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Towards Sustainable Cities trough a Decrease in CO_2 Emissions Based on Creating Consciousness on Human Habits and Its Relations to Body CO_2 Emissions and Associated Impacts

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Abstract

When people see themselves as producers of CO_2 emissions coming from their metabolic activities and are aware that through simple good practices and habits, those emissions could diminish, there is going to be a real lowering of them. We believe that many social mechanisms are going to be triggered if people develop good and conscious practices in the following major aspects: listening; feeling; good communications; writing and reading, gentle exercise; appreciation and recognition of people, of self and nature; slow and conscious eating; meditation; chanting; conversation, friendship and sharing. All these habits will help regulate metabolic oxygen use, decrease human body CO_2 emissions, diminish food use and help avoiding waste. If these changes occur synchronized with conscious behavior and high quality attention, the effect is going to be permanent and is going to be associated with states of happiness, personal and group pride and satisfaction management.

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Introduction

CO_2 and breathing

Human respiration implies the insertion of air into the lungs with volumes that oscillate between 500 ml during low breathing rate to around 4000 ml during maximum breathing rate and at frequencies associated with the type of activities that occurs. With this, there is an exchange of gases between the external and the internal environment (Frydrysiak) [1]. This includes the movement of air between the inside and outside of the lungs; the exchange of gases with the pulmonary blood; the transport through the bloodstream to the cells and their subsequent diffusion across cell membranes. These steps allow the consumption of O_2 and release CO_2 in the cells. The cellular respiration is the oxidative metabolism, based on the oxidation of nutrients necessary for the generation of metabolic energy. Naturally, besides the respiratory system, the cardiovascular system, blood circulation and the neural apparatus that regulate functions are essential aspects of energy metabolism. In addition to gas exchange, the respiratory system develops other functions, such as the pulmonary capillary bed acting as a filter for blood, so that small clots, debris or air bubbles are eliminated. The airways are designed to prevent the entry of pathogens into the body; the breathing participate in homeostatic mechanisms such as temperature control, control of bodily fluids and acid-base control.

All this functions and relationships mean that breathing is a powerful indicator of metabolism. Table 1 (adapted from Noriega) [2] shows the typical gas exchanges that occur in the breathing system. Based onthis typical values, the estimated CO_2 flow is 0.035 kg/hr (0.84 kg/day).

CO_2, food usage and metabolism

The CO_2 flow, of course, is associated to food consumption. Table 2, (adapted from Merrill) [3] and [4], estimates CO_2 flows departing from energy and mass associated to typical daily food consumptions in terms of proteins, fat and carbohydrates from animal and vegetable origin These were estimated averaging seven daily nutrient intakes (Merril) [3] and their energy and mass correlates.The estimated average CO_2 generated (0.85 kg/day) is quite close to the value gotten from the respiration gases analysis of Table 1 (0.84 kg/day).

Parameter	units	Inspired air	Expulsed air
O_2	% vol	20.93	15.26
CO_2	% vol	0.04	3.42
N_2	% vol	78.53	75.13
H_2O	% vol	0.50	6.19
Breathing rate	times/min	15.0	15.0
Temperature	°C	21.0	36.0
Gas density at 1 atm	kg/m^3	1.193	1.125
Volume in each breathing	m^3	0.00060	0.00066
Mass flow	kg/hr	0.644	0.667
O_2 flow	kg/hr	0.15	0.11
CO_2 flow	kg/hr	0.00039	0.03519
N_2 flow	kg/hr	0.49	0.49
H_2O flow	kg/hr	0.0020	0.0261

Table1: Gas exchanges in the breathing system.

Energy usages have special behaviors. In a particular study of 15 various physical activities of 275 subjects (Seliger) [5], it was found that energy expenditures did not correlate well with the intensity of the motional activity, which suggests that there are more complex physiological and mental influences at work besides observed motion. Illness, previously consumed food and beverages, environmental temperature, and stress levels can affect energy expenditure (Durnin) [6]. Also, the same type of activity may be associated with wide variations in the metabolic response.

