AIR POLLUTION EMISSION AND GLOBAL WARMING

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Extended summary

Air pollution is increasing at an alarming speed with the growth in population. It is from the local emissions as well as from the pollutants from the neighbouring countries. It implies that it is not enough to clean once own country emission. Air pollution is the instrumental for the global warming up. The temperature of the mother earth has increased by 0.8 deg from 1990. if it goes to 2.65 deg , the consequences will be disastrous. It is a serious problem . To control the global warming the sources of pollution should be charted out and measures are to be taken to control them.

The major sources of pollution are, aviation, airports, automobiles, ships, industrial activity centres and respiratory system. It is possible to control the emissions from the industrial activity centres but from the other sources is not possible.

The pollution is harmful to the human being as well as to the structures. The damage is both physical as well as chemical. Physical due to the change in temperature and chemical due to the interaction of the pollutant gasses with the binders.. In the modern buildings with the insulation and heating, the apartments gets warm but the chemicals ; glue etc, used in quick construction decomposes.. The radiation includes formaldehyde, which causes headache, skin sores, allergy etc. The possible solution is to use environmentally friendly binders like industrial by- products, such as blast furnace slag, fly ash etc and the recycled aggregates it will reduce the GHG, and will decrease the disposal cost of the industrial waste at the same time will save energy and the nature.

With the increase in population the aviation, automobiles ships etc, have increased by many folds, Thereby their exhaust gasses are polluting the atmosphere , which is significantly large. It is not possible to cut down their frequency but it is discussed to discover low carbon fuel instead of fossil fuel.. It will create clean sky and healthy air, it will stop global warming and will decrease the deleterious effect on human health, saving good amount of money spend otherwise on health care.

Key words, Air Pollution, Human health, emission, GHG, Global warming

INTRODUCTION

Atmosphere is a complex dynamic natural gaseous system that is essential to support life on the earth planet. It is modified with the gasses released due to the increase in the industrial activity centres and population growth. These substances are referred as pollutants. Air is no longer clean. It is contaminated with the pollutants . Some of the worst air pollution occur in the developing countries. This is result of increase in the industrial activity centres and increase in the population.. The pollutants are emitted in particular country or they are imported with the wind from the neighbouring country. Six major air pollutants have been identified as causing health problems and detrimental to the building ; cultural heritage. ;

Carbon mono oxide, lead, nitrogen dioxide, ozone particulate matter and sulphur dioxide.

Pollutants can be classified as either primary or secondary. Primary pollutants are substances directly emitted from a process These primary pollutants usually react within a few days under the influence of oxygen, sunlight, temperature and humidity to form secondary pollutants An important example of a secondary pollutant is ground level ozone- one of the many secondary pollutants that make up photochemical smog.. Some of the pollutants , however, may be both primary and secondary.
Major primary pollutants produced by human activity include;

Sulphur oxides (SOx) , Nitrogen oxides (NOx) , Carbon mono oxide , Carbon di oxide,

Volatile organic compounds (VOC), such as hydrocarbon fuel vapours and solvents
Toxic metals , such as lead , cadmium and copper, Chlorofluorcarbons (CFCs), Ammonia (NH_3) emitted from agriculture process and Radio active pollutants produced by nuclear explosions

Major secondary pollutants.;
. These new compounds are found in gas phase (SO_3, HNO_3, HCL, Organic acids, and =3), in particle form (H_2SO4, NH_4SO_4, $(NH_4)_2SO_4$ or dissolved in water (acid droplets) (CH, NH_4, HSO_3, SO_4 2,NO_2, NO_3.

NOx compounds comprise a large portion of the air pollutants found in urban environments and they originate mainly from automobile exhaust. Nitrogen dioxide , which is a primary component of NOx is produced when fuel is burned in motor vehicles , power plants , industrial boilers , and other sources. The exhaust of gasoline powered cars normally contain 100-1000ppm NO and 10-100 ppm NO_2. The NO/ NO_2 ratio rises in the ambient air due to the oxidation of NO_2 to NO_3 in the presence of ozone.

SO_2 It is produced by power plants and industries that burn fossil fuels that contain sulphur, such as coal and oil, and by the phosphate industry though its production of sulphuric acid.. It is also a major pollutant in the urban environment although its level is diminishing with the burning of low sulphur containing oil and coal and with the use of flue gas cleaning system.

CO It is colourless, odourless, non irritating but very poisonous gas. It is produced by incomplete combustion of fuel such as natural gas, coal or wood, vehicular exhaust is the major source of carbon mono oxide.

CO2, Carbon dioxide; it is Green House Gas (GHG) , and is produced from combustion , from cement kilns, lime kilns etc.

2. Sources of Pollution

The major source s of air pollution are automobiles, aviation, airports, human respiratory system and industrial gasses.

2.1 Aviation

In 1993aircrafts emitted 350 million .pounds(175 kg) of VOC's and NOx during landing and taking off cycles, more than double 1970 levels, according to the Natural Resources Defence Council (NRDC) report. These two classes of compounds are precursor of ground level ozone, which can interfere with lungs function. During summer, between 10 and 20% of all East Cost hospitals admissions for respiratory problems may be ozone related.
Airports are amongst the greatest sources of air pollution. A major airport is idling and taxing planes can emit hundreds of tons of VOC and NOx annually. JFK Int. airport is the second largest source of VOC's in New York city, La Guardia is amongst the major source of NOx.

VOC emitted by the airports may comprise a variety of toxic chemicals , according to 1993 study by the Environment Protection Energy (EPA) Chicago airport released more benzene and formaldehyde than most factories.
Apart from the air traffic, the other sources , which add to the pollution are; ground access vehicles, such as passenger cars and busses entering and leaving the airport often exceeds aircraft emission. According to the EPA's report ground access vehicles emit 56% of VOC's, while aircraft taking off and landing give off 32.6%. Ground access vehicles emit 39.3% of NOx, trailing closely behind emissions by aircraft
CO2(GHG) is mainly from the respiration of the persons travelling and working at the airport, and the visitors. One adult exchanges 15 kg of air per day, thereby the total emission will be some good million tons of GHG, depending upon the size of the airport.

2.2 Water Pollution

De-icing- The airlines use a mixture of 55% glycol and 45% water , heated to 185o F to clean the planes from snow. Without recapture efforts 50-80% glycol may end in the loc al waterways. It may also contain other chemicals used at the airports.

2.3 Environmental melt down

Glycols and other chemicals used to free the plane from snow during snow weather can be toxic to animals and humans. But glycols give most attention. Ethylene glycol is both more effective and more toxic than the propylene glycol. The lethal dose for humans of ethylene glycol is a little over 3 ounce (1 ounce= 27 g) according to a report from EPA. Less can damage the kidneys. Propylene glycol is relatively innocuous. However both ethylene glycol and propylene glycol consume high level of oxygen during decomposition: This can deplete waterways of oxygen and thereby kill the fishes.

