarbons are included in other international negotiations(figure 1-3). In September 2016, the New York Declaration on Forests urged a global reduction in the use of HFCs.[6] On 15 October 2016, due to these chemicals' contribution to climate change, negotiators from 197 nations meeting at a summit of the United Nations Environment Programme in Kigali, Rwanda reached a legally-binding accord (the Kigali Amendment) to phase down hydrofluorocarbons (HFCs) in an amendment to the Montreal Protocol.[7][8][9] As of February 2020, 16 U.S. states ban or are phasing down HFCs. COVID-19 relief legislation, which included a measure that would require chemical manufacturers to phase down the production and use of HFCs, was passed by the United States House of Representatives and United States Senate on December 21, 2020.

2. Organofluorides:

Hydrofluorocarbons (HFC) are potent greenhouse gases (GHG) that have global warming potentials that range from hundreds to thousands of times that of carbon dioxide. They are the fastest growing GHGs emitted globally.Hydrofluorocarbons are typically found in applications such as refrigeration, air-conditioning, aerosols, and foams. Depending on the application, different HFCs can be used as a single compound or in a blend.Under the United Nations Environment Programme’s Montreal Protocol, chlorofluorocarbons and hydrochlorofluorocarbons were recognized as ozone depletion substances (ODS). The U.S. EPA defined a phase-out schedule for the different classes of ODS. Hydrofluorocarbons were developed to be substitutes for these ODS; however, HFCs were recognized as potent GHGs.

3. Green House Gases

Any gas that has infrared (IR) absorption bands can be a GHG. Natural occurring GHGs in the atmosphere are water vapor, CO_2, methane, nitrous oxide, and ozone. Anthropogenically produced GHGs are sulfur hexafluoride, perfluorocarbons (PFCs), hydrofluorocarbons (HFCs), and they are ozone-depleting. They have high global warming potential (GWP) (USEPA, 2010). GHGs can be better recognized as longer-lived climate pollutant (LLCPs) in the troposphere such as chlorofluorocarbons, methane, and nitrous oxide, which are considered trace GHG species and short-lived climate pollutants (SLCPs) such as carbonaceous soots whose pronounced heating effect has been addressed in the Northern Hemisphere by global-scale modeling (Jacobson, 2002).The GHGs listed by the IPCC (CO_2, methane, nitrous oxide, HFCs, PFCs, and sulfur hexafluoride) are discussed below. Water vapor, although the most abundant GHG, is not discussed because it is impossible to predict its concentration as its natural occurrence and fluctuations far outweigh anthropogenic influences. Ozone is an indirectly RF GHG. Other ozone-depleting substances are HFCs, PFCs, and sulfur hexafluoride (IPCC, 2010).

-Carbon dioxide (CO_2): CO_2 is the most important anthropogenic GHG and accounts for more than 75% of all anthropogenic GHG emissions. It has long atmospheric lifetime (on the order of decades to centuries) and thus remains in the atmosphere for decades after its emission. Even if very efficient GHG mitigation efforts to reduce GHG concentrations are promulgated, it will take decades long time to control its concentration in the atmosphere (IPCC, 2007a). CO_2 increase in the atmosphere is mainly due to emissions from the burning of fossil fuels, gas flaring, cement production, iron and steel industry, and land use changes. Three-quarters of the current RF is likely caused by anthropogenic CO_2 emissions. Fossil fuel combustion and the global manufacture of cement are responsible for more than 75% of human-caused CO_2 emissions (IPCC, 2007b); approximately one-quarter of RF results from land-use changes (IPCC, 2007b). Since the Industrial Revolution, the concentration of anthropogenic emissions of CO_2 has increased most notably from ∼280 to 379 ppm (more than 35%) (IPCC, 2007b). IPCC estimates that the present atmospheric concentration of CO_2 has not been exceeded in the last 650,000 years and is likely to be the highest ambient concentration in the last 20 million years (IPCC, 2007c).

