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AIR POLLUTION, ITS CONSEQUENCES AND SOLVING IT

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The abstract:

Pollution is a significant problem that Egypt faces and air pollution is its most dangerous type of pollution. Gases like carbon monoxide and nitrogen oxides increased concentration affects health which is mostly produced by combustion reactions in car fumes or factories. Also, it causes diseases like asthma, Alzheimer's, even cancer and also affect the economy by affecting crops growth and decreasing it. The negative effect of air pollution on plants can be used as a bioindicator of pollutants concentration by noticing the growth of pollution-sensitive plants as lichens in polluted areas; the more its growth is affected, the more the pollutants are concentrated. One of the most dangerous pollutants is nitrogen oxides; most of the pollutant's concentration comes from traffic emissions. Nitrogen oxides can cause severe health issues as irritation of the respiratory tract, and it can reduce immunity to lung infections. Also, carbon monoxide is a hazardous pollutant that may cause loss of balance, vision problems, memory problems, loss of consciousness and eventually, death. The increased concentration of pollutants and greenhouse gases like chlorofluorocarbon and nitrogen oxides damages the ozone layer critically. It threatens human health as the ozone layer is the earth's shield against harmful rays coming from space as ultraviolet rays, for example, exposure to UV rays causes skin cancer premature ageing and other skin damage eye damage and Immune system weakness. Polluting gases are mostly produced by combustion reactions providing both heat and additional residue in the form of pollution as mentioned earlier, thermodynamics rules these reactions and expresses them. The first and second laws of thermodynamics discuss these reactions and help us get a better view of the problem which can help scientist find better and more efficient solutions in the future by understanding the roots of the problem.

The keywords: air pollutants, air pollution in Egypt, air pollution Effects, air pollution solutions, bioindicators

The introduction:

Burning fossil fuels is a significant factor in increasing air pollution and soil contamination by high rates. Due to dangerous gases resulted from combustion like SO₂ which forms acid rain ruining crops, it also can affect neighboring areas citizens' health severely and cause diseases like asthma and even cancer, however in (ES.1.10), studied alternatives to fossil fuels that cause less pollution than fossil fuel like solar energy. As studied in (ES.1.11) found that the Lignite has the least amount of carbon. Anthracite has the most amount of carbon Table (1). At burning the anthracite emission high percentage of CO₂. As studied in (ES.1.13), at burning fossil fuel it emits CO₂. Some of this carbon dioxide reacts with the water in the atmosphere to form a weak acid, called carbonic acid (H₂CO₃). At burning coal, coal has five percent percentage of sulfur. When the coal is burned, the sulfur is emitted as sulfur dioxide gas (SO₂). The sulfur dioxide then reacts with oxygen and then with water in the atmosphere to form sulfuric acid. $SO_3 + H_2O \Rightarrow H_2SO_4$

Table 1: percentage of carbon and heat content of coal

Coal Rank	Carbon Content (%)	Heat Content (Btu per lb)
Lignite	25-35	4000-8300
Sub-bituminous	35-45	8300-11,500
Bituminous	45-86	10,500-14,000
Anthracite	86-98	≥ 14,000

Tracking down pollution amounts in specific regions and expecting the pollution increment rate can be predicted by graphing exponential functions which learned to perform (MA.1.08) which is essential in predicting and controlling pollution rates

The study for thermodynamics 1st law (PH.1.11) and(CH.1.15) that concludes that energy is neither created nor destroyed but it can transform from one form to another; however, the second law prohibits the ability of a system to reach 100% efficiency, so the input energy

produces two types of energy which useful energy output and pollutants, can minimize the pollutant output by recycling or eco-friendly disposal to achieve a pollution-free environment.

These changes can lead to shifting the balance among plant species in affected areas as high-level exposure to ozone lead to reduced growth, which causes economic issues and also creates a domino effect on the food chain as studied in (BI.1.12).