2.4 Automobiles

Cars have two opposite personalities. One is friendly and attractive and the other is destructive and can be lethal. The desire to own a car is linked to pleasure , sexuality , convenience and freedom. Men lust for women and women desire men with attractive, prestigious cars. Car manufacturers have long used attractive lightly clad women to advertise their latest auto designs. Men are also interested in power , performance and want to know something about the engine , although modern engines sufficiently complex to discourage even the professional mechanic. Some of the new engines complexity involves emission control systems that require electronic monitoring and adjustment of engine performance under different operating conditions . Several devices are added to monitor and control engine performance. Most car engines designed after 1996 have a standard port that allows a diagnostic computer access to information about engine performance.

Driving a car is the most polluting act an average citizen commits . emissions from passenger vehicles are increasing despite attempts to make engines more fuel efficient and despite the addition of anti pollution [Car Exhaust, Air Pollution and Environment] devices. The two main reasons are: 1. vehicle use has increased , 2. cars are getting bigger and pick-up- trucks , vans and sport vehicles are often replacing the smaller, light passenger cars. The average new vehicle in 2003 consumed more fuel that its counterpart in 1988. In the USA in 1987 cars averaged 25.9 miles to the gallon. Fuel efficiency dropped to 24.6 miles /gallon by 1998 and is dropping further as more larger vehicles replace smaller ones. ((5 miles-8 km. 1 gallon -5 liters).

Despite scientific evidence of climate change , governments in most affluent countries have avoided their responsibility to reduce emissions of green house gasses worldwide. USA emissions have increased to 7 billion tons of CO_2 in 2004, 16% higher than emissions in the late 1990's. The UK has done better reducing their emissions to about 0.8 billion tons, 14% below 1990.

Exhaust from all combustion engines combine to produce local adverse effects on the health of the car users and all innocent bystanders. Cities have become islands of toxic chemicals from the uncertain use of vehicles burning fossil fuels. Cars are noisy , ugly and dangerous dominate the experience of modern living.

Pollution caused by auto mobile will become worse in China and India, as the countries vehicle ownership rises , an official report has warned

" The next 15 years will see a sharp increase in the number of cars to 100 million , which will together with the low level industry pollution control s cause more severe pollution , warns a report released at the fifth session of the third China Council for International Cooperation on Environment and Development in Peking.".

The number of vehicles in China has risen by 22% every year since 1980's, to hit 43 million cars and 94 million motorcycles in 2005.

" If the current trend continues , Chinas environment and natural resources will face great problems , such as energy resources security , the co-existence of water shortages and waste , a sharp reduction in biological diversity and diseases caused by environmental pollution in 2020 read the report".

2.5 Human resource

Average adult exchanges 15 kg of air per day in comparison to 1.5 kg of food and 2.5 kg of water consumption. With levels of CO_2 rising in the atmosphere to nearly 20 billion tons/year. It

is estimated that the annual CO_2 emission/per person has to be below 1.69 ton on 1990 world population figures of 5.3 billions. This is imperative in order to prevent additional CO_2build up in atmosphere which by 2025 AD would have to be between 1.18 and 1.05 depending upon population growth. [Technorama 1999]

2.6 Ships

Another big source of SO_2 are the boats and ships, Mostly those who are staying at the Goteborg port .They use cheap fuel containing higher amount of SO_2 Though there is less charge for the ships using refined fuel. But looking at the prices, this rebate is not economical., as the price of refined fuel is too high, compare to the concession offered

The port is lying close to the town so the pollutants blow straight to the town centre. The ships which are only passing through the port do not emit so much. Commercial ships emit almost half as much particulate pollution as do cars and trucks around the world, according to a federal study report [ships,2009].
Researchers for the National Oceanic and Atmospheric Administration and the University of Colorado concluded that ship pollutants affect both the global climate and the health of people living along coastlines.
"Since more than 70 percent of shipping traffic takes place within 250 miles (5miles=8 km)of the coastline, this is a significant health concern for coastal communities," Particulate from vessels can stay in the air seven to 10 days. Particulate suspended can enter the lungs and bloodstream, causing respiratory and cardiovascular problems including asthma and heart attacks.

It really doesn't matter that the ship is not visible," . "The pollution is always there."

The study authors estimate that commercial vessels emit about 2.2 million pounds (2.2 pounds= 1 kg) of particle pollution each year.
"It's a pretty big number when you think about how many ships there are " the world shipping fleet, consists of more than 100,000 vessels.
Previous studies have estimated ship pollution based on fewer vessels surveyed. The results give researchers more confidence in those studies, Lack said, and should be useful to policy makers considering regulations.
Some researchers analysed the pollutants They have found out three types of particulate: sulfates, tied to the amount of sulfur in their fuel; organic material, such as oil or tar; and soot or black carbon. Sulfates tend to absorb water, form clouds and fall out of the air faster.

Ships also emit carbon dioxide, which has an opposite effect on the climate than particulate, according to the study. While carbon dioxide warms, the particles have a cooling effect that is at least five times greater than the global warming effect from the ships' carbon dioxide emissions.The primary cooling effect is from the formation of clouds, which have a shading effect.

2.7 Industrial Pollution

Amongst the major industries responsible for pollution are refineries, petrochemical industries, steel plants, lime and cement manufacturing plants etc (Fig.1). cement and concrete industries contribution to the air pollution is elaborated.

2.7.1 Cement and concrete Industry

The production of Portland cement is the third most energy consuming process, after aluminium and steel.

To produce one ton of Portland cement, 1.6 tons of raw materials are needed. These materials include good quality limestone and clay. Therefore to manufacture 1.6 billion tons of cement annually, at least 2.5 billion tons of raw material is needed .

The production of Portland cement is the third most energy consuming process, after aluminium and steel. In fact, for each ton of Portland cement, about six million BTU of energy is needed (technorama1)

Figure 1: Flue gas from the chimney

To produce 1ton of Portland cement, 1.6 tons of raw material are needed. These materials include good quality limestone and clay. Therefore, to manufacture 1.6 billion tons of cement annually, at least 2.5 billion tons of raw materials are needed (14)

A new cement plant of one million ton capacity, costs over 200 million dollars. The cost associated with the production of Portland cement, along with the CO2 emissions and energy issues make it unlikely that the developing countries will be able to employ such technology. Also the government regulations of GHGs will likely force the cement industry to create blended cements and use supplementary cementing materials for blended cements in order to meet the societal development needs (4,6)

One of the important benefits of the increased use of other cementitious materials is the reduction of GHGs emissions. With a replacement of cement with other recycle blends resources up to 15% of worldwide CO2 emissions would be reduced. A replacement of 50% of cement worldwide by other cementitious material would reduce CO2 emissions by 800 million tons. This is equal to removing approximately ¼ of all automobiles in the World (wikiped encyclopedia)

Energy demand and the emissions generated from the production of cement and concrete are shown in the tables: 1 and 2

Table I
Energy demand and emissions generated in the production of 1 kg. cement

Energy		Emission to air	
Coal	1.9 MJ	CO_2	0.71 kg

Coke	0.51 MJ	CO	2.7 mg
Diesel	0.03 MJ	NO_x	0.7 g
Car tyres	0.42 MJ	SO_x	0.09 g
Bone meal	0.01 MJ	CH4 (methane)	2.6 g
Electricity	0.48 MJ	HC (Hydrocarbon)	1.3 mg

