Population Growth as a Biological Factor in Climate Change

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ABSTRACT

Climate change is a concept that is directly correlated with everyday life. Extreme weather events are occurring with greater intensity and frequency, most likely caused by an increase in the Earth's average temperature. Dozens of studies have been based on the anthropogenic contribution of the increase in greenhouse gases, which are identified as the main cause of global warming. But what is the contribution of the human species itself as a biological factor in this increase?.

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I. INTRODUCTION

A few years ago, in a BBC documentary for the bunkers of World War II in the English Channel, southeast England, a question was asked about the heating of the space and its source. Guide's answer was disarming, naming the only source of heat as the presence of thousands of people inside the bunker. Bunker's system is a small closed system in which, however, the biological presence of human had left its thermal footprint.

The purpose of this study is to prove the possible contribution of global population to a much larger closed system, that of earth's atmosphere, in temperature increase and in atmospheric composition.

1.1 Methodology

1.1.Human Body

Human body produces heat through metabolic activities. An average human body consumes 2000 Calories per day (1 Cal = 4,184 × 103 joules) which is equal to 8,37 × 106 Joules per day. Since most of this energy escapes body as heat, it implies that an average body emits 348.000 J/hr which is equal to ~100Watts [1] [2].

Therefore, the energy produced by a human in a year is:

$$8.37\times106 \times 365 \text{ days} = 3{,}055\times109 \text{ J/yr} \quad (1)$$

1.1.2 Conversion of Energy Into Temperature

To convert energy to temperature it is sufficient to divide it by the mass of the heating medium (atmospheric air in kg) and divide the result by the Cp of the air which is ~1006 J/kg oC.

Since 1kg of atmosphere requires 1006 J to rise T = 1 degree Celsius, the total mass of the atmosphere requires:

$$5{,}181\times1021 \text{ J to rise T} = 1 \text{ degree Celsius} \quad (2)$$

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The mass of atmosphere is:

$$\sim 5{,}15\times1018 \text{ kg} \tag{3}$$

(1),(2) result to the annual thermal footprint of a human body in Earth's atmosphere:

$$0{,}589\times10\text{-}12 \text{ degrees Celsius} \tag{4}$$

1.2 Worldpopulation growth

World population is increasing during last decades [5].

1960: 3,035×109

1970: 3,7×109

1980: 4,458×109

1990: 5.327×109

2000: 6,143×109

2010: 6,956×109

The population growth from 1960 to 2010 (fig.1) is:

$$3{,}921\times109 \text{ persons} \tag{5}$$

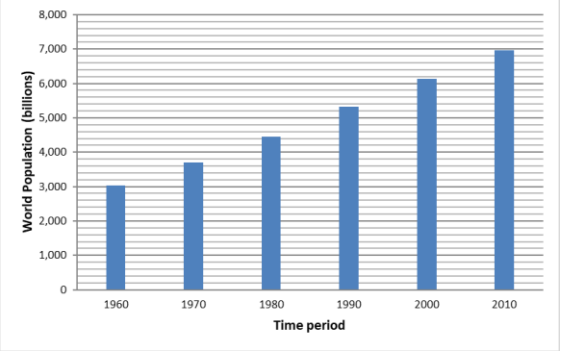

Fig. 1: Global population growth from 1960 2010.

1.3 Global Temperature Increase

Global temperature is increasing last decades with a temperature increase of ~0.65 degrees Celsius (1960: ~0.0 degrees Celsius, 2010: ~0.65 degrees Celsius (fig.2).

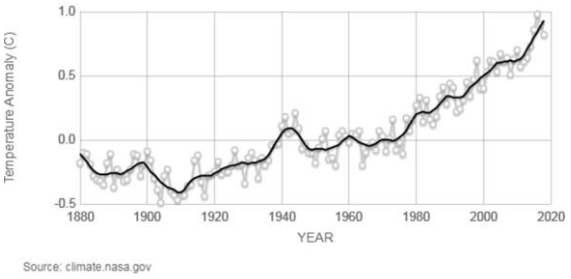

Fig. 2: Global temperature increase from 1890-2018.

Therefore from (1),(4),(5) we calculate the contribution of world population over a period of 50 years in temperature increase which is:

$$0{,}58\times10\text{-}1 \text{ degrees Celsius} \sim 0.06 \text{ degrees Celsius} \quad (6)$$

This value constitutes a minimum ~9% of the total temperature increase during period 1950-2010 and by reduction to actual daily action conditions [6] (~170Watts), this contribution reaches a ~15%

1.4 Atmosphere

Human body consumes and produces several gases.