Methane: Methane is the second largest GHG with a GWP of 21 compared with CO_2 (IPCC, 2007b). It is the main component of natural gas. The anthropogenic activities, which contribute to the emissions of such a large quantity of methane, are cattle raising, growing rice, burning natural gas, and coal mining. Atmospheric methane has increased from a preindustrial concentration of 715 ppb to 1775 ppb in 2005 (IPCC, 2001; NOAA, 2008).Methane reacts with hydroxyl radical to form the methyl radical (CH_3) and subsequently the methylperoxy radical, which can react with nitric oxide to form nitrogen dioxide):The methoxy radical (CH_3O) then can react with molecular O_2 leading to the formation of formaldehyde and hydroperoxyl radical:

-Hydroperoxyl radical react with N_2O producing nitrogen dioxide and OH radical and thus leading to the chain reactions to form nitrogen dioxide and ozone. Formaldehyde can photolyze to form another hydrogen atom and the formyl radical (HCO) (Eq. 5.12):
This process can be followed vice-versa, by the reaction of both products with oxygen to form carbon monoxide and hydroperoxyl radical. On the other hand, formaldehyde can react with hydroxyl radical by abstraction to form the formyl radical and water (Eq. 5.13):
Here the consequent reaction of the formyl radical with oxygen will lead to the formation of carbon monoxide and hydroperoxyl radical.

-Nitrous oxide: Nitrous oxide is a potent GHG, with a GWP of 310 (IPCC, 2007b). The major sources of nitrous oxide are agricultural processes, nylon production, fuel-fired power plants, nitric acid production, and vehicle emissions. Nitrous oxide is also used in rocket engines and racecars and as an aerosol spray propellant. Agricultural processes that result in anthropogenic emissions of nitrous oxide are fertilizer use and microbial processes in soil and water. Nitrous oxide concentrations in the atmosphere have increased from preindustrial levels of 270–319 ppb in 2005, an 18% increase (IPCC, 2007b). It also produce free radicals (Eq. 5.14)
HFCs:HFCs have high GWPs and are ozone-depleting substance. They are manmade, and they do not exist naturally in ambient conditions. These chemicals are used in commercial, industrial, and consumer products (EPA, 2010). HFCs are used in automobile air conditioners and refrigerants. The most abundant HFCs, in order from the most abundant to least, are HFC-134a (35 ppT), HFC-23 (17.5 ppT), and HFC-152a (3.9 ppT).

Perfluorochemicals

Perfluorochemicals (PFCs) are a group of chemicals used to make fluoropolymer coatings and products that resist heat, oil, stains, grease, and water.The most abundant PFCs are tetrafluoromethane (PFC-14) and hexafluoroethane (PFC-116). These manmade chemicals are emitted largely from aluminum production and semiconductor manufacturing processes. PFCs are extremely stable compounds that are destroyed only by very high-energy UV rays, which results in the very long lifetimes of these chemicals (EPA, 2010).

Sulfur hexafluoride

Sulfur hexafluoride, another manmade chemical, is used as an electrical insulating fluid for power distribution equipment, in the magnesium industry, and in semiconductor manufacturing and also as a trace chemical for study of oceanic and atmospheric processes (EPA, 2010). In 1998, atmospheric concentrations of sulfur hexafluoride were 4.2 ppT and are steadily increasing in the atmosphere. Sulfur hexafluoride is the most powerful of all GHGs listed in IPCC studies, with a GWP of 23,900 (IPCC, 2007b).

Global warming potential

GWP is for comparison of the global warming potential of GHGs. It is defined as a measure of energy absorbed by the emissions of 1 ton of a particular GHG over a given period of time, compared with the emissions of 1 ton of CO_2. The higher the GWP is, the more given gas warms the earth atmosphere compared with CO_2 over given time period. The time period usually used for GWPs is 100 years. Table 5.6 enlists the GWPs of chemically reactive GHGs.

Table 1. Chemically reactive greenhouse gases and their precursors: abundances, budgets, lifetimes, trends, and global warming potentials (GWPs) (Seinfeld and Pandis, 2006).