Table 2
Energy demand and emissions generated in the production of 1 m3 concrete

Energy		Emission to air	
Oil	15 MJ	CO_2	1.5 kg
Electricity	33 MJ	CO	0.86 kg
		NO_x	2.3 g
		SO_x	3.3 g
		CH4 (methane)	1.7 g
		HC (Hydrocarbon)	0.32 g

2.7.2 Environmental Impact Assessment

An environmental impact studies on cement production has shown that the environmental load from cement production has decreased during the last 10 years (Fig.2). This study included; Global warming potential (GWP)), eutrophication Potential (EP), Acidification Potential(AP), Photochemical Oxidant Creation Potential (POCP) and toxicity of Superplasticizers. The GWP has changed least, with a reduction of about 80%. The reduction in GWP is mainly because of the replacement of part of fossil fuels to alternative fuels. Much waste is used as fuels in the cement production. The reason for the large reduction is probably that the incineration of the fuel and the cleaning of Emission have improved over the 10 years period. Emission of Hydrocarbon (HC) are 1% in 1995. The reason for the decrease in AP is more sulphur removal in the production. There was 5 times as much NOx emission from cement production in 1995. The reduction in EP is due to the lower emission of NOx , of which to day s emission is only 1/3 of 1995

Energy balance

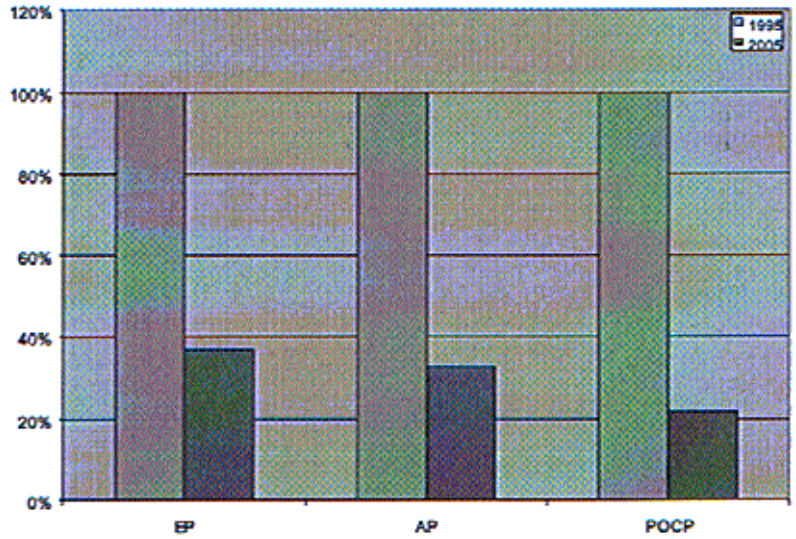

Figure 2. Difference in environmental impact from cement production between 1995 and 2005

3. Pollutants Transported from the Neighbouring Countries

Pollutant gasses can be transported from the neighbouring countries. It is shown in Figure 3. Sweden's own emission of SO2 is 121 thousand tons, whereas the total is 313 thousand tons. Rest is coming from the neighbouring countries. It implies that it is not enough to put the measures to reduce own emissions, it is essential to help the neighbouring countries to decrease the emissions if they do not do themselves due to financial reasons or due to the slackness.

Goteborg has the highest amount of SO_2 in Sweden. This decreases to words north and east. It is because SO_2 is transported through south west wind from central Europe .However, during the way due to the dry and wet deposition the amount will decrease.

NOx

Even NOx in the Goteborg area is high. These spreads with the south west wind and decrease towards East and North. The amount of SO_2 g and NOx is high near to the coast because the rainfall is high .

Higher rain, bigger damages. The dry deposition of NOx is difficult to measure., because the gas particles stick to the vegetation. But the wet deposition is possible.

It has been observed that the rain becomes acidic during 1950,s. It has been due to the presence of sulphur and NOx gasses. It has also relation between impurities and wind direction. The wind which blows from south cost passes through the central Europe carries the pollutants from there. There was decrease in the in the sulphur power fuel but NOx was difficult to decrease, because of the increasing automobiles aviation exhaust gasses

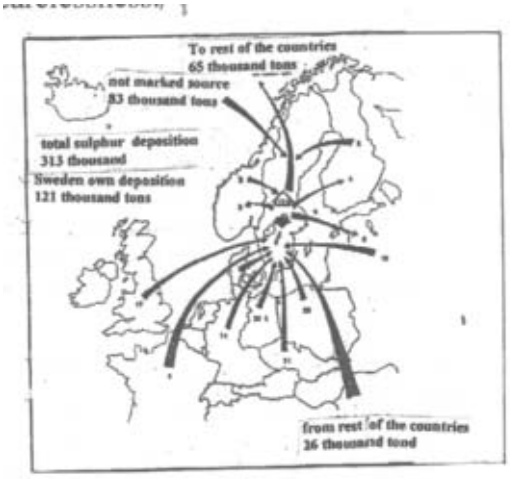

Figure 3. Pollutant gasses from the neighbouring countries.

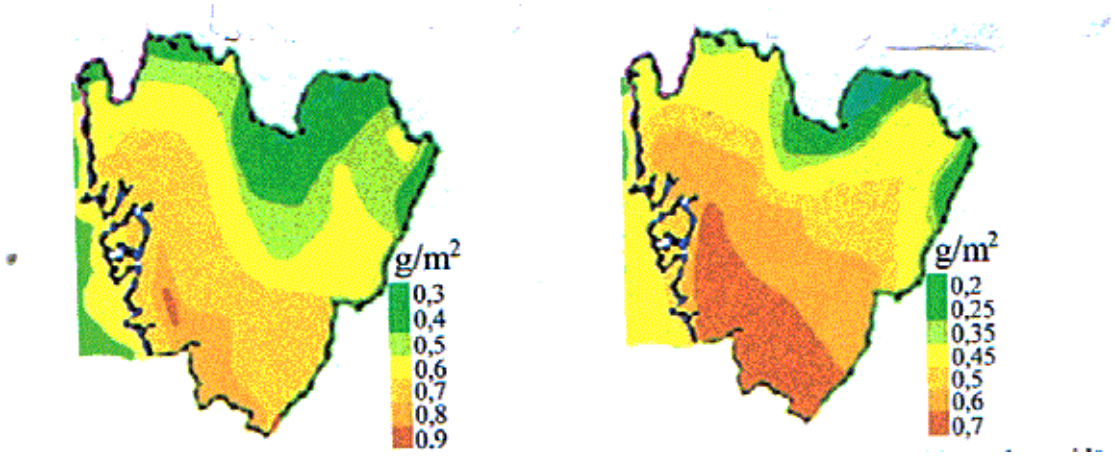

Figure 4. concentration of SO2 and NOx

4. Acid rain

Acid Rain , Rain, which has pH lower than 7 is classified as acid rain. It occurs due to the interaction of the pollutant gasses with moisture in the atmosphere. These can be sulphur dioxide, nitrogen dioxide[Acid Rain; Saving our Environment: Pollution_Acid Rain]. Sulphuric oxide readily dissolves in water to form sulphurous acid

$SO_2\,(g) + H_2O \rightarrow H_2SO_3\,(aq)$

In the presence of oxygen in the air, this acid is slowly oxidised to sulphuric acid.

