Review Article

Strategies to Control Environmental Pollution through Detoxification of Toxic Gases by Chemical Processes

*Virendra Goswami**

Abstract

In the present investigation, the efforts are focused to discuss strategies to control environmental pollution (air, water, toxic gases) and control ozone layer depletion through conversion of toxic gases, particularly GHG (methane, CO_2) to ethanol by catalytic processes and develop hybrid fuels like bio-ethanol and bio-diesel and go for electricity from biomass and non-conventional energy sources, e.g., solar energy. The emission of CO_2 has been reduced by the absorption of CO_2 from air by di-π-cyclopentadienyl cobalt, $C_5H_5Co^+$ and methane got mitigated by converting it to non-toxic substance, e. g., ethanol/methanol by means of catalytic process. Also, efforts have been put to develop pollution control devices, e.g., catalyst-beds, and "carbon sinks" either by increasing forest cover or through chemisorption/absorption of CO_2 by chlorophyll-enriched transgenic plants.

Further, absorption-beds, (CoO)-catalyst converters, etc., for limiting greenhouse gases and inhibit the generation and widespread release of toxic chemical substances have been suggested along with magnetic refrigeration (MRT) using transition metal oxide catalysts (e.g., cobalt oxides) in correlation with the magnetic susceptibility values and the catalytic activity has been found an alternative of CFC.

Next, to study these chemical properties and control of GHG, the LIDAR techniques in combination with other chemical analysis as well as infra-red laser-atmosphere comprising of TEA (transversely excited atmospheric pressure) CO_2-LIDAR and NISAR (NASA-ISRO synthetic aperture radar) are to be used in future to study and control the environmental pollution and climate variability.

The emphasis in the proposed research has been given on the study of spatial and temporal resolutions of atmospheric aerosols and detoxification of toxic gases, e.g., GHG (CO, CH_4, nitrous oxide, CFC), i.e., particularly, greenhouse gases, vis-a-vis to find out the correlation between the physico-chemical characteristics (viz. magnetic susceptibility, surface area, chemisorption, DTA and catalytic activity through mitigation and detoxification of environmental pollutants and toxic gases, e.g., GHG, i.e., (methane,CO_2,CFC and ozone) in particular, by making use of the transition metal oxides catalysts, viz., cobalt oxides as selective catalyst-beds, MRT (magnetic refrigeration techniques), lunar cooling to control the global warming and climate variability.

Keywords: Environmental pollution detoxification, Toxic gases.

Introduction

Toxic gases e.g. particularly, greenhouse gases (GHS), viz., carbon-dioxide and methane, nitrous oxide, CFC (chloro-fluro carbon) are responsible for environmental pollution and polluting the air in particular affecting the health and resulting climate variability. The climate is getting adversely affected by toxic gases polluting the air to a very large extent. As per a report that appeared in the Times of India (TOI dated 17th Jun 2015), air pollution is killing 10,000 to 30,000 people in Delhi (India) each

*Visiting Scientist UNIDO, ICTP, ITALY&NCAR (USA), Expert Panel, NOAA (NASA), ICAO (Canada), UNV & AIU Rosters. Former Vice Chancellor, Sangam University & Sunrise University.

year, i.e., @ 80 deaths per day. Country-wide toll could be 4.0 lakh (four hundred thousand). This premature death toll is due to air pollution from respirable particulate matter (PM2.5), due to heart attacks and strokes. 85% of such deaths are avoidable if Delhi meets WHO's air quality standards.

The increase of temperature of earth surface has got direct relation with the rise of concentration of various toxic gases, e.g., greenhouse gases (GHS), viz., carbon-dioxide and methane, nitrous oxide, CFC (chloro-fluro carbons), resulting in major changes in various climate parameters such as absolute humidity and precipitation, annual rainfall and net terrestrial and global solar radiation including rise of the sea levels by melting of polar ice caps. GHG emissions and CO_2 emissions in particular are responsible for global warming.

