ARTICLE

Dual Anthropogenic Origin of Global Warming through GHGs and IR Radiation Emissions from Artificialized Soils

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1. Introduction

The responsibility for human activities is unequivocal in greenhouse gas emissions and the artificialization of soils. These, mainly due to the construction of roads, pavements, buildings, etc., have serious consequences for the environment [1,2]:
- Decrease in areas constituting carbon sinks.
- Modification of the albedo and therefore the perception of incident solar radiation: the first is reduced and therefore the second is increased in far infrared radiation emissions from artificial surfaces.

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Table 1. Coefficient of albedo according to the nature of the surface

<table>
<thead>
<tr>
<th>Surface</th>
<th>Albedo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh asphalt</td>
<td>0.04</td>
</tr>
<tr>
<td>Wom asphalt</td>
<td>0.12</td>
</tr>
<tr>
<td>Forest</td>
<td>0.15</td>
</tr>
<tr>
<td>Bare soil</td>
<td>0.17</td>
</tr>
<tr>
<td>Desert sand</td>
<td>0.40</td>
</tr>
<tr>
<td>New concrete</td>
<td>0.55</td>
</tr>
<tr>
<td>Ocean ice</td>
<td>0.60</td>
</tr>
<tr>
<td>Fresh snow</td>
<td>0.80</td>
</tr>
</tbody>
</table>
soils has an issue that must be well understood in order to limit the earth's greenhouse effect and therefore global warming. To do this, it is useful to make the analogy between the greenhouse effect in a solar collector and the terrestrial greenhouse effect.

2. Methodology for Characterizing the Greenhouse Effect

2.1 Greenhouse Effect Used in a Solar Collector

For those experienced in the field of solar energy [2], the greenhouse effect has always been used to allow solar collectors (water or air) to heat well. Indeed the collector without glazing does not heat too much, it may be used for low temperatures. The glass sensor (single or double) allows higher temperatures to be reached. The secret lies in the selectivity of the glazing which allows solar radiation to pass, the spectrum of which ranges from ultra-violet to near infrared \([0.25 - 2.5 \mu m]\), and on the other hand is opposed to infrared radiation. Far wavelength that exceeds \([4.1 - 41 \mu m]\), emitted by the dark surface of the absorber.

![Figure 1](image1.png)

**Figure 1.** Construction of a double-glazed solar collector. Creation of the greenhouse effect.

Figure 2, the Black-body emission curves from the sun \((T = 5780 \text{ K})\) and the earth \((T= 290 \text{ K})\), shows the operation of Wien’s Law. The two graphs are not to scale.

Indeed for the sun at 6000K, the corresponding average wavelength \(\lambda_{\text{mean}}\) is given by:

\[
\lambda_{\text{mean}} = \frac{2898}{T} \text{ }= 0.5 \text{ } \mu m
\]

And the spectrum spreads to

\(0.5. \lambda_{\text{mean}} \text{ at } 5. \lambda_{\text{mean}}\)

Or to say: \([0.25 - 2.5 \mu m]\),

For the radiation emitted by the absorber assumed to be at 80 °C for example on average,

\[\lambda_{\text{mean}} = 8.2 \mu m\]

And the spectrum spreads to \(0.5. \lambda_{\text{mean}} \text{ to } 5. \lambda_{\text{mean}}, \text{ that is to say: } [4.1 - 41 \mu m]\),

2.2 Terrestrial Greenhouse Effect

The terrestrial greenhouse effect is necessary for life on earth, however it is increased as a result of global anthropogenic emissions. These emissions concern not only GHGs but also infrared radiation emitted by artificial surfaces [4-14]. This contributes to global warming, further accentuated by the heat released by the combustion of fossil fuels, which moreover generate the greatest amount of greenhouse gases.

![Figure 2](image2.png)

**Figure 2.** Solar and terrestrial radiative spectrum [3].

2.2.1 Greenhouse Gases

There are many greenhouse gases, more than forty have been identified by the Intergovernmental Panel on Climate Change (IPCC), including

- water vapor \((H_2O)\),
- carbon dioxide \((CO_2)\),
- methane \((CH_4)\),
- ozone \((O_3)\),
- nitrous oxide \((N_2O)\),
- hydrofluorocarbons \((HFCs)\),
- perfluorocarbons \((PFCs)\),
- sulfur hexafluoride \((SF6)\).

The proportions of anthropogenic greenhouse gases emitted by human activities are as Table 2.