Oxides of nitrogen also contribute to acid rain . In the presence of oxygen and water , nitrogen dioxide is converted to the nitric acid

$4NO_2\,(g) + 2H_2O + O_2 \rightarrow 4HNO_3\,(aq)$

Acid rain erodes structures and thus , making them weak. Some famous structures lie the Statue of Liberty have been damaged by acid rain.

4.1 Kills Trees

When acid rain hits the earth, nutrients essential for the trees in the soil are washed away and then toxic metals are freed. If the trees absorbs these toxic metals , they would die as they are deprived of their vital nutrients , such as calcium and magnesium. Some of the sulphur dioxide in the leaves clog up the stomata in the leaves, causing them to eventually fall of.
This reduces the trees ability to make food

4.2 Kills Marine Life

Acid rain lowers the pH of lakes and rivers, it makes them more acidic . When the water becomes too acidic , the fishes begin to die.
In addition to that, other plants will also disappear. It is said that when the pH value of the water gets to 4.5, pretty much everything in the lakes and rivers are dead.
Acid rain frees the toxic metals which are present in the ground and washes them into water sources . The water eventually gets to our drinking water supply and contaminates it. <when the water is acidic enough , I may even corrode then water pies , adding in dissolved copper and lead to then water supply.
In Sweden , there was a period of time where drinking water had so much copper in it, that just drinking water can turn your hairs green.
The process is complex as the elements have individual effect as well as synergistic effect. The damage caused by the synergistic effect is much larger than the sum of the damage done by the individual elements.

5. **Air Pollution and Cultural Heritage**

Atmospheric pollution is not only harmful for mankind , it is equally detrimental to the building structures. The structures both historical monuments as well as others in the public sectors have shown premature deterioration. In some cases the damage is severe and it is increasing significantly. There is no so much attention given to restore and conserve them. There is risk that some o f the historical monuments will disappear in this case. The problem is both knowledge for the restoration and the funding. But mainly it is associated with funding. So the cultural heritage is at risk.
The damage occurs mainly because of two reasons, 1. the materials and technic used , 2. and the environmental conditions.


Figure 5. typical example of salt crystallisation, and acid rain, Malta (2007

The Swedish institute for conservation has done an investigation of the stone buildings in the whole country in the beginning of 1990's. it was seen that 83% of all the investigated buildings have some type of damage. The amount of damage was related to the type of Building materials, age of the building and the geographical situation , the atmosphere in the nearby. Some typical examples are shown in the figures 5,6,7, and 8.This building is situated at the sea shore at Malta (Fig.5).: It clearly shows the leaching of alkali and the salt crystallization. Figure 6, shows the white precipitated salt, on the stones at Vallgrav, Goteborg. It is crystallized salts of the alkies leached out.Fig.67 shows deterioration of the reinforced concrete platform ay Maria plan, Goteborg. The reinforcement is corroded, calcium hydroxide is leached out and recrystallized seen as white drops under side. It is an example of moisture, salt and pollution damage. Figure 8, shows fading of ornaments , rendering has fallen, cracks have been developed on the walls, facade became dark due to the smoke and the precipitation of the salts formed .

Figure 6. white precipitated salts, sticking hard over the blocks, Vallgrav, Goteborg.

During an investigation it was observed that the frequency of damage in inside town is 95% compare to the 60% in the country side.. It is a synergistic effect of the pollutant gasses and the high humidity , being close to the sea side

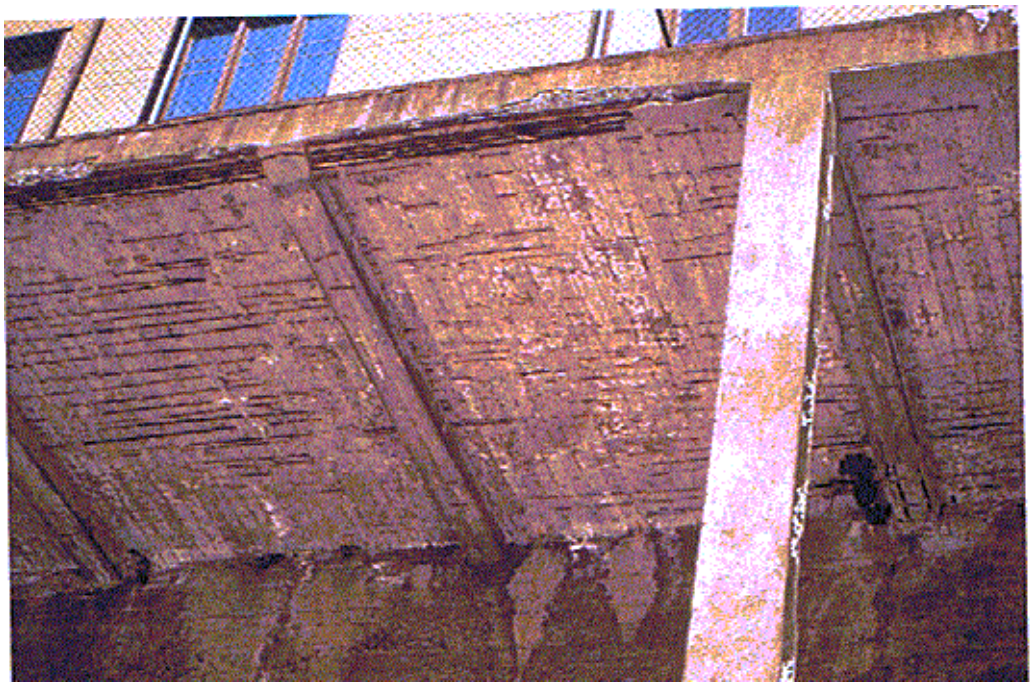

Figure 8. Deterioration of concrete platform, reinforcement is corroded. Calcium hydroxide is leached out and re-crystallized seen as white drops underneath. It is atypical example of moisture, salt and pollution deterioration, Maria plan, Goteborg

In the past , the buildings were constructed with earth , mud clay, lime, sand, and other locally available materials. These were healthy and durable. Where as today the structures constructed with the modern materials and advanced technique are showing premature damages. Unfortunately there is not good documentation about the materials and the techniques used by the ancient builders, The knowledge about the technique and materials used successfully is successively disappearing" One obvious reason is that those construction techniques are time taking and needs patience , Unfortunately today, both the things are missing. There is shortage of time, as all the projects are evaluated in terms of money, there is no waiting time. It is another thing that the people does not have patience to wait. They want to see quick results.