	Formula	Abundance ppt		Trend 1990s	Annual emission late 90s	Lifetime (year)	100-year GWP
		1998	1750				
Methane	CH_4 (ppb)	1745	700	7.0	600 Tg	8.4/12	23
Nitrous oxide	N_2O (ppb)	314	270	0.8	16.4 TgN	120/114	296
Perfluoromethane	CF_4	80	40	1.0	~15 Gg	>50,000	5700
Perfluoroethane	C_2F_6	3.0	0	0.08	~2 Gg	10,000	11,900
Sulfur hexafluoride	SF_6	4.2	0	0.24	~6 Gg	3200	22,200
HFC-23	CHF_3	14	0	0.55	~7 Gg	260	12,000
HFC-134a	CF_3CH_2F	7.5	0	2.0	~25 Gg	13.8	1300
HFC-152a	CH_3CHF_2	0.5	0	0.1	~4 Gg	1.40	120

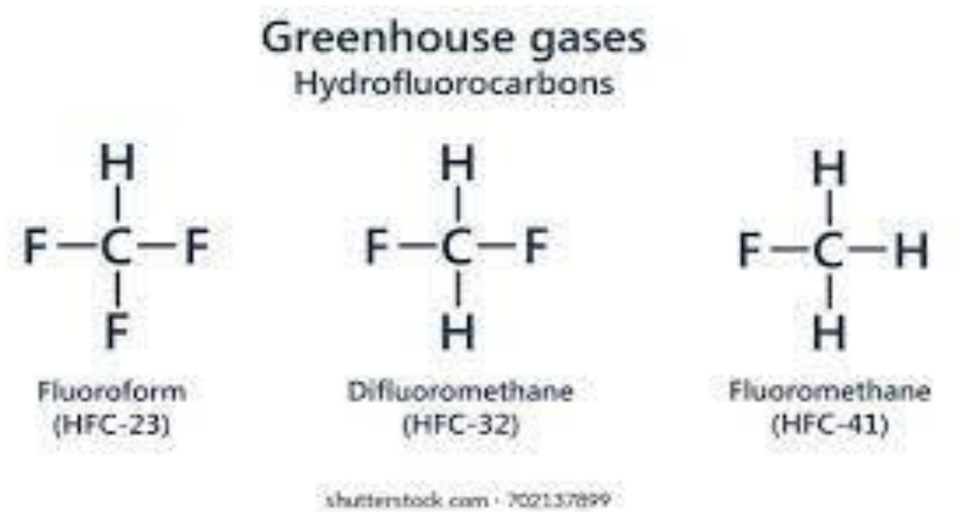

Figure 1:some green house gases

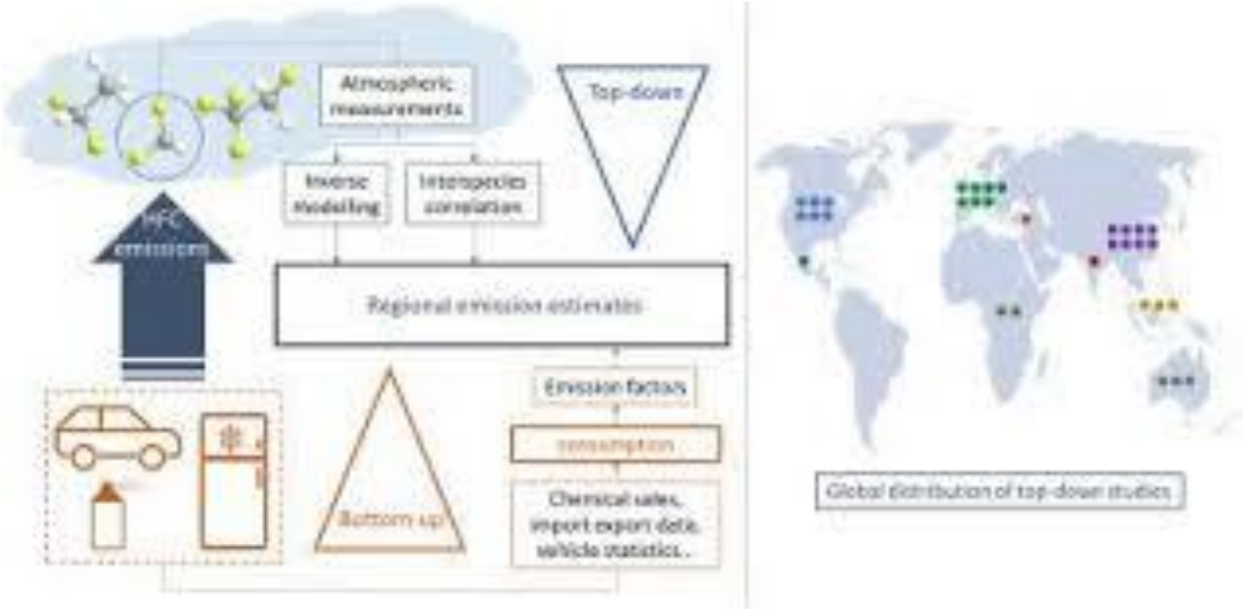

Figure 2:Regulation of Green emission of Hydrofluorocarbons