<table>
<thead>
<tr>
<th>Gaz</th>
<th>Origin</th>
<th>Proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon dioxide ((CO2))</td>
<td>• Combustion of fossil fuels (petroleum, coal), • Combustion of biomass.</td>
<td>70 %</td>
</tr>
<tr>
<td>Nitrous oxide ((N2O))</td>
<td>• Agricultural activities, • Combustion of biomass and chemicals such as nitric acid</td>
<td>14 %</td>
</tr>
<tr>
<td>Méthane ((CH4))</td>
<td>• Agriculture (rice fields, livestock), • Production et distribution of gaz and oil, • Coal mining, • Combustion of petroleum and coal, • Landfills.</td>
<td>12 %</td>
</tr>
<tr>
<td>Fluorinated gases ((HFC, PFC, SF6))</td>
<td>• Refrigeration Systems, • Aerosols and insulating foams, • Semiconductors industry. Fluorinating gases have a heating power 1,300 to 24,000 times that of carbon dioxide and have a very long service life. This is why they represent a real danger despite the modest share they represent in total GHG emissions.</td>
<td>4 %</td>
</tr>
</tbody>
</table>
2.2.2 Contribution of Each Gas to the Greenhouse Effect

Different gases do not all contribute to the greenhouse effect at the same level. Indeed, some have a greater heating power than others and/or a longer lifespan. The contribution to the greenhouse effect of each gas is measured by the global warming potential (GWP).

The GWP is an indicator which groups together the added effects of the 6 gases contributing to the greenhouse effect which are currently taken into account by the Kyoto Protocol. It takes into account the radiative power returned by each gas to the ground (we speak of "radiative forcing"), accumulated over a period of 100 years.

This indicator is calculated using the respective GWP of the six gases considered. These GWPs are determined relative to that of CO₂, which is set at one [15].

### Table 3. Global warming potential for GHGs

<table>
<thead>
<tr>
<th>GHG</th>
<th>Relative GWP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon dioxide (CO₂)</td>
<td>1</td>
</tr>
<tr>
<td>Methane (CH₄)</td>
<td>21</td>
</tr>
<tr>
<td>Nitrous oxide (N₂O)</td>
<td>310</td>
</tr>
<tr>
<td>Perfluorocarbons (PFC)</td>
<td>6 500 at 9 200 (depending on the molecules considered)</td>
</tr>
<tr>
<td>Hydrofluorocarbons (HFC)</td>
<td>140 at 11 700</td>
</tr>
<tr>
<td>Sulfur hexafluoride (SF₆)</td>
<td>23 900</td>
</tr>
</tbody>
</table>

So,

- if we emit 1 kg of methane into the atmosphere, we will produce the same effect, over a century, as if we had emitted 21 kg of carbon dioxide;
- if we emit 1 kg of sulfur hexafluoride into the atmosphere, we will produce the same effect, over a century, as if we had emitted 23900 kg of carbon dioxide.

Not every gas contributes the same way to the GWP (global warming power or potential). In 2007, the contribution of GHGs to the PRG was established in metropolitan France as follows:

### Table 4. Contribution of GHGs to the PRG

<table>
<thead>
<tr>
<th>GHG</th>
<th>Contribution to GWP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon dioxide (CO₂)</td>
<td>69.5 %</td>
</tr>
<tr>
<td>Méthane (CH₄)</td>
<td>12.1 %</td>
</tr>
<tr>
<td>Nitrous oxide (N₂O)</td>
<td>14.8 %</td>
</tr>
<tr>
<td>Fluorinated gases (HFC, PFC, SF₆)</td>
<td>3.6 %</td>
</tr>
</tbody>
</table>

Source: CITEPA - Substances relatives à l'accroissement de l'effet de serre - Mai 2009.

In addition, greenhouse gas emissions are measured in carbon equivalent. The carbon equivalent of a gas is calculated from its GWP:

- by definition, 1 kg of CO₂ is equal to 0.2727 kg of carbon equivalent, ie the weight of carbon alone in the compound "carbon dioxide",
- for the other gases, the carbon equivalent is worth: relative GWP x 0.2727 (Table 5).

### Table 5. Carbon equivalent of GHGs

<table>
<thead>
<tr>
<th>GHGs</th>
<th>Carbon equivalent per kg emitted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon dioxide (CO₂)</td>
<td>0.273</td>
</tr>
<tr>
<td>Methane (CH₄)</td>
<td>5.73</td>
</tr>
<tr>
<td>Nitrous oxide (N₂O)</td>
<td>84.55</td>
</tr>
<tr>
<td>Perfluorocarbons (PFC)</td>
<td>1 772,73 à 2 372,73</td>
</tr>
<tr>
<td>Hydrofluorocarbons (HFC)</td>
<td>38.2 à 3 190.9</td>
</tr>
<tr>
<td>Sulfur Hexafluoride (SF₆)</td>
<td>6 518.2</td>
</tr>
</tbody>
</table>

Scientifically speaking, regarding global warming, we speak of the concept of radiative forcing, but commonly in public language of the greenhouse effect, which is half incorrect, because, during the day, an agricultural greenhouse heats up too much in the spring due to radiative forcing. In order to lower the temperature, it suffices to create a current of air when opening the doors.