Those materials used in the ancient period were neither energy consuming nor adding to the atmospheric pollution. Lime was burnt using cow-dung cakes, coal and wood, mixing was done by manmade devices. No machines were used demanding energy. These houses were designed carefully taking into consideration , ventilation , light , air etc. These were warm in the winter and cool in the summer. There was no emission or polluted air inside. There is freshness in the indoor climate.

Figure 8. Deterioration after 20 years of exposure

Figure 8. Mohen'jo-daro

Figure 9. Mohen'jo-daro 2300 BC, India , sun baked bricks

Clay is an unique building material . It provides elasticity , workability, holds water, absorbs organic material and encapsulates the heavy metals so that they do not react directly. It also interact with the natural polymers which were used like leaves …etc. which has lignin , wax , and fibers , which work like reinforcement and thus reduce shrinkage cracks. It also worked as pozzolanic material, It means it interacts chemically with the lime producing the natural compounds available in nature. Thu these were stable. The strength increased slowly , but it gained with the time .The compounds produced with the chemical interactions densified the porous structure, there by the permeability decreased . Consequently the strength also increased. The structures became hard like stones. Decrease in permeability made them resistance against the chemical degradation , as there was significant decrease in the permeation ability.

The atmosphere was not so aggressive . Some of these monuments are still existing in good condition speaks about their durability and the skills of the ancient builders.
Today concrete is made with Portland cement as a binder. It hardens fast, gives high strength in short time., but it does not produce stable hydration products, which have natural balance like in the case of ancient concrete. Therefore there is no chemical stability in the structure: it is always prone to the chemical environment.. The demand of the houses was very big so these were constructed in very short time with out considering the long time durability aspect.

6. Modern Building Damage Details

Concrete

Concrete is made of a binder; cement, aggregates and water. . when it hardens water is evaporated and pores and capillaries are formed together with some micro-cracks. Thus it is not a flawless structure. The only thing is how to minimise these flaws. It is said;

If the concrete is produced with right amount and type of cement.
Right and good quality of aggregates
Right amount of water
Mixed properly
Cured according to the specifications.

There is no problem it will last for ages.

There are so many right in this case, There are not so many pure materials. There are impurities embedded in them.. Besides the atmosphere became more aggressive due to the urbanisation and atmospheric pollution.

Right amount of water , it means the amount of water required for complete hydration of cement, that all the cement particles have been hydrated. If there is less water, some cement particles will stay as fine aggregates. When this concrete will hardens and dried will be susceptible to the out side moisture. The particles will hydrate , the hydration products will crystallize . There will be movement inside the structure, concrete being hard to accommodate these volume changes , develops cracks.

If the water is more, it means that there is surplus water, this stays over the concrete cast surface. During hardening , the water evaporates and its place is taken by the air. It means the concrete becomes more porous. This will influence upon the strength and the durability.
If the aggregates are alkali sensitive, they will react chemically with the alkalis produced during the hydration of Portland cement and will firm, leachable salts, creating more porous structure . This makes easy penetration of the deleterious gasses and salts. The concrete looses the binder , strength decreases.
One of such examples is Ölands bridge in Sweden., only after 12 years damages were seen.. Salt water accelerates the reaction, deterioration process.

Danish stones , Sjostones have been used in several concrete constructions in Goteborg, mostly in the north east. In Hjälbo, the problem is solved by covering the damage with mortars. In Angered similar material is used.

High chloride content increases corrosion and frost damage in the winter time. The reinforcement corrosion takes place, creating expansion. The concrete develops cracks. Due to the volume expansion . The concrete is repaired with the material available .

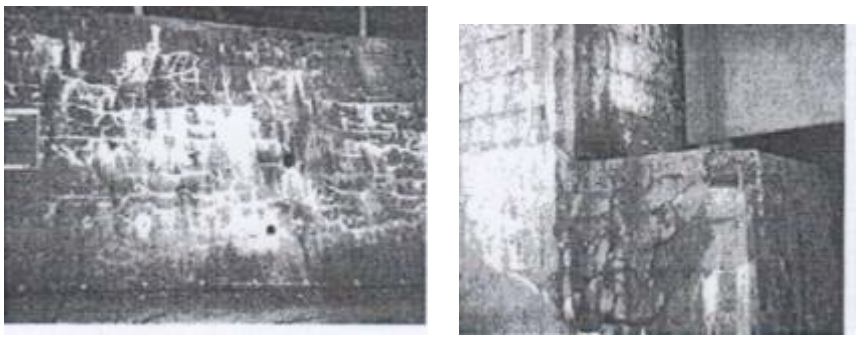
Figure 10 damage due to alkali aggregate reaction

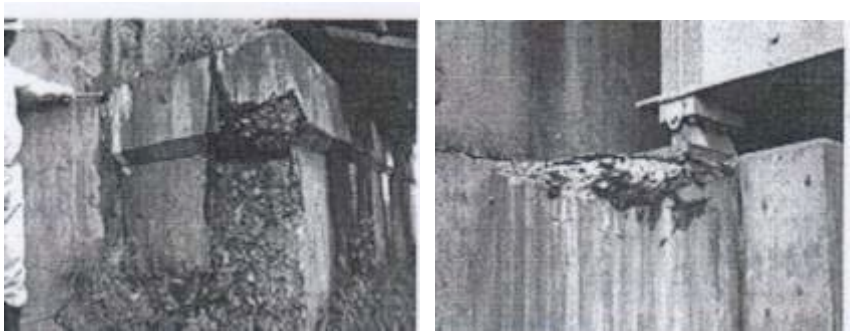
Figure 11. Damage due to freezing

7. Mechanism of damage

7.1 Interaction of pollutants with the cements

It has been known for a long time that some of these pollutants cause serious corrosion problems on metals, e.g SO_2 gas causes accelerated corrosion of steel and zinc . It is also known that the SO_2 g gas in the atmosphere causes corrosion to the calcarious stones converting them to gypsum. Furthermore this process is accelerated in the presence of NOx.

Atmospheric pollutants may deposit on the concrete in two ways.; namely dry and wet deposition. In dry deposition gaseous or particulate pollutant is first adhere to the surface of concrete. In the presence of moisture, fog it dissolves and is present as acid droplet and then enters into the concrete structure. These react chemically and produce water soluble salts which leach out and expansive salts, which crystallises, resulting in the cracks . These make easy penetration of the deleterious aero sols. In wet process these interact with the moisture ion the atmosphere and convert to the acid rain.

$3CaO.\ SiO_2 + H_2O \rightarrow \quad 2CaO.\ SiO_2\ H_2O + \ Ca(OH)_2$

$Ca(OH)_2\ ^{+}\ SO_2\ + H_2O \rightarrow\rightarrow \quad CaSO4.x\ H_2O$ (expansive salt) expansion 32%

$Ca(OH)_2\ + Cl2 + H_2O \rightarrow$ CaCl2 (leach out)
$Ca(OH)_2\ + NOx + H_2O \quad \rightarrow Ca(NO_3\ )2$ (Leach out9

$CaO.Al_2O_3\ + SO_2\ + H_2O \ \rightarrow CaO.Al_2O_3.\ CaSO_4\ 32\ H_2O$ (ettringite (132% expansion9

$CaO.Al_2O_3\ + Cl_2\ + H_2O \ \rightarrow CaO.Al_2O_3.\ CaCl_2\ x\ H_2O$ (Friedel salt)

Freidel salt + CO2 → Thaumesite CACCO3. xH2O.
Besides transformation from one crystal structure to the other also cause deletation.