This has been further authenticated by the 66th Nobel laureate meet in Lindau, Germany (HT 5th Jul 2015) ended with a signed "Mainau Declaration-2015" on climate change that made an emphatic appeal for climate protection with an agreement that there was overwhelming evidence that GHG emissions cause global warming. Brian P. Schmidt, Nobel laureate and spokesperson for the "Mainau Declaration-2015" said, "With this declaration, we outline the scale of the threat of climate change and we provide the best possible advice." He added that if left unchecked, the ever-increasing demand for food, water and energy would eventually overwhelm the earth's ability to satisfy the needs of humanity.

Hindustan Times dated 23rd Aug 2015 reports that most of the world's glaciers may disappear in the next century if, the environmental pollution is not checked by detoxification of toxic gases, particularly GHG. This is based on recalculation of the dates at which boulders were uncovered by melting Glaciers at the end of the last Ice Age.

It has been observed by Prof. Peter Clark, OSU College of Earth, Ocean and Atmospheric Sciences, that the glacier retreat was due to rising levels of carbon dioxide and other GHG, as opposed to other types of forces. Due to industrial revolution other human activities, carbon dioxide level has increased manifold than it was at that time. If this continues, then the most of glaciers would disappear in the next few centuries. Also, the glacier loss in future will contribute to rising sea levels and in some cases have an impact on local water supplies as well as give rise to water pollution as per the author's presumptions.

The above findings of Prof. Clark are based on recalculation of the ages at which more than 1100 glacier boulders from 159 glacial marines around the world were exposed to the atmosphere after being buried for thousands of years under ice. Prof. Peter says, "The data now show that as soon as HG level began to rise, the glaciers began to melt and retreat."

Ozone Layer Depletion

(a) These GHG absorb both short-wave and long-wave solar radiations and play a dominant role in the earth's thermal budget. O_2 absorbs solar radiation in 950–1200 mm wavelengths and contributes up to 7% of global warming. The 13% global warming has been reported by the troposphere O_3 during 1980–1990. The estimation shows that a 50% increase in tropospheric ozone would increase the global surface temperature by 0.3 °C. This is due to the growing use of petroleum fuel.

The formation of O_3 in the atmosphere is due to series of complex photochemical reactions energized by sunlight. The volatile hydrocarbons of non-methyl group and oxides of nitrogen and methane are the main reactants in the atmosphere participating in formation of ozone. The absorption capacity of O_3 per mole is approximately 2000 times more than that of CO_2. Although the stratospheric O_3 is of 90% in relation to the 10% in the troposphere, but on a per mole basis the radiative capacity of ozone molecules in the troposphere is much higher than that of stratospheric ozone.

Ozone concentrations have more than doubled over its pre-industrial concentrations of 15–20 ppm, and the rate of increase is 1–3% per year. The O_3 measurements made by using Dobson-Spectrophotometer show no precipitable increasing or decreasing trend in total O_3 amount and its vertical distribution but an increase in surface O_3 amount during sunlight hours indicating the photochemical production in the lower tropospheric exchange, turbulence and mixing in the boundary layer and increased anthropogenic gases. The change in the O_3

distribution may cause an alteration in the amount of solar ultraviolet radiation atmospheric circulation and weather.

(b) Ozone layer depletion (Hadley cell circulation): Climate change is inducing circulation pattern in the upper layer of the atmosphere (stratosphere and above) resulting in ozone concentration adversely.

Although, the study results of system of air quality weather forecasting and research (SAFAR), IITM, Pune, and as per the summary document of scientific assessment of ozone depletion published in 2014 by the United Nations Environment Program (UNEP) and the World Meteorological Organization (WMO) indicates the ozone layer to 1980 level before the middle of this century as regards to non-tropical regions of the world but due to severe climate change impacts on India and other tropical countries of the world are going to face the problem of ozone depletion by the end of the century due to changes in tropical circulation of winds (Hadley cell circulation). Dr. Beig (IITM) shares his findings that concentration of aerosols, suspension of the liquid droplets in the atmosphere often particulate air pollution, can negatively impact the ozone layers over the tropics because of their chemical properties.

Next, he added that emissions from fossil fuel, bio-fuels, industries and power sector are increasing tropospheric or ground-level ozone, which is a toxic gas, in India. The estimation shows that a 50% increase in tropospheric ozone would increase the global surface temperature by 0.3 °C.