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Parameter	units	
Protein mass use	gr	115
Fat mass use	gr	94
Carbohydrate mass use	gr	299
Total mass use	gr	509
Gross energy in food used	Kcal/kg	2772
Protein	%	22.61
Fat	%	18.51
Carbohydrate	%	58.88
Energy in Protein, effective	kcal/kg	4052
Energy in Fat, effective	kcal/kg	8930
Energy in Carbohydrate, effective	kcal/kg	4030
Total energy, effective	kcal/kg	4942
Efective daily energy	kcal/day	2513
Effective energy/gross energy		0.91
Estimated carbon in Protein	% C	54.9
Estimated carbon in Fat	% C	78.0
Estimated carbon in carbohydrate	% C	40.0
Carbon available in food	kg/day	0.26
Carbon digested	kg/day	0.23
CO_2 generated by digested food	kg/day	0.85
CO_2 generated	Kg/kg food	1.68
CO_2 generated	Kg/Kcal gross	0.00031

Table 2: Typical mass and energy associated to daily food consumption

Oxygen usage, taken from Table 1 is 0.86 kg/day, quite similar to CO_2 generation. Of this, 0.62 kg/day are used for carbon oxidation and the rest, for hydrogen oxidation of food. The CO_2 generated instantaneously will depend on the type of activity, as each type consumes different amounts of energy. Table 3 presents typical values [4], (Deakin University) [7], (FAO) [8] for a wide set of activities.

One important activity is the basal one. Basal Metabolic Rate (BMR), the minimal rate of energy expenditure compatible with life (Durmin) [6], which depends on age, sex, height and weight and is associated with fundamental organs of the body. See Table 4. Note in it, the importance of the brain and the liver, accounting for almost half of the BMR.

Organ	%
Liver	27
Brain	19
Skeletal Muscle	18
Kidneys	10
Heart	7
Other Organs	19
Total	100

Table 4: Energy expenditure breakdown at BMR.

Activity	Energy, kcal/h	food, kg/ day	CO_2, kg/day
BMR, Basal metabolic rate, woman, 30 years age, 160 cm height, 60 kg weight	54	0.24	0.40
BMR, Basal metabolic rate, man, 30 years age, 170 cm height, 70 kg weight	67	0.30	0.49
Sleeping	67	0.30	0.49
Lying still, awake	77	0.34	0.57
Light leisure activities	94	0.41	0.69
Eating	101	0.44	0.74
Sitting work	101	0.44	0.74
Sedentary or light activity lifestyle, daily average	103	0.45	0.76
Active or moderately active lifestyle, daily average	118	0.52	0.87
Driving car to/from work	134	0.59	0.99
Typingrapidly	140	0.62	1.03
Cooking	141	0.62	1.04
Dressing or undressing	150	0.66	1.11
Vigorous or vigorously active lifestyle, daily average	151	0.66	1.11
Personal care (dressing, showering)	154	0.68	1.14
General household work	188	0.83	1.38
Walking on level at 4.8 km per hour	200	0.88	1.48
Walking at varying paces without a load	214	0.94	1.58
Walking up 8% gradient at 4.8 km/hr	357	1.57	2.63
Sawing Wood	480	2.11	3.54
Jogging at 9 km per hour	570	2.51	4.21
Cycling on level at 9 km per hour	804	3.54	5.93
Rowing at 20 strokes per minute	828	3.65	6.11
Exercise , 5 min. and more, low values	336	1.48	2.48
Exercise , 5 min. and more, high values	1092	4.81	8.06
Exercise, 1-3 min, low values	462	2.03	3.41
Exercise , 1-3 min, high values	1890	8.32	13.95
Exercise , 1-30 sec, low values	2856	12.58	21.07
Exercise , 1-30 sec, high values	7350	32.36	54.24

Table 3: Metabolic and CO_2 data for several activities.

Global impact of metabolic CO_2

Using the average value for CO_2 generation, the existing world population of some 7.311 million people, Table 5 presents an estimate of the global impact of human metabolism CO_2 emissions. It is clearly a large impact, as seen from its equivalent in necessary coal combustion to generate CO_2 associated with average metabolism.

In this sense, human beings in their metabolism are real representations of all the processes in life that employ carbon,

Parameter	Units	Value
Estimatedworldpopulation (2015)	Persons	7 311 390 000
Average CO_2 generation by metabolism	Kg/day-person	0.85
Total CO_2 generation by metabolism	Ton/day	6231414
Approximate CO_2 generated in coal combustion	kg/kg coal	2.20
Equivalent coal combustion to generate CO_2 associated with average metabolism	Ton/day	2 832 461
Coal use in the world	Ton/day	21 430 137

Table 5: Global impact of metabolic human CO_2

with oxygen, to generate CO_2, the more important global warming gas. Now, it can be said, that, differently to CO_2 emissions from coal (and from other fossil fuels) combustion, metabolic CO_2 is part of a renewable cycle. This is because food comes from plants trough photosynthesis CO_2 consuming processes, which close the cycle and so, do not contribute to global warming.