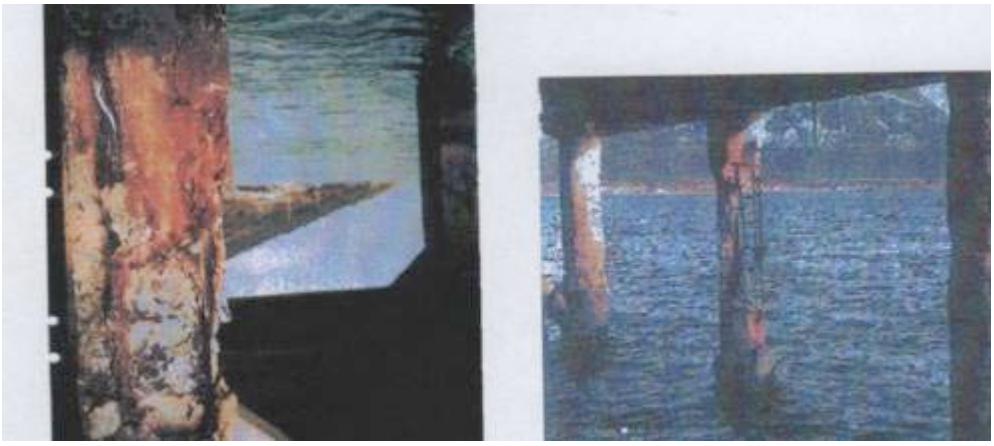

Figure 12 Photograph of pillar damaged by chlorides

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7.2 Ozone (O_3)

Ozone distribution varies very much. At certain situation the amount is very high. But because ozone is formed due to the photochemical reaction(which is controlled by light). Ozone has influence upon the organic materials. Paper will be dry, and fragile, the textile will loose its flexibility. High content of ozone does not have direct influence upon stone and metals., On the other hand indirectly it produces sulphuric acid. It is f9ormed through the auto mobile traffic. And transported through the south west winds.

7.3 NaCl, sea water (chlorides)

The air in the coastal area is laden with the salt, which interact with the components of concrete and damage it. This reaction is accelerated in the warm climate. This type of deterioration is very typical in the Gulf countries It also destroys reinforcement.

In the Figure 12 , a pillar of the bridge is shown, which was in grip of chloride from sea water.

The salt content is high in the coast area. It significantly decreases towards the country side. . This high salt content together with the moisture damages very much at west coast and Goteborg. by chemical interaction.

7.4 Temperature change

High temperature develops stresses in the stones and the metals. The chemical reactions are accelerated in warm climate. When the material is wet with the salt water and then dried, the salt crystallizes and falls. With the repetition of the process the salt solution becomes saturated , with increase in salt solution the crystallization takes place, creating expansion and consequently cracks are formed in the structure. With further increase there is re-crystallization takes place and bigger crystals are formed.. .big amount of salt crystals will be formed, which increases the volume creating stresses ,leading to the distortion of concrete In winter time with low temperature, freezing takes place and subsequently these are detached and fall out. these falls like flakes. This temperature variation is typical in the west coast in summer, the often it is warm in the day with the sun, and cool in the nights, in winter the temperature goes up to zero. After winter these damages are seen like white flakes over the concrete surface.

$CaCO3 + H2O \quad Ca(OH)2$

$Ca(OH)" + H2O + CO2 \quad CaCO3$

It is a general believe that the higher amount of cement will produce high strength concrete and will be more durable, but in the authors opinion it is not correct. Higher amount of cement create more durability problems. The reason is as follows;

Today the concrete is made with low water to cement ratio. Thus there is good amount of cement left, which is not hydrated. This is prone to the moisture. The new hydration products formed reacts with the pollutants, and produces leachable and expansive salt, These produces cracks and damages the structure.-

Figure 13 Temperature change, white flakes Figure Torpa stone house, frost damage

8. Air Pollution and Health

8.1 Health effects caused by air pollutants may range from subtle biochemical and physiological changes to difficulty in breathing, wheezing, coughing and aggravation of existing respiratory and cardiac conditions. These effects can result in increased medication use,

increased doctor or emergency room visits, more hospital admissions and premature deaths The human health effects of poor air quality are far reaching, but principally affect the body‘s respiratory system and the cardiovascular system. Individual reactions to air pollutants depend on the type of pollutant a person is exposed to, the degree of exposure , the individuals health status and genetics.

8.2 Water Pollution

More than 4 million gallons of glycols are used for de-icing at 93 airports during 1989-91, according to a survey by FAA, Glycols are the most voluminous water pollutants from the airports. There are over 500 certified airports in USA, the actual emitted may be more.

8.3 Indoor Climate

A lack of ventilation indoors concentrates air pollution where people often spend the majority of their tome. Radon (Rn) gas , a carcinogen, is exuded from the earth in certain locations and trapped inside houses. Building materials including carpeting and ply wood emit formaldehyde (H2CO) gas. Pint an solvent give off volatile organic compounds (VOC’s) as they dry. Lead paints can degenerate into dust and be inhaled. International air pollution is introduced with the use of air fresheners, incense, and other scented items. Controlled wood fires in stoves and fireplaces can add significant amounts of smoke particulates into the air, inside and out. Indoor pollution fatalities may be caused by using pesticides and other chemical sprays indoors without proper ventilations.

8.4 Carbon mono oxide

CO is poisoning and fatalities are often caused by faulty vents and chimneys, or by the burning of charcoal indoor. Chronic carbon monoxide poisoning can result even from poorly adjusted pilot lights. Traps are built into all domestic plumbing to keep sewer gas, hydrogen sulphide out of interiors. Clothing emits tetra-chloro-ethylene, or other dry cleaning fluids, for days after dry cleaning.

8.5 Asbestos

Though its use has been banned in many countries, the extensive use of asbestos in industrial and domestic environments in the past has left a potentially very dangerous material in many localities. Asbestosis is chronic inflammatory medical condition affecting the tissue of the lungs. It occurs after long term, heavy exposure to asbestos from asbestos containing materials in structures. Sufferers have severe dyspnoea (shortness of breath) and are at an increased risk regarding several different types of lung cancer. A clear explanation are not always stressed in non –technical literature , care should be taken to distinguish between several forms of relevant diseases. According to the world Health Organisation, these may defined as asbestoses, lung cancer, and mesothelioma (generally a very rare form of cancer, when more vide spread it is almost always associated with prolonged exposure to asbestos.

8.6 Biological Source

Biological sources of air pollution are also found indoors, as gasses and airborne particulates. Pets produce dander, people produce dust from minute skin flakes and decomposed hair, dust mites in bedding, carpeting and furniture produce enzymes and micron size faecal droppings, inhabitants emit methane , mould forms in walls and generates mycotoxines and spoies, air conditioning systems can incubate Legionaires disease and mold, and house plants , soil and surrounding gardens can produce pollen, dust and mold. Indoors, the lack of air circulation allows these air borne pollutants to accumulate more than they would otherwise occur in nature.