As studied in (CH.1.11) types of chemical reactions burning fossil fuel is a combustion reaction, this type of reactions occurs when a hydrocarbon reacts with oxygen, this equation of burning benzene in oxygen:



Products are always carbon dioxide and water. Although incomplete burning does cause some by-products like carbon monoxide that is hazardous because Carbon monoxide poisoning occurs when too much carbon monoxide is in the air, the oxygen is replaced by carbon monoxide in red blood cells of the body. Which leads to serious tissue damage or even death. Carbon monoxide is produced by burning organic compounds.

As studied in (CH.1.14) from electrochemistry can generate electric energy from chemical reaction that is less harm than burning fossil fuel to generate electricity.

The pollution effect in Egypt cannot be ignored for its many consequences on both health and economy. Solutions, like decreasing factories' polluting activities and applying restrictions to cars that produce much polluting exhaust, must be applied in a wide range and rapidly to contain pollution's consequences.

Literature review and theoretical Analysis:

Air pollution has many negative effects on the ecosystem and especially the vegetation, an experiment has been conducted to determine the impact of air pollution on the growth of two different plant specimen in various locations with different amount of air pollution, the results concluded that the plants' growth and chlorophyll amount decreased when exposed to more pollution, this decrement can be used as a biomonitor to the industrial pollution. Table (2)

It is essential to monitor the amount of air pollution as it affects Egyptians negatively. it can cause asthma and cancer from long term exposure and skin diseases, especially to children and infants. It can also affect Egyptians indirectly as the ascending gases like Sulphur dioxide from factories can accumulate and form acid rain which can severely harm vegetation and marine life which leads to passing the pollutants to humans after consuming the affected plants and fish. Figure (1)

	Concentration ($\mu\text{g m}^{-3}$)			
	Site 1		Site 2	
	Mean \pm SD ^a	Max. 24 h	Mean \pm SD ^a	Max. 24 h
SO ₂	156 \pm 56	310	88 \pm 41	190
NO _x	135 \pm 44	200	79 \pm 36	160
NH ₃	68 \pm 31	110	48 \pm 21	116
TSP	680 \pm 250	1200	528 \pm 195	884
Pb	1.8 \pm 0.3	3.1	0.8 \pm 0.2	1.9
Cd	0.08 \pm 0.02	0.17	0.04 \pm 0.01	0.08

^aSD = Standard deviation. Table 2: shows the concentration of pollutants in the two sites

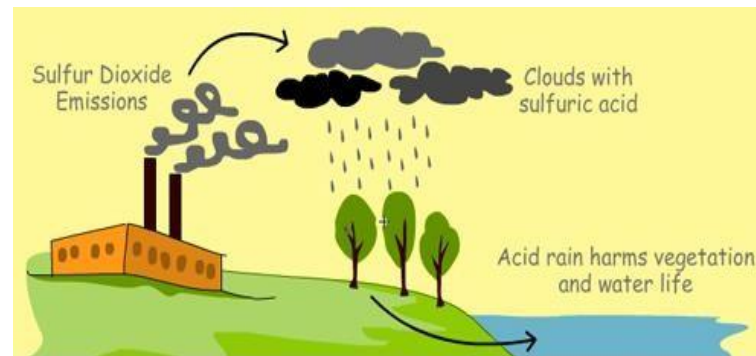


Figure 1: effect of SO₂ on vegetation and water life

<https://eschooltoday.com/pollution/air-pollution/effects-of-air-pollution.html>

This effect may also affect the economy and the ecosystem as plants growing under polluted air have decreased leaf area and plant height which leads to reducing the plants' dry weight, the change in the amount of an element in the food chain can severely affect it especially if it is a producer, this may shift the balance among plant species in addition to decreasing the harvest amount which causes economic issues.