Due to successful implementation of Montreal Protocol that mandated phasing out ozone-depleting substances, e.g., CFC (chloro-fluro carbons) used in refrigerators and air conditioners and solvents, the ozone problem has been tackled unto larger extent by through replacing CFC by HFC (hydro-fluro carbons) though do not harm ozone layer but, they are potent GHG and contribute heavily to global warming. GHG emission is growing @ 7% per year and this would contribute significantly to climate change in the next decade.

How to Mitigate Environmental Pollution and Climate Change?

It is our moral responsibility to save mother Earth from the adverse effects of climate change not only for our survival but for our future generations too.

China's New Anti-air Pollution Law

Under the earlier law, half of Beijing's lakhs of vehicles had been ordered off the roads to clean up the air by using a system of registration plate numbers to restrict some vehicles from plying on certain days in the major cities of China. However, this law has been reversed on 31st Aug 2015 with the introduction of a new anti-air pollution law wherein the Government will set up 15 remote sensors in Beijing to monitor vehicular pollution.

Similarly, we may also enact some laws suiting to our country within the framework of the Constitution of India.

Earthquakes Do Have Adverse Effects on Earth's Ecology vis-à-vis Climate Change

The Chinese study that appeared in *Times of India* dated 17th Jun 2015 states that the 7.8 magnitude quake that hit Nepal on 25th Apr 2015 (>8700 people killed), reversed the gradual north-easterly course of the world's highest peak to the southwest and moved the Mount Everest 3 cm (just over an inch) but did not change the height (8848 meters or 29,029 feet). The report of the China's National Administration of Surveying, Mapping and Geo Information found that Mount Everest had moved 40 cm to northeast over the past decade at a speed of 4 cm per year and risen 3 cm over the same period. The reason of this change attributes to Nepal which rests on a major fault line between two tectonic plates-one bearing India pushing northward into a plate carrying Europe and Asia @ 2 cm per year-the process that created the Himalayas. Prof. Roger Bilham, Geological Sciences, Univ. of Colorado, agreed with the Chinese findings with a rider of his e-mail note: "The Everest region was a mere bystander, and was pulled slightly by this movement by a few cms south and a little bit down."

NISAR-2020-21

To understand the Earth planet's processes and climate change, ISRO and NASA are jointly working on the NISAR, i.e., NASA-ISRO synthetic aperture radar mission is a joint project to co-develop and launch a dual-frequency synthetic aperture radar satellite (SARS). This is going to be the first radar imaging satellite to use dual frequency to be used for remote sensing to observe natural processes of the earth to understand earth's crust, global

ecological and climatologically changes (*Hindustan Times* 20th May 2015).

As per Dr. Kiran Kumar, Chairman ISRO, the target to launch NISAR is by 2020-21 by building the satellite by ISRO and payloads by NASA. ISRO plans seven launches till Mar 2016 including three for navigation with future plans to study asteroids.

The spectra of our efforts to mitigate adverse effects of climate variability ought to be scanned as below.

- Efforts are to be focused to convert GHG (methane, CO_2) to ethanol by catalytic processes and develop hybrid fuels like bio-ethanol and bio-diesel and go for electricity from biomass.
- Reduce the use of fossil fuels by replacing with non-conventional energy sources (NCES), i.e., non-fossil energy sources comprising nuclear, electric, wind, water, and solar energy (NEWS).

Mitigation of CO_2 Emission

i. By absorption of CO_2 from air by di-π-cyclopentadienyl cobalt, $C_5H_5Co^+$ and methane got mitigated by converting it to non-toxic substance, e.g., ethanol/methanol, by means of catalytic process.
ii. Efforts have been made to develop pollution control devices, e.g., catalyst-beds,
iii. Next, to study these chemical properties and control of GHG, the LIDAR techniques in combination with other chemical analysis as well as infra-red laser-atmosphere comprising of TEA (transversely excited atmospheric pressure) CO_2-LIDAR are to be used in future.
iv. Absorption-beds (CoO), catalyst converters, etc., for limiting greenhouse gases (GHS) and inhibiting the generation and widespread release of toxic chemical substances, have been suggested.
v. To create the "carbon sinks" either by increasing forest cover or through chemisorption/absorption of CO_2.
vi. CO_2 sequestration techniques.

