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TMJ Blogs

CO_2 emissions by humans caused by breathing

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Atmospheric CO_2 concentration is measured in parts per million, total tonnage and "emissions". There is a naural carbon cycle because plants can remove CO_2 by photosynthesis. It is suggested that in a "natural" world this cycle would be in equilibrium and that increasing CO_2 concentrations are due directly or indirectly to human activity, either by increasing CO_2 production (burning fossil fuels etc) or decreasing CO_2 adsorption (by deforestation), of which the former is the greater factor. However, this means that all sources of CO_2 emissions need to be measured, and it is to be expected that the direct and indirect effects of human activity will augment climate damage as the global population increases. I ask here a simple but infrequently asked question: What is the contribution to global carbon dioxide emissions from humans breathing? This is important because it is not alterable *per capita* but will increase as populations grow.

Humans obtain oxygen from the air by breathing and use it as their source of energy via metabolism (that is, burning) of glucose. The products of combustion, as in a fire, are water and carbon dioxide. The CO_2 is exhaled. The chemical equation using glucose as the source of energy is

$C_6H_{12}O_6 + 6O_2$ è $6H_2O + 6CO_2$

The equation shows that, when glucose is the fuel, the volume of CO_2 produced is equal to the quantity of O_2 consumed. During photosynthesis the arrow in the chemical equation points to the left.

The calculation proceeds via several stages:

1. Calculation of the oxygen consumed per person per year, in litres. I will assume that using physiological data at low to moderate exercise levels will be satisfactory, accounting for daily activity in the half of the world seeing daylight.
2. Convert that to the equal amount of CO_2 and convert again to molar units using the gas equation of state PV = nRT (rearranged to n = PV/RT, where n is the number of (chemical) moles in the system), then to mass units (g) by n × CO_2 molecular weight (44). Then convert from grams to metric tonnes.
3. Multiply that by the current world population (approximately 7.9 bn)
4. Express the total CO_2 exhaled by humans as a percentage of the global CO_2 emissions.

The tidal volume at rest is 500 ml (males) and 400 ml (females) and I have used 450 ml (0.45 L) in the calculation. The minute volume at 18 breaths per minute is thus 8.1 L. This contains 1.701 L of O_2, as the proportion of air in the atmosphere at sea level is 21%. Expired air contains 16% O_2 (1.296 L/min) and the volume of O_2 absorbed per minute is the difference (0.41 L). These gas volumes are at normal (sea-level) temparatures and pressures.

Oxygen consumption per person per year = 0.41 × 60 × 24 × 365 L = 212868 L = 212.9 m^3. This is also the volume of CO_2 emitted by humans due to breathing. This volume is converted to moles (n) using the gas laws in which n = PV/RT. In this equation, P is in Pascals which for 1 atmosphere is 101325, V is in cubic metres, R is the gas constant (8.314 per $m^3.Pa.K^{-1}.mol^{-1}$) and T is in degrees Kelvin. At an ambient temperature of 15°C, T = 288K).

Thus the number of moles of CO_2 emitted per person per year is

$$n = \frac{101325 \times 212.8}{8.314 \times 288} = 9005 \text{ moles of } CO_2$$

CO_2 has a molecular weight of 44 and therefore weighs 44 g/mole. Thus the mass of CO_2 produced per year by 1 person breathing at just over resting level is 44 × 9005 = 396220 g = 396.2 Kg = 0.396 metric tons. The global population is currently approximately 7.905 billion. The global mass of CO_2 produced by human exhalation is therefore 7.905 × 0.396 = 3.13 bn metric tonnes.

CO_2 emissions value before the COVID-19 pandemic (2019) was 36.7bn metric tons (it fell to 34.8 bn in 2020). Therefore humans account for 8.5% (3.13/36.7) of the total global emissions just by breathing. This is an inevitable fact of human existence at the current population and in our current state of nature and industry. During the pandemic in 2020, as total emissions declined to 34.8 bn tonnes, the percentage increased to about 9%.

The global population continues to rise, and with that the quantity of exhaled CO_2 will also rise. There is also a strong multplier effect caused by other actions by individuals such as driving, cooking and power consumption, as well as the support from polluting industries such as mining, fishing, farming, aviation and deforestation. It is therefore reasonable to conclude that IF "climate change" and "global warming" are real and require mitigation, one factor that deserves intervention is overpopulation.

I have not attempted to calculate the contribution to emissions from respiring animals and marine life. This is likely to be substantial.

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