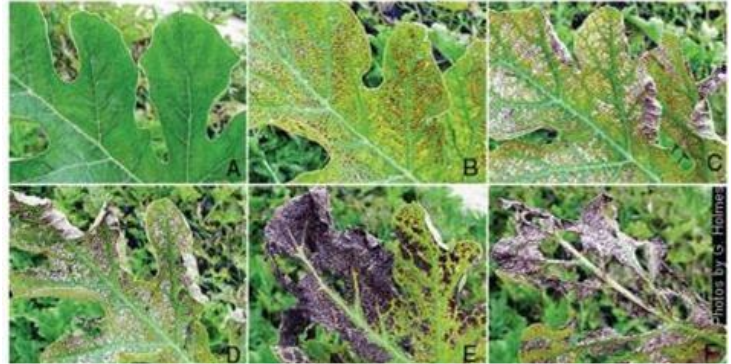


Figure 2: the result of long-term exposure to ozone damage on watermelon foliage <https://extension.umd.edu/learn/air-pollution-effects-vegetables>

Figure (2)

In (ES.1.13) the dangerous impact of fossil fuel usage on the environment, causing both air pollution and soil contamination. Studied that other alternatives are cleaner and cheaper like solar energy and wind.

Mango trees and lichens were found to be the most suitable specimen for bioindication of air pollution levels as they showed apparent reaction when exposed to air pollution. The method of using bioindicators has been proven to be better than using chemical indicators for many reasons:

1. Usage of bioindicators leads to scientists realizing that the biota itself is the best indicator to change in ecosystem balance and presence or absence of pollutant.
2. Bioindicators achieve lower costs than chemical indicators while maintaining higher efficiency. If pollutants are present, individual plants will not grow in the affected area.

From research: [1].

Thermodynamics laws rule energy and help explain its transformations in the universe. These laws limit any closed thermal system like our universe. The first law of thermodynamics states that energy is neither created nor destroyed.

As a universal principle, improving the use of energy is essential

$$\Delta U = Q - W$$

Change in internal energy Heat added to the system Work done by the system

Figure 3: second law of thermodynamics

$Q_{in} = Q_{out}$. (PH.1.11) and (CH.1.15)

<http://hyperphysics.phy-astr.gsu.edu/hbase/thermo/firlaw.html>

The second law of thermodynamic (Figure (3)) discusses the randomness of thermal systems and energy benefit, or what is known as entropy. This relates to air pollution, so mostly non-renewable energy sources are used and burned to produce fuel, this increases air pollution and significantly increases the entropy, with the increasing heat the entropy increases and wastes much energy

without benefit and the environment becomes polluted because of air pollution and frequent harmful greenhouse gas emissions this affects the Ozone layer and pollutes the air. Figure (4)

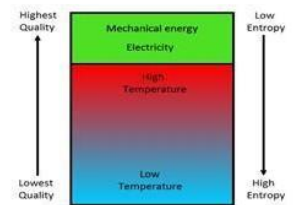


Figure 4: when the entropy of a system increases the temperature, quality decreases which is why low-quality heat cannot be transferred to a useful work

<https://energyeducation.ca/encyclopedia/Entropy>

When fuel is produced from non-renewable sources such as coal, petroleum, and natural gas, it provides an amount of energy equal to that which was used according to the first law of thermodynamics, but in different phases, the entropy ratio is high according to the second law of thermodynamics, this prevents achieving 100% efficiency which means there will always be a harmful useless excess energy in the form of pollution and This excess energy increases the environment energy(temperature) in another place as the first law states that it can never be gone,

renewable and clean sources must be used instead. To decrease waste during energy transformation from one form to another and to raise its efficiency as well as reducing pollution and not increasing the entropy. From research: [IX]

Table 3: the amount of carbon dioxide emissions in Egypt and other countries of the world during (1990:2010) the unit (million ions equivalent)