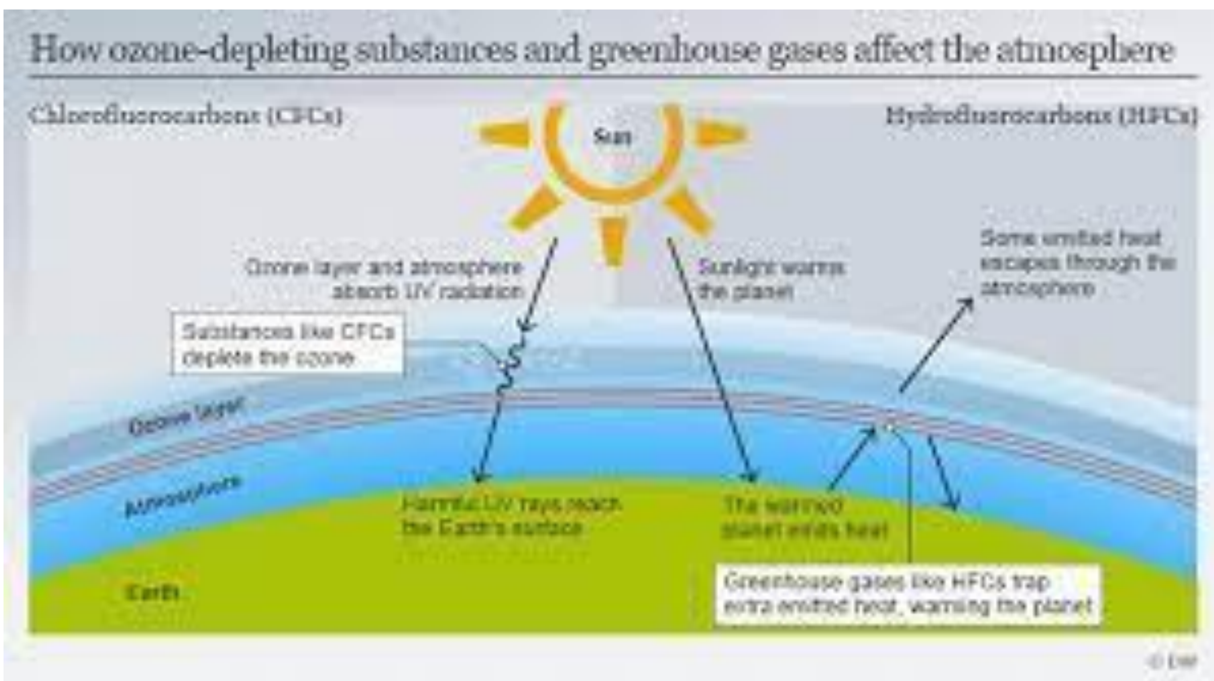

Figure 3: How ozone depleting substances and green house gases affect the atmosphere

CONCLUSION;

Green procurement involves purchasing green product types covered by mandatory and non-mandatory environmental programs. Hydrofluorocarbons (HFCs) are potent greenhouse gases (GHGs). To reduce their effects is by phasing down their production and consumption, maximizing reclamation and minimizing releases from equipment, and facilitating the transition to next-generation technologies through sector-based restrictions on HFCs.

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