However, it is not that simple. Food consumption is related to a huge set of operations, which contribute enormously to CO_2 generation, to pollution, waste and to non-renewable resources use. Any lowering of the CO_2 human metabolic emissions will have a significant impact on global warming gases control. We postulate that will be very educative that human beings have, as much as possible, awareness of themselves as direct sources of CO_2. Human activities are interrelated, in such a way that any one activity, not matter how small, has to do with all other activities and it will be highly educative that human beings discover connections between their action and all activities.

Methods

Relaxed and emphatic states, oxygen use and CO_2 generation

Data shows that certain habits tend to increase CO_2 specific emissions, while other ones tend to lower them. Meditative states generate special metabolic patterns (Farrel) [9], (Ding) [10]. In those, catecholamine levels drop, galvanic skin resistance increases, respiration rate and volume flow decrease significantly without significant change in arterial partial pressures for O_2 and CO_2; there is also decreased vascular resistance, lowered oxygen and CO2 consumption, and a decline in blood lactate. The person stays vigilant, but the body goes into a state of muscle relaxation. This state, which has been called the relaxation response, in addition to having important influences on physical health, is the initial step defining the physiology of most forms of prayer, contemplation, and meditation across cultures (Wallace) [11].

There is also an especial behavioral state, of empathic nature, which we will call **object experimentation**. In this state, the person acts as an observer that is able to experiment and feel the situation that is being experimented by another object, (which can be another person or being; a thing; an idea; a situation). The observing person puts her attention on the other being, forgets about herself, entertain herself in any detail that observes in the object and feels how is to be identical to the observed object.

When this is done, intentionally for a short time, the person notes a change in her respiratory pattern, which becomes slower, more abdominal in nature, controlled by the diaphragm and more tranquil and deep. At some point in the process, the observing subject experiments a kind of motion that puts her inside the space occupied by the object.

But not only this, she feels different, close, identified with the object, capable on putting herself in a new perspective, more equilibrate and, in many ways, wiser. She experiences empathy, the psychological identification with the feelings, thoughts, or attitudes of others. It is interesting to note that experiencing empathy, not only with persons, but also with things, beings and ideas, is associated with lower oxygen consumption rates and, consequently, with lower metabolic energies and CO_2 generation.

Habits, good practices and consciousness

The relaxation and empathic practices form the basis for establishing new practices and habits and to develop awareness towards nature and conservation, especially when the other one, the thing being observed, the object of experimentation is nature, in the many ways it presents itself to the dedicated and conscious observer.

There was a great North American writer who gave rise to the idea that consciousness could be connected to nature: Henry David Thoreau. It began for him as a personal experiment. During two years, from 1845 to 1847, he lived deliberately, by his own means, in a natural zone, and that inspired him to write its classical poetic work, Walden, in 1854. Observation inspired him to write.

Nature writing is one of the major innovations of American literature, which also includes Rachel Carson, the initiator of modern environmental awareness. Other significant figure is Ansel Adams, the American photographer and environmentalist, well known for his beautiful photographs of the American West and Yosemite National Park.

It is amazing how much the environmental movement owns to them and, at the same time, how little their subtle methods for consciousness development though empathic practices are employed. As Edward Wilson [12] says: "Henry David Thoreau was thought by many in his own time, and many in our own, to be an eccentric who escaped from the mainstream of real life in order to dream. He was the opposite of that. He understood intuitively what we now know in more concrete and objective terms, that humanity is a biological species and thus exquisitely adapted to the natural world that cradled us. Thoreau was the scientific observer and lyrical expositor who hit upon the power of this conjunction between science and the humanities".

We propose that empathic practices will facilitate the opening of new spaces for changing viewpoints and for expressing new belief systems. Trough conversation, leadership, sharing, writing and activism, these experiences will be more relevant when shared in human groups, the learning process and the viewpoint changes being highly exponential in this group environment. This applies not only to others, but also to persons teaching and conducting human groups.

The fact is that human beings are the product of thousands of years of evolution that have allowed them to possess a very powerful tool, which is the nervous system, and that is what allows people to experience empathic practices and turn them into conscious behavior and good habits. Researchers of human behavior such as Gregory Bateson and Carl Rogers posit that there are important mechanisms

of positive feedback, which allow for harmonious habits in people and organizations. Bateson brought to light that the desirable change should not only refer to our actions, but most of all, to our thoughts. He called this "ecology of mind". We could call it ***empathic object experimentation*** applied to ideas.