Countries	1990	1995	2000	2004	2008	2010	Rate of change (1990-2010) %
America	4821.2	5209.1	5961.9	6049.4	6302.3	6104.2	26.6
England	579.7	569.6	580.1	587.3	590.2	591.6	2.05
Indonesia	214.0	303.0	365.6	378.3	381.4	434.5	103.04
France	364.0	351.1	387.7	373.7	378.5	380	4.4
Australia	278.6	312.4	337.7	336.8	341.7	356.6	28.0
Egypt	75.5	95.1	138.7	158.2	170.3	182	141.06
Morocco	23.5	30.3	34.3	41.2	44.2	46.1	96.2
Jordan	10.2	13.6	15.5	16.5	18.4	19.8	94.12

Source: www.ar.wikipedia.org

It is clear from table (3) that Egypt occupies the first place among all the states mentioned in the table where the rate of increase in those emissions reached 141.06% in 2010 in comparison with 1990 in which it amounted to about 75.5 million tons.

Air pollution is a great threat to Egypt. It affects soil negatively. Air pollution harms ecosystem as studied in (BI.1.12) and how to save it. Table (3)

Reducing damages generated from vehicles exhaust, such as replacing leaded gasoline with unleaded gasoline, as well as the tendency to use compressed natural gas instead of using gasoline because gas is a clean fuel are ways to decrease pollution. Also using renewable resources is better for the environment and renewable. Burning garbage causes air pollution, so we must stop it from decreasing air pollution. Table (4)

Table 4: the proportion of emissions in Egypt for the world

Years	The amount of emissions in Egypt million tons equivalent of carbon dioxide	Ratio of the amount of emissions for the world
1990/1999	107	0.40%
2004/2005	150	0.55%
2005/2006	152	0.57%
2010/2011	388	1.08%

Source: Egypt and climatic changes- the unity of climatic change- the Ministry of State for Environmental Affairs- Arab Republic of Egypt 2011

First, spread environmental awareness, and this is one of the most effective in reducing pollution rates because the perception is the weapon of victory. If we realize the consequences of our actions, we will choose well and stop what causes harm. There must be awareness-raising campaigns for young people.

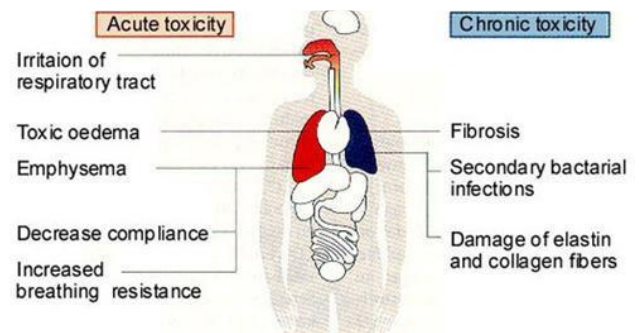
Also, reducing pollution by applying laws like Implementation of the Environmental Protection Law No.4 of 1994 concerning the agreement between industrial buildings and its provisions to maintain the cleanliness of the air. From research: [X]

The ministry of the environment monitors environmental pollutants due to its direct impact on public health and facilities. The ministry tracks its concentrations to assess the air quality in the areas where the measurement is done. These pollutants include the following:

1. Nitrogen oxides (NO_x)

Nitrogen oxides are a common primary product. However, its high concentration causes severe health issues. Traffic emissions are the primary source of nitrogen oxides, while some small

Figure 5: symptoms upon NO_x exposure



<https://greenanand.blogspot.com/2018/08/nitrogen-oxides-nox.html>

concentrations are produced from power stations and some other industrial sources. However, emissions from power plants and industrial areas are in most cases high, and their rise helps to spread of pollutants in the atmosphere. Figure (5)

2. Carbon monoxide (CO).

the primary source of carbon monoxide is traffic emissions, but the amount of emission is significantly affected by the car's speed and engine efficiency and is at its highest when the vehicle speed is at its lowest rates. figure (6)