8.7 Energy saving

In order to save energy , keep warm houses three glass pan windows are used. This no doubt saves energy for warming up, but creates stagnant air indoors, the ventilation is influenced . The air indoors become dry . It influences upon the skin of the tenants. Most of the times people suffer from dry skin . Apart from this there is condensation close to the window frames. This damages the concrete around the windows. Due to the change of temperature and humidity the chemicals used in fast building decomposes and produce harmful elements like formaldehyde etc. This may cause headache, allergy etc.

The floors are also heated. This creates the salts which are in the wet state in the concrete to get saturated and crystallize on the surface, being not able to be transported out . They crystallize behind the wall paper. These are seen like a wet spot and when crystallization is advanced , they break through the wall paper or paint, and are seen like cracks.

It is seen in the churches. Before the heating was introduced the paintings were in good condition. The atmosphere inside was cool and refreshing, though it was cold. With warming up, the temperature inside is raised , it become comfortable for the visitors. But it has created problems for the paintings , building and the structure, inside climate.

The salts which are driven up with the water from the ground start accumulating over the surface of the paintings, it is seen like wet surface, spots over the walls. With advance the salt solution becomes saturated , and they start crystallizing over the surface, the painting becomes fed. Due to this warming , the convection currents are developed . There is temperature gradient , and moisture variation. This indoor climatic changes are harmful and have deleterious effect on the materials and

9. Case studies

This study was done on the bridges and the tunnels

Bridges

Influence of the pollution on the building materials was done at the Chalmers University of Technology. The salient features of the Studies are as follows,

In Sweden there re 25,000 bridges , of these 9000 are made of concrete. Approximately 100 million SEK per year are required for repair and maintenance.

A leading example ids the severe damage of the Euroes longest bridge Ölands bridge (length 6072 meters) The damage came only after 15 years of construction The cost of repair works was 300 million SEK and took 5 years to repair. The real cause of damage could not be establish. However it is estimated there are 2 main reasons;

Use of sea water for concrete mixing and the use of alkali sensitive aggregate from Denmark,

The buildings close to the industrial area are significantly more damage than those in the suburbs.

3 bridges were selected

9.1 Trollhattan bridge

The bridge is situated over the river Göta Älv. It was built in 1926 (Fig…14). The abutment, stiffening girders and arch beams are made of concrete , quality K350 and the rest with K200.

The hanger connect the arch and the stiffening girder. The concrete was repaired using epoxy base mortars.. It is seen that repaired layer ahs been detached, and the inside concrete is exposed. The concrete is deteriorated to the extend that the stone pieces can be picked up by hand.

Figure 14, Trollhattan Bridge

The main cause of the , stressed in this report is freezing and thawing in the presence of salts and other pollutant gasses

9.2 The Floby bridge

This is a railway bridge over a canal built in 1857. The bridge is resting on arches made of stones Fig… . It was deteriorated and in 1937, it was repaired by injection with cement paste . In 1951 a double railway track was constructed. During this time the bridge was widened and new edge beams were laid. In this case two types of damages are seen, one is the stones, and the other is the mortar joints. It is seen like thick white precipitate sitting hard over the stones surface., and over the joins.

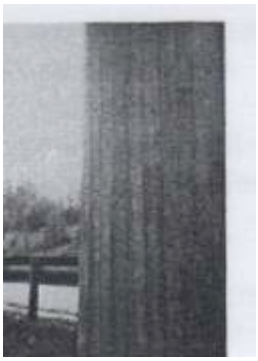
Figure 15, Floby Bridge

The other type is the damage over the concrete. The concrete edge beams seems to be repaired using a n epoxy resin at a later stage, which did not adhere to the concrete and was sitting hard like an adhesive tape holding the deteriorated concrete. The epoxy resin has built up a impermeable layer. This has created pressure in the old concrete resulting in pop outs and separation of the repaired layer. Figure shows further cracks.

9.3 Trannemo Bridge

This bridge is over highway. These columns are situated next to the highway. It was built in 1974 according to B5-65 and b5-68. There is discoloration over the piers facing the high way. Whereas on the other side there is not so much discoloration.. There were some cracks and some

chipping has started. Under the microscope it was observed that there was some dripping , which could be leaching of alkali, binder.



…
Figure 16; Trannemo Bridge

In another study, it was seen that the buildings close to the traffic lights were more damaged than on the highway. It is because of the accumulation and high concentration of the exhaust gasses from the vehicles.

9.4 Tunnels

It was seen that the tunnel which is ventilated has minimum damage, compare t the one without ventilation. The damage is due to the exhaust gasses from the vehicles.

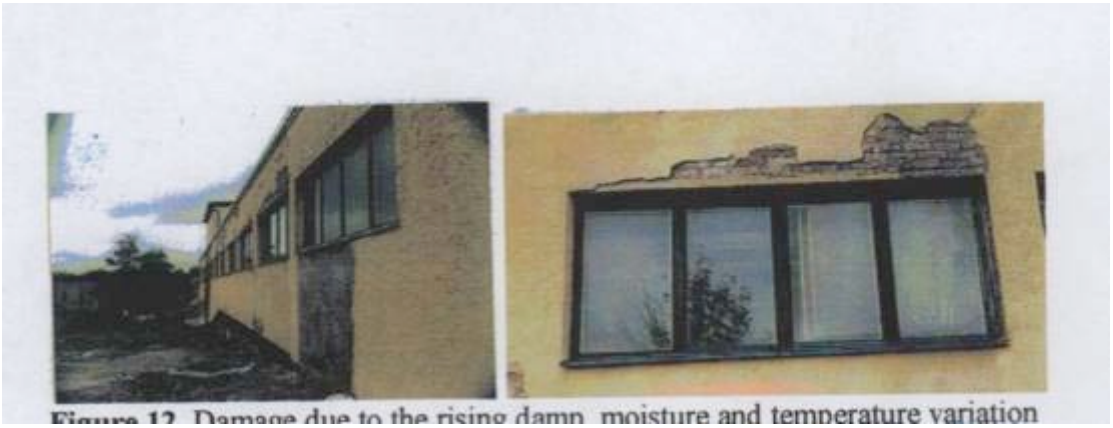


Figure 12. Damage due to the rising damp, moisture and temperature variation

10. Sustainable Construction Material

Kofi Annan, UN, secretary general said in 2002," We have the human and material resources needed to achieve sustainable developments, not as an abstract concept but as concept Reality" (18). Professionals involved in the cement and concrete industries have the responsibility to generate lasting innovations to protect both the industries future viability and the health of our environment... Due to the stricter environmental regulations, the disposal costs for by products are rapidly escalating. Recycling and creating sustainable construction designs not only