Rogers is the father of the so-called humanistic school, which developed the concept of empathy when working with people, assuming the position of the other as a working method to achieve good human relationships. Humanistic psychology emphasizes nonverbal experience and exploration of all the states of consciousness as a means to realize the full human potential.

Good habits and practices are developed especially when people observe empathically their own levels of consciousness, "respiring" them, inspired by empathic closeness to nature. This is a transformation of their present ways of interpreting and experiencing nature, which will help in the attainment of sustainable cities. These new viewpoints require a more complete and integral use of the entire nervous system, which will be able to integrate two necessary aspects: objective observation and poetic like empathic and subjective approximations (Posada) [13,14]. This process will not only establish states that consume less oxygen and generate less CO2 but that will enliven life. Table 6 compares the logical and the emphatic estates for an ample range of human functioning aspects. It is proposed that both ways are to be considered and integrated.

Aspect	Logical	Empathic
Dominion	Mind - The conscious	Body - The unconscious
Perception	Thoughts - Sensations	Feelings – Intuition
Memory	Words - Numbers - Parts - Names	Images - Faces – Patterns- Global
Expression	Verbal – Oral – Counting - Writing	Nonverbal – Gesture - Drawing- Pothooks
Thought	Analytical - Linear - Logical - Rational Sequential - Convergent	Visionary - Spatial - Analogical – Creative - Simultaneous - Divergent
Action	Probing - Executing	Visualizing - Projecting
Organization	Norms – Capital - Resources	Vision - Values - Motivation
Definition	White and black – Sure - Assertive – Clear - Direct	Grayish colored- With alternatives - Suggestive and integrative – Indirect

Table 6: Two major aspects for enriching life and reaching good practices.

Results

Sustainable cities should stimulate good habits that have impact

Now we propose several habits that could be enhanced socially and that are associated with states that generate, as such, lower metabolic CO2 emissions, either because they are closer to the basal metabolic rates or because they include emphatic or relaxation practices. For each one we give indications of ways in which those habits would have much deeper implications on CO_2 emissions lowering than the habit itself.

With the use of monitoring equipment to measure CO_2 concentration in expired air and respiration cycles, it is possible to provide real data to establish feedback loops between empathic practices, consciousness and lowering CO_2 metabolic emissions.

Listeningto others with attention, especially with empathic attention that pays recognition and appreciation to the other one, not matter what ideas, personal stories, social or economic status the other person has, is a good habit of enormous impacts that have not been explored as much as desired in the practice of human communications or relationships. The usual habit is to judge the other person with hardness and defensive attitudes, to label her with disqualifying names or attributes, to be ready to discuss or contradict her ideas, to be uncompromising, distrustful and unbelieving; all of those are states which demand exited metabolic functioning and excess CO_2 generation. Attentive listening facilitates social encounters, is conductive to learning, to induce compassion and focused attention. It facilitates group work, which will generate creativity and projects oriented towards the environment. We propose this practice, in groups, to originate ideas and designs for the projects a sustainable city requires. We propose to create abundant spaces for group work, conversations and nature contemplation. When listening is extended to nature, this practice calms the mind and induces relaxation states.

Meditation and relaxation practices especially when practiced in group, are positive in all aspects of group and personal human behaviour and have large impacts, even when practiced by a minority of the population. We propose that these practices be taught and encouraged in the educational system and that institutions and companies facilitate spaces and times for the regular practice of their employees and associates.

Conversation and sharing, which includes the idea of friendship, family life, small communities, communal activities, open possibilities to be optimistic and joyful, to develop projects with large beneficial, ecological and social impact. Conversation enriched by empathic attitudes, create high quality attention and peaceful environments. The extreme opposite to this, war, is always associated with major environmental disasters and violence, high generators of excited metabolic states and CO_2 emissions. Sustainable cities must be pleasant and peaceful. An especial situation is the one that occurs with major catastrophes, a constant menace for cities, which in general have negative and unpredictable impacts on the environment. Establishing coherent sharing and communal attitudes is a must for a sustainable city to be able to handle these situations.

Conscious writing, representing, art work and reading will create self-esteem, self-reference, leadership and a sense of compromise. With this we refer to the creation of city narratives and memories that enhance healthy pride, participation and projects that permit establishing personal and group goals and sharing and stimulation of values. We do not refer here to the idea of attaining fame or glory with elite sports or the professional cultivation of the arts (also important, but in general limited to a selected minority). What we propose is a generalized stimulation of good cultural habits that all sustainable citizens can enjoy and practice.