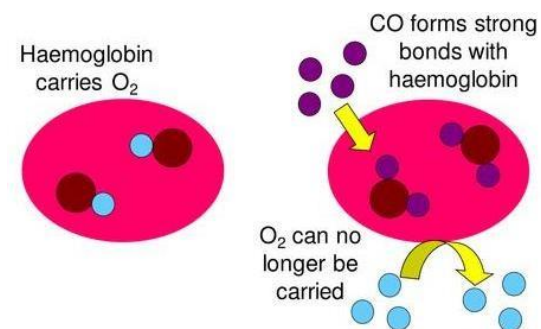


Figure 6: the effect of carbon monoxide on hemoglobin

<https://www.tes.com/teaching-resource/effect-of-carbon-monoxide-on-erythrocytes-6095583>

<https://cf2.ppt-online.org/files2/slide/t/OViMAjQenXUW72xbZSGsh8FEKNpvI9a5TdyDgmPH/slide-7.jpg>

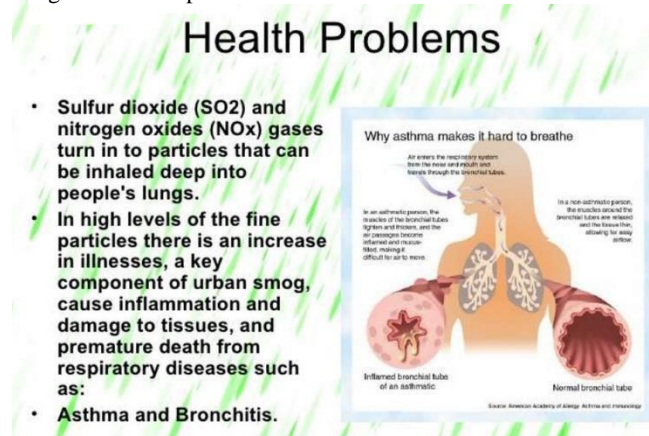
3. Sulfur dioxide (SO₂).

Sulfur dioxide (SO₂) is formed as a product of the sulfur residue oxidation processes present in some fuels during the combustion process. It causes asthma and similar conditions on the long term. Figure (7)

As studied in (ES.1.13) found that the burning of

coal emission sulfur dioxide that react with water form (H₂SO₄) From research: [II]

Figure 7: health problems come from sulfur dioxide



Air pollution is estimated to cause approximately two million premature deaths worldwide per year. Sex steroids mediate many processes in the body. This means that toxicologically speaking, female gender is more vulnerable to toxicants than men, one explanation being down-regulation of plasma proteins by sex steroids or the larger relative fat mass that allows larger distribution volume for fat-soluble substances, as most environmental chemicals are highly lipophilic.

Sugar cane factory pollutants are one of the most important causes of air pollution facing many countries in the world, including Egypt. The primary pollutants emitted by these factories are sulfur dioxide (SO₂), nitrogen dioxide (NO₂), carbon monoxide (CO), black smoke (BS) and particulate matter (PM₁₀). Air pollution is a big problem in connection with the sugar factories in Kom-Ombo district of Aswan governorates of Egypt. The air in Kom-Ombo is polluted in the surrounding areas around the factories, the quality standards for small particles (PM₁₀) are severely violated as indicated in executive regulation of environmental law 4/1494 limits Table (5).

In the present study hematological investigations found that the mean RBCs count and hemoglobin percentage were significantly lower in patients compared to controls ($p = 0.000$), the prevalence of anemia was significantly higher in the polluted area (63.33% Vs 21% $p < 0.000$). At the same time, there were no statistically significant differences as regards to total leucocytic count (TLC), renal functions or liver functions between both groups. ($p > 0.05$) (table 6 & 7), these results were by Nikolić et al., (2008) who attributed anemia to toxic materials from air that leads to significant damage of red blood cells, reduced hemoglobin concentrations, number of erythrocytes and hematocrit, thus leading to anemia. Ziaei et al., (2005) found a similar effect but he stated that it is difficult to determine whether one of the measured pollutants, alone or in combination, was responsible for the observed effects. Also, it was less clear which pollutants are most responsible for anemia.