Mitigation of CFC

In the author's view, the CFC can be replaced in refrigeration and air conditioning through magnetic cooling, i.e., magnetic refrigeration techniques (MRT) and through lunar cooling (LC) by harnessing lunar energy.

i. Magnetic refrigeration techniques (MRT) using transition metal oxide catalysts (e.g., cobalt oxides) in correlation with the magnetic susceptibility values and the catalytic activity have been found an alternative of CFC.
ii. Lunar cooling may be an alternative to replace CFC in refrigeration and air conditioning if one is able to harness lunar energy.

The emphasis to be given on the study of spatial and temporal resolutions of atmospheric aerosols and detoxification of GHG (CO, CH_4, nitrous oxide, CFC) to find out the computational correlation between the physico-chemical characteristics (viz., magnetic susceptibility, surface area, chemisorption, DTA and catalytic activity as well as chemical characteristics, e.g., reaction kinetics of hydrogenation, dehydrogenation, oxidation, reduction, mitigation and detoxification of GHG, i.e., (methane, CO_2, CFC and ozone), by making use of the transition metal oxide catalysts, viz., cobalt oxides as selective catalyst-beds, MRT (magnetic refrigeration techniques) to control the global warming.

Finally, computational correlation predicting models (CCPM) for detoxification of GHG may be developed through physico-chemical properties of solid catalysts.

The possible warming of climate due to greenhouse effect of increase in carbon-dioxide and methane, etc., can be lessened by reducing the incoming solar radiations by an overall increase in cloud cover due to increased transports from the oceans in tropical and mid-latitude regions.

Mitigation of Methane

i. Mitigation of methane by converting it to non-toxic substance, e.g., ethanol/methanol by means of catalytic process.
ii. To mitigate the emission of greenhouse gases (GHS) by improving energy efficiency and expanding renewable and clean energy technologies, viz., power generation from biomass, reducing the use of ozone depleting substances, and reduce carbon emissions.

Energy from Vibrations

IISC scientists have harnessed energy from vibrations. This harnessed vibration energy could power small LED lights, fire and smoke alarms, biomedical devices by harvesting energy using piezoelectric materials called poly vinylidine fluoride (PVDF) and stacking many PVDF layers one on the top of the other, which effectively generates more strain and thus more power.

Ambient vibrations and reverse energy: In the author's view, the ambient vibrations ever felt through the heavy vibrations from a heavy vehicle passing by, an aircraft flying at low levels, powerful water pumps, turbines, railway trains, an AC or fridge can be harvested to convert vibrations into energy resulting a source of clean energy.

Next, in the author's view, reverse energy be developed to use back the energy produced by the ambient vibrations back to run the ambient vibrations-producing devise directly or indirectly to substantiate the other systems of the devise.

Biofuel from Liquor Waste by Scottish Scientists

Edinburg-based Celtic Renewable plans to build up a production facility in central Scotland after manufacturing the first samples of bio-butanol from by-products of whisky fermentation. Scotland scientists are the first to produce biofuel capable of powering cars from residues of whisky industry.

The bacterial fermentation process known as acetone-butanol-ethanol (ABE), produces n-butanol and ethanol from starch. The ABE fermentation was first developed in UK a century ago, but died out in competition with the petrochemical industry. Bio-butanol is now recognized as an advanced bio-fuel, a direct replacement of petrol. The biofuel is produced from draff-the sugar rich kernels of barley soaked in water to facilitate the fermentation process necessary for whisky production and pot ale the copper-containing yeasty liquid that is left over following the distillation.

Scotland's distilleries currently produce around 750,000 tons of draff and 2 billion of pot ale annually. The technique could transform the Scottish whisky industry and generate upto100 million GBP of transport fuel a year, transport minister, Andrew Jones states.

UN's top climate change official, UNFCCC Executive Secretary, Christiana Figueres said, "I wish the solar impulse team the very best in their visionary endeavor. The plane's technology has become a