The habit of **understanding activities in term of their impact on CO_2 generation** and having them in the collective and individual mind as indicators of commitment with sustainability is very good practice. A sustainable city should establish indicators and goals that citizens could understand and help attaining. If people were able to connect the indicators with their habits, they could do something real about that, in comparison to simply seeing the problems as something they cannot confront and, much less, help solving.

With some examples, this idea can be better understood, as shown in Table 7.

Activity	CO2 generator indicator	Sustainable actions
Transportation and driving	CO_2 generated according to driving practices, number of occupants and type of vehicle	- Conscious driving -Ridesharing - Use of masstransport -Establish city indicators of total daily CO_2 generated by transportation
Usingelectricity	CO_2 generated according to origin of used electricity and type of urban practices	- Electricity saving - Communal and individual projects to generate electricity with renewable sources
Solid waste generating and disposal	CO_2 and CH_4 generated according to waste disposal methods being used and scale of recycling and reuse	- Recycling - Less generation of waste - Individual and communal projects to recycle and reuse
Industrial and commercial emissions	Regional and urban indicators of specific emissions according to major processes and activities	- Companies calculate their contribution to the indicators and establish goal to improve - Citizens know this and contribute to improvements trough vigilance and participation

Table 7: Example of areas that can be object of establishing CO_2 indicators.

Improving on food consumption habits is an area of opportunity. Eating meat is a very important CO_2 generator. In an analysis of the EU-27 countries, (Schwarzera) [15], beef had the highest GHG (global greenhouse gases) with 22.6 kg CO_2-eq/kg. The consumption of beef meat is increasing at higher rates than the population.

A good habit is to include more protein sources in the diet coming from vegetables or from other meats, so that beef meat is combined with them. On the other hand, the simplest and most cost-effective way to reduce CO_2 food footprint is to minimize food waste. Although not all food waste is under the control of citizens, purchasing, cooking and eating habits can play a large part in reducing food losses. Food waste can generate significant amounts of methane through anaerobic decomposition. In a wet boreal/temperate climate zone, typical methane emissions are about 1.4 kg CO_2 per kg of wet food waste.

We propose the habit of eating slowly and in a conscious way as a very good practice with large implications on metabolism and CO_2 generation. Enjoying and distinguishing flavors, tasting them is empathic, as the observer puts her attention on the act of eating as a gift from life, as a communion with nature and earth, as the result of so many dedicated and loving people working in agriculture, in the transportation, distribution and preparation of food. This empathic attitude, besides diminishing direct metabolic CO_2 emissions, is a driver to avoid waste and to share with others.

A whole set of additional possible habits and good practices could contribute to attain sustainability in a city, among them:

- Tackle problems in a calm, intelligent and conscious way, in comparison to accusing, blaming and using stress generating solving methods.
- Diminish, separate, recycle and reuse waste.
- Seek rational use of water and energy in every human daily activity.
- Seek changes in the smoking of tobacco (and marihuana), or entirely avoid them, as these are bad habits generate huge amounts of CO_2.

Conclusion

Direct human metabolism is an important contributor to CO_2 in the atmosphere. Using the average value for metabolic CO_2 generation, the existing world population of some 7 311 million people will have CO_2 emissions estimated at more than 6 million ton/day. This represents an equivalent coal combustion of some 2.8 million tons per day, which is significant as compared to a daily use of coal in the world of 21.4 million tons. While metabolic CO_2 is part of a renewable cycle, as food comes from plants trough photosynthesis CO_2 consuming processes, food consumption is also related to a huge set of operations, which contribute enormously to CO_2 generation, to pollution, waste and to non-renewable resources use. Any lowering of the CO2 human metabolic emissions will have a significant impact on global warming gases control.

Relaxation and empathic practices form the basis for establishing new practices and habits and to develop awareness towards nature and conservation. This has direct impact on the metabolism and tends to reduce CO_2 emissions, but also enhance that people become conscious observers, which facilitate the establishing of good environmental and energy saving practices.

A set of such good practices are proposed, some of well known, while other ones are novel and related to emphatic and relaxed ways of behavior.

Competing Interests

The authors declare that they have no competing interests.

Author Contributions

All the authors substantially contributed to the study conception and design as well as the acquisition and interpretation of the data and drafting the manuscript.

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