In this study, found that 26.66% of patients presented with manifestations of respiratory system diseases in the form of cough, expectorations and chest wheezes, if compared to 10.33% of controls, the difference was statistically highly significant ($P = 0.000$). This result is by Brook et al., 2008, and Eder et al.,

Table 5: laboratory parameters of the studied groups

parameters	Group A	Group B	t test	p
CBC (mean± SD)				
RBCs count ($10^3/cm^3$)	3.64 ± 1.3	4.7 ± 1.4	1.2	**
Hb%	10.2 ± 1.01	11.1 ± 0.37	0	**
TLC ($10^3/cm^3$)	7.88 ± 1.6	6.02 ± 1.3	1	NS
Urine analysis (no. %) #				
Glucosuria	20 (6.7%)	17 (5.7%)	0.98	NS
Pus cells	155 (51.7%)	114 (38)	11.3	**
Albuminuria	50 (16.7%)	22 (7.3%)	42.96	**
Renal functions (mg/dl) (mean± SD)				
Serum creatinin	1 ± 0.46	0.9 ± 0.3	0.999	NS
Blood urea	26.7 ± 16.08	26.3 ± 14.7	0.654	
Serum uric acid	4.3 ± 3.7	4.17 ± 2.9	0.684	
Liver functions (mg/dl) (mean± SD)				
SGOT	30.23 ± 17.2	28.7 ± 16.23	0.867	NS
SGPT	31.7 ± 16.17	29.8 ± 14.6	0.934	

Table 6: average concentration of pollutants (ug/m^3) in Kom-Ombo in relation to the maximum allowed limits

Pollutants	Concentration in Kom-Ombo	Maximum allowed limits	Ratio
CO	30	10	3
SO ₂	89	60	1.5
NO ₂	43	40	1.1
PM ₁₀	278	70	4.1
Black smoke	144	60	2.4

(Egypt state of the environment report; 2009)

Table 7: maternal outcomes of the studied groups

Maternal outcomes	group A		group B		X ²	P
	no.	%	no.	%		
Anemia	148	49.3%	83	27.67%	29.74	0.000
PIH	83	27.7%	22	7.3%	42.96	0.0000
UTI	155	51.7%	114	38 %	11.3	0.0008
Chest troubles	80	26.7%	31	10.3%	26.5	0.0000
PROM	77	25.7%	47	15.7%	9.15	0.0024
PTL	96	32 %	52	17.3%	17.4	0.0000

PIH: Pregnancy induced hypertension UTI: Urinary tract infection
 PROM: Premature rupture of membranes PTL: Preterm labor

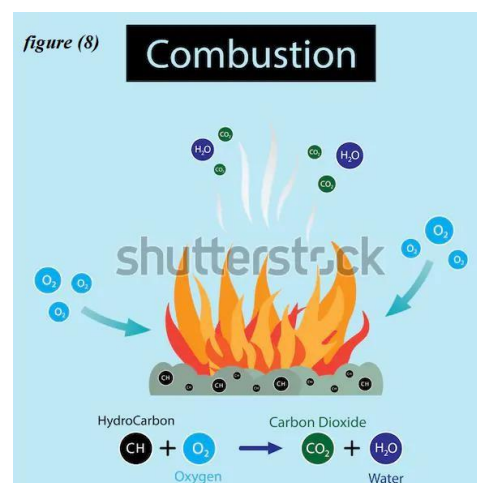
2009. The biological effect of air pollution on the respiratory system was attributed to pro-inflammatory pathways and the generation of reactive oxygen species that lead to pulmonary inflammation, airway obstruction, and increased susceptibility to infection and sensitivity to allergens (Simkhovich et al., 2008).