Contractors should reuse industrial by-products and post consumer wastes that should be considered for use in concrete includes glass, plastics, tires and aluminium, steel and tin cans The use of F/A in concrete began in the 1930's, but volcanic ash has been reused for mortars and concrete for several millenniums in Egypt, Italy, Greece, Mexico and India

One of the important benefits of the increased use of other cementitious materials I the reduction of GHGs emissions. With a replacement of cement with other recycle blends resources up to 15% of worldwide CO_2 emissions would be reduced. A replacement of 50% of cement worldwide by other cementitious material would reduce CO_2 emissions by 800 million tons. This is equal to removing approximately ¼ of all automobiles in the World (Malhotra 2004)

F/A availability in 2002 is estimated at 100 million tons, and in 2010 it is 160 million tons, While Portland cement availability in 2002 was 80 million tons, and in the 2010, it is 100 million tons. Production of 1 ton of Portland cement produces about 1 ton of GHGs (Malhotra 2004). One of the biggest threats to the sustainability of the cement industry is the dwindling mount o limestone in some geographical regions... As limestone becomes a limited source, employment and construction associated with the concrete industry will decline. Therefore those involved with these industries must develop new techniques for creating concrete with minimal use of limestone. Concrete production is not only a valuable source of societal development, but also a significant source of employment. Concrete is second only to water consumption in all materials consumed worldwide. About 3.5 billion cu yd of concrete was produced in 2002 worldwide. This equals to more than ½ cu yd of concrete produces per person worldwide. Therefore , to create not only sustainable societal development, but also to sustain employment, , the concrete industry must continue to evolve with the changing needs and expectations of the world.

Air pollution and Global warming is interweaved and cannot be divorced from each other
Till now the average temperature of mother earth has increased by 0.8 degrees, compare to the year 1900. if the increase will be 2 degrees C, according to some of the researchers 1.65 deg C, the planets climate will be out of bounds, It will result into more extreme weather, draughts, floods, land increase, leading to the increase in the poverty, and danger in the economic fall crash and the downfall of all the nations.[Goteborg Posten 16th Dec. 2009]

We also influence by acidifying the sea, fishing, forest cutting mountains.. etc. At the same time we have today more possibility to take care of this growing problem.
It has attracted the worlds attention so much so that the 2008 noble prize was allocated to the air , and was awarded to Mr. al Gore from USA and MR. R: Pachuari from India. .

And an international conference was organized to discuss the ways and means to curb the global worming at Copenhagen in December 2009.
To diminish the global warming the concentration should be given to the root cause of the air pollution and root them out, like in Ayurveda, "We treat the diseas3 and not the symptoms, like in the modern medicine, doing by-pass surgery when the cran-shell is not working, and not trying to regenerate it.
Industrial pollution can be controlled to a great extent by producing sustainable constructions, using alternative binders, industrial by-products, and recycle aggregates. It will contribute to the reduced disposal cost and will aid in the conservation of natural resources

It will decrease the green House Gas /GHGs) emission, reduce the fuel consumption and will produce sustainable concrete structures with long life. On top of this it will decrease th health hazards, saving enormous money needed for health care.
Aviation industry an other giant source of air pollution has formed a group, who acknowledges in its pledge that the efficiency and bringing down the carbon content of their fuel as overall are critical components of reducing global warming.
The reality is that so long the planes are flying , they need fuel, it is advisable to think of an alternative fuel that can alleviate the damage caused by fossil fuel extraction and combustion and benefit rather than tear apart local communiti4s and our environment.

An international survey reports that it costs 1% of the global BNP to stop heating
A new study by the world bank reports that the rich countries will develop deals only with 0.3% of the global BNP. A cheap life insurance.

Government Intervention

Government should focus on application of environment friendly technologies for all upcoming new projects in the fields of power and chemical sectors with attended energy efficiency. Emphasis should be given on conservation of power and minimization of burning of fossil fuels which ultimately reduces the emission of green house gasses to the atmosphere. City planning and industrial waste disposal norms should be stringent. Solid waste management and methane capture should be the integral part of upcoming construction sector and should be introduced as norms. Deforestation should be checked strictly. Stringent actions against deforestation and land clearing should be taken by the government, especially before setting up of new industry or especial economic zones. Government should launch new schemes for promotion of equipment bases upon renewable energy resources. R&D efforts on renewable energy domain should be strengthened. Stresses should be given on recyclable and degradable products.

The human and resources are available to combat air pollution and to achieve sustainable development, it is needed to join hands and investigate the means to achieve this goal.

References

Carl Eric Larsson, Influence of atmosphere on the cultural Heritage, B-Uppsats iu Archaelogy, Institute of Archaeology, Goteborg University, Examins arbete, (in Swedish), 2003
Chandra S, influence of Pollution on Mortars and Concrete, Document D6- 1990, Swedish council for Building research, Stockholm, Sweden, 1990, p77
Chandra S, Durability problems in concrete, 25th Int. Conf, Our World of Concrete and structures, Singapore, August 2000.
Chandra S, Sustainable waste management and recycling, ed. Limbachiya, M.C, 2004, Implications of using recycled construction demolition waste as aggregates in concrete p 105

Chandra S, Damage of concrete sleepers by calcium chloride, Cement and Concrete Research, vol. 12, 1983, pp87-92
Chandra S,, Use of Industrial by-products in Concrete Manufacture, publ. Noyes Publications. USA 1996

Concrete for Environment, Published on behalf of Nordic Network concrete for the Environment, Swedish National Research Institute, Borås, Sweden, June 2003, 8 p
Concrete thinking for a sustainable future, Cement association of Canada, http:// www. Ecement/cement.nsf/28BAAE6AB42AB69C85525467B60056B657?opendocument, May 2004.
Malhotra, V.M, Role of Supplementary Cementing materials and superplasticizers in reducing green house gas emissions, proc. ICFRC, Int.conf on Fibers composite, high s performance Concrete and Smart Materials, Chenbnai, India, Jan 2004, p4489-499

Naik, T.R, and Kraus, R.N, The role of flowable slurry in sustainable developments in civil engineering, proc. ASCE conf. on materials and structures- exploring the connections, Cincinanati, ohio, 1999, 9p
Sjunnesson,m J. Life cycle assessment of concrete, masters thesis 2005, Lund University, dept. of science

Time magazine August 26. 202, pA8

Concrete; Free Wikipedia Encyclopedia. http

Worrel, E. and Gglttisky, C,. Energy efficiency improvement and cost saving opportunities for cement making, Lawrence Berkley National Lab. Pub,l. nr. LBNNL, 5436, Jan 2004, 62p

Wu, Z, Development of High Performance Blended cement, PhD thesis, Advisor T.R.Naik, dept. of civil eng. and mechanics, college of engineering and applied sciences, USA 2000, 177 p.
Ships; Study ; ships big source of particulate pollution, Associated Press 27th Feb 2009

Goteborg Posten 16th Dec 2009

Acid Rain; Saving our Environment:Pollution_Acid Rain; http:///libary. Thinkquest.0rg/C0111401/acid_rain.htm

Car Exhaust, air Pollution and environment, health Effects of Exhaust chemicals, www.nutramed.com/environmental/cars.htm