1.4.1 O2

The average human breath is ~7,5lt air/min [3] resulting to:

$$3{,}942\times106 \text{ lt/yr} \quad (7)$$

21% of this volume is O2 resulting to:

$$0{,}828\times106 \text{ lt/yr} \quad (8)$$

During a breath 3-6% of O2 is retained -we assume an average of around 4% (9)

(7),(9) result to the volume of O2 removed from atmosphere by the respiratory system of an average human:

$$0{,}033\times106 \text{ lt/yr} \quad (10)$$

Therefore from (5),(10) we calculate the volume of O2 removed from atmosphere by the respiratory system of population growth over 50 years:

$$3{,}24\times1015 \text{ lt} \quad (11)$$

$$\text{One lt of O2 weights } 1{,}43\times10\text{-}3 \text{ Kg} \quad (12)$$

(11), (12) result to the mass of O2 removed from atmosphere by the respiratory system of population growth over 50 years:

$$4{,}64\times1012 \text{ kg} \quad (13)$$

According to measurements [7], the natural decrease in O2 is 4ppm per year (Fig.3) which results to:

$$5{,}64\times10\text{-}9 \text{ kg/l} \quad (14)$$

(13), (14) result to the mass of O2 removed from atmosphere due to natural reasons over 50 years:

$$1{,}452 \text{ x}1015 \text{ kg} \tag{15}$$

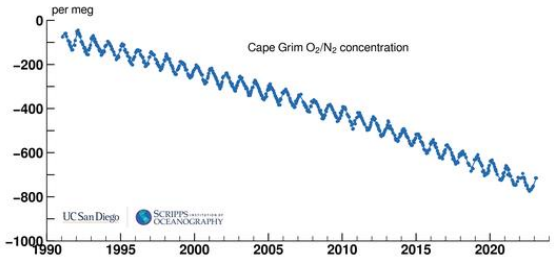

Fig.3: O2 decrease from 1990-2023

1.4.3 CH4

An average human produces about 0,35lt/day [4] which results to:

$$127{,}75\text{lt/yr} \tag{16}$$

(5), (16) result to the volume of CH4 produced by the population growth over 50 years:

$$250{,}4\times109 \text{ lt} \tag{17}$$

$$\text{One lt of CH4 weighs } 0{,}6682\times10\text{-}3 \text{ Kg} \tag{18}$$

(17), (18) result to the mass of CH4 produced by the population growth over 50 years:

$$0{,}167\times109 \text{ kg} \tag{19}$$

Cows produce about 250-500lt/day (average=325lt) resulting to:

$$0{,}118\text{x}106 \text{ lt/yr} \tag{20}$$

The population of cows is

$$1{,}5\times 109 \tag{21}$$

(18),(20),(21) result to the mass of CH4 produced by the cow population over 50 years:

$$0{,}119\times1015 \text{ kg} \tag{22}$$

1.4.4 Atmospheric pressure and sea level

Average Pressure is 1013.25hPa and it is correlated to the mass of atmosphere (5,15 × 1018 kg).

Human respiratory system has removed mass of O2 affecting MSL pressure in an order of 0.9x10-3 hPa over the last 50 years while natural O2 decrease has affected MSL pressure in an order of 0.28hPa.

Human digestive system has produced mass of CH4 affecting MSL pressure in an order of 0,033x10-6 hPa over the last 50 years while CH4 increase due to cow population has affected MSL pressure in an order of 0.023hPa.

In total the change in MSL pressure is ~0.258hPa (23)

1hPa atmospheric change = 10mm of sea level change

II. RESULTS

The contribution of world population in temperature increase is ~+0.06-0.150C and to the composition of atmosphere due to human respiration is -4.64×1012Kg of O2 and +16.73×106 Kg of CH4 (50 years period) (Table 1).

Table 1: Results

	Heat (°C)	O^2 (Kg)	CH_4 (Kg)
Human	+0.06-0.12	$-4.64x10^{12}$	$+0.167x10^{9}$
Total	+0.65	$-1.452,5\ x10^{12}$	$+118,8 \times 10^{12}$

III. CONCLUSIONS

The study results to a strong contribution of world population to temperature increase (9-15% of the total temperature increase during the period 1960-2010) while the contribution in O2 declination is very small (0.3% of current declination), and in CH4 increase is negligible (comparing to current increase).

Further work is needed to investigate the contribution of O2 and CH4 in changes of mean atmospheric pressure and mean sea level.

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