As studied in (CH.1.11) about types or reactions found that combustion reactions that are resulted from the burning of fuel CO_2 and H_2O , this type of reactions occurs when a hydrocarbon reacts with oxygen: $\text{CH} + \text{O}_2 \Rightarrow \text{CO}_2 + \text{H}_2\text{O}$.

figure (8)

Products are always carbon dioxide and water, although incomplete burning does cause some by-products like carbon monoxide that is hazardous. Because Carbon

Figure 8: combustion process



<https://www.shutterstock.com/image-vector/illustration-chemistry-combustion-diagram-1135836608>

monoxide poisoning occurs when carbon monoxide accumulates in the bloodstream, NO_2 is formed as a product of all combustion processes that are carried out at high temperatures. Traffic emissions are the primary source of NO_2 , while some small concentrations are produced from power stations and some other industrial sources. From research: [VI]

Ecologically, air pollution can cause serious environmental damages to groundwater, soil, and air. It is also a serious threat to the diversity of life. In terms of health hazards, every unusual suspended material in the air, which causes difficulties in the normal function of human organs, is defined as air toxicants. Many experimental and epidemiologic studies have shown the direct association of air pollutant exposure and cardiac-related illnesses. Skin is the body's first

line of defense against a foreign pathogen or infectious agent, and it is the first organ that may be contaminated by a pollutant. Table (8)

Table 8: standard level of criteria air pollutants and their sources with health impact

Air pollutants*	Major source of emission	Averaging time	Standard level	Health impact target organs
Particle pollutants				
PM _{2.5}	Motor engines, industrial activities, smokes	24 h	35 µg/m ³	Respiratory and cardiovascular diseases, CNS and reproductive dysfunctions, cancer
PM ₁₀		24 h	150 µg/m ³	
Ground-level ozone	Vehicular exhaust, industrial activities	1 h	0.12 mg/m ³	Respiratory and cardiovascular dysfunctions, eye irritation
Carbon monoxide	Motor engines, burning coal, oil and wood, industrial activities, smokes	1 h	35 mg/m ³	CNS and cardiovascular damages
Sulfur dioxide	Fuel combustion, burning coal	1 h	75 µg/m ³	Respiratory and CNS involvement, eye irritation
Nitrogen dioxide	Fuel-burning, vehicular exhaust	1 h	100 µg/m ³	Damage to liver, lung, spleen, and blood
Lead	Lead smelting, industrial activities, leaded petrol	3 months average	0.15 µg/m ³	CNS and hematologic dysfunctions, eye irritation
Polycyclic aromatic hydrocarbons*	Fuel combustion, wood fires, motor engines	1 year	1 ng/m ³	Respiratory and CNS involvement, cancer

*Air quality standards according to the European Union. *PM_{2.5} is stand for PM of 2.5 µ or less. PM₁₀ is stand for PM of 10 µ or more. PM = Particulate matter, CNS = Central nervous system

As studied in (CH.1.14) the governments could generate electric energy from chemical reaction instead of burning fuel and (ES.1.11) found that the anthracite generates more carbon dioxide than lignite. As studied (ES.1.10) about using alternative energy that is not emit harmful gases.

From research: [IV]

Air pollutants mentioned before affect the ozone layer as following:

CFCs compounds deplete the ozone layer by three steps:

1-UV waves strike CFCs (CFCI₃) molecules then carbon-chlorine bond breaks producing a free chlorine atom

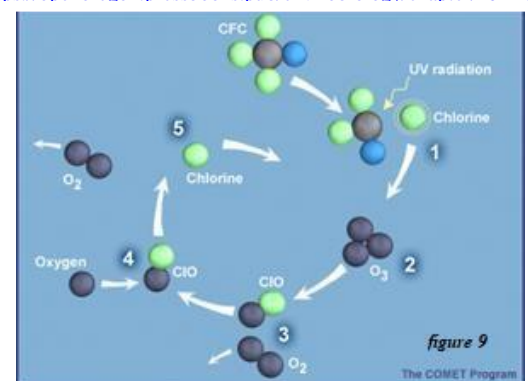
2-the chlorine atom then reacts with an ozone molecule producing O₂ and chlorine monoxide (ClO)