The concentration of carbon dioxide affects the energy supply of the atmosphere; a first order approximation gives: The variation of the radiative forcing is:

\[
DF = 5.35 \times \ln \left( \frac{C}{C_0} \right)
\]

where \(C\) is the CO₂ concentration in parts per million by volume, ppm (v) or ppmv, and \(CO\) a reference concentration, for example, 280 ppm (v) for the CO₂ concentration at the threshold of the industrial age. DF is the change in radiative forcing in watts per square meter (Figure 3).

![Figure 3. Radiative forcing of climate between 1750 and 2005 [16]](image)

2.3 The Artificialization of Soils

This concerns roads, cities (building, urban expansion, etc.). Due to the fact that these soils can no longer absorb and store carbon dioxide, can no longer absorb rainwater, these soils will see:

- their reduced albedo (reflection coefficient of incident
sunlight) because their dark calor
- their increased absorption of solar radiation
- their increased infrared radiation emissions (this ra-
diation will be returned to the earth by the atmosphere,
all the more polluted causing greenhouse phenomenon by
radiative forcing, and inducing the global warming.

The "protective mantle" that is our atmosphere is
fragile: its way of filtering the sun's rays and conserving
the earth's heat totally depends on the gases therein. For
millions of years, it was essentially made of air (a mixture
of nitrogen, oxygen, etc.). But, by adding more and more
molecules, human beings have changed this balance enor-
mously over the past sixty years.

Among these molecules, those called "greenhouse
gases" are those which tend to heat the surface of the
Earth by modifying its atmosphere. Greenhouse gases
are molecules that absorb some of the infrared that the
Earth's surface emits \[17\]. They thus prevent this heat from
returning to space, as in a greenhouse which lets in the
heat of the sun, but keeps it behind its windows. The main
greenhouse gases are water vapor (H₂O), carbon dioxide
(CO₂), methane (CH₄), nitrous oxide (N₂O), ozone (O₃)
and several gases containing fluorine (such as CFCs and
sulfur hexafluoride SF₆). By disturbing our atmosphere,
these gases therefore cause overheating of the air and the
surface of the Earth, but also a whole procession of dis-
"turbances of the movements of air in the atmosphere. This
is called climate change. And it is high time to go back:
for now, the enormous amounts of greenhouse gases that
humans send into the atmosphere are partly "absorbed" by
the oceans, but they are on the verge of indigestion.

3. Results and Discussion by Recapitulating

Table 6 recapitulates the effects of the actions of the
man on the global warming and this by: 1) the gas emis-
sions for purpose of greenhouse, but also by 2) the atifi-
cialisation of the grounds which modify their albedo and
thus the absorption of the solar radiation and thus their
reheating and consequently their infrared emissions which
is a fundamental component with the GHGs to cause the
global warming. Finally one shows modification 3) due to
heat released by the combustion of any type of combust-
tible fossil or renewable \[18\]. Is it also allowed (finally?) to
evoke the absorptive heat of the solar radiation by all the
artificialized surfaces and become darker that what they
were naturally.

4. Conclusions

The global warming du to the greenhouse effect ca be
reduced by reducing the two factors that make it up ac-
cording to the scientific name: radiative imprisonement:
- For the factor: imprisonement, there is a need to re-
duce the greenhouse gas emissions; and thus is known and
evoked by all,

<table>
<thead>
<tr>
<th>Naturally</th>
<th>One century ago</th>
<th>Desired greenhouse effect for the life on the earth</th>
</tr>
</thead>
<tbody>
<tr>
<td>[Diagram] Clean atmosphere</td>
<td>Terrestrial infrared radiation at 15 °C</td>
<td></td>
</tr>
<tr>
<td>Humann Modification1</td>
<td>Effet of combustion product CO₂</td>
<td>Imbalance. Increase of the Green House Effect</td>
</tr>
<tr>
<td></td>
<td>GHGs 3.5.10² tCO₂e</td>
<td>Global warming</td>
</tr>
<tr>
<td></td>
<td>Infrared Radiation at 15 °C</td>
<td>2 to</td>
</tr>
<tr>
<td>Humann Modification2</td>
<td>Effect of the artificialisation of the floors</td>
<td>Imbalance. Increase of the Green House Effect</td>
</tr>
<tr>
<td></td>
<td>Infrared Radiation at 15 °C</td>
<td>Global Warming</td>
</tr>
<tr>
<td></td>
<td>Radiation from artificialized floors</td>
<td>at ? °C/centu</td>
</tr>
</tbody>
</table>
- For the factor: radiative, there is a need to reduce or at least limit the expansion of soil artificialisation which mainly concerns cities and roads, which absorb a lot of solar radiation during the day mainly because of their dark color, unlike bare soils.

References


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