3- ClO then reacts with an oxygen atom producing O₂ and a

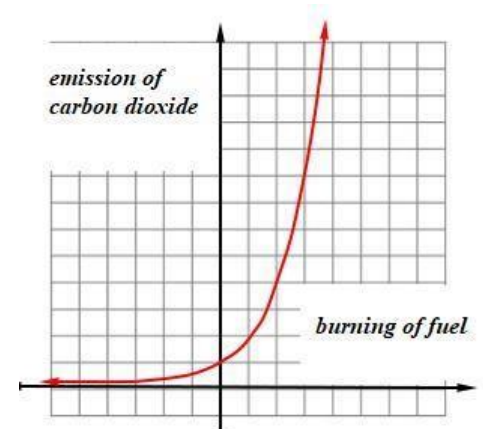
free chlorine atom which resumes its cycle destroying ozone layer (Each CFCs compound destroy over 100000 ozone molecule). Figure (9)

Figure 9: show how (CFCs) effect the ozone

<https://openoregon.pressbooks.pub/envirobiology/chapter/10-2-ozone->



A photon of ultraviolet light hits a NO_2 molecule, breaking an N-O bond and forming an $\cdot\text{NO}$ molecule and an O atom. the nitrogen monoxide reacts with an ozone molecule, breaking it apart and destroying the ozone. The reaction forms a nitrogen dioxide molecule and an oxygen molecule. Then a free oxygen atom reacts with the nitrogen dioxide to form oxygen and nitrogen monoxide. The nitrogen monoxide is free to repeat the process of destroying more ozone molecules. The nitrogen monoxide is a catalyst because it reacts at the beginning and is regenerated at the air pollution permanent exponential spread can



Graph 2: show the relation between the burning of fuel and emission of carbon dioxide

be represented using the exponential function in (MA.1.08). Graph (1) From research: [\[VII\]](#)

Conclusions:

Pollution is a significant problem that Egypt faces and air pollution is its most dangerous type. It has significant effects on plants and the ecosystem in Egypt. The plants can be an indicator of air pollution. Mango trees and lichens were found to be the most suitable specimen for bioindication of air pollution levels as they showed an apparent reaction when exposed to air pollution. The harmful gases affecting the air we breathe like Sulphur-dioxide and nitrogen-oxides and ones formed by incomplete combustion of fuel like carbon monoxide are all products of combustion processes. These harmful gases can affect the health of the Egyptians because it can cause cancers, anemia and respiratory system diseases which lead to affect the economy of the country negatively.

The second law of the thermodynamics explains the randomness of a thermal system which is called entropy as studied in physics and chemistry, and as thermodynamics defines the nature of combustion reactions even ones that produce pollutants, more in-depth knowledge of thermodynamics might help us get a better perspective of the problem and better understanding to find the most efficient solution to the problem. The increased concentration of pollutants and greenhouse gases like chlorofluorocarbon and nitrogen oxides damages the ozone layer critically. This damage is fatal if it increases as the ozone layer is earth's shield against harmful rays coming from the sun like UV rays, for example, exposure to UV rays affects human health and causing melanoma skin cancer, cataracts, pterygium and immune system suppression.

Recommendation:

Environmental awareness must be spread, awareness campaigns implemented, and awareness of the danger of pollution to life. Actions that increase pollution must be criminalized and the application of deterrent laws and environmental protection.

It is important to increase green areas, cultivation, and build factories in uninhabited areas far from green areas and use clean energy sources to produce energy.

It's better to use bioindicators instead of chemical or physical ones as they're cheaper, more efficient and give us a glimpse of what the pollution effect on vegetation would be like

Using filters for factory chimneys to decrease pollutants concentration and harm and disposing of pollutants in a safe way

Decreasing the production of greenhouse gases and applying restrictions to factories and countries that produce excess amounts of chlorofluorocarbon (CFCs) to protect ozone layer

Benefiting from COVID-19 to apply more efficient solutions to air pollution as pollution rates dropped after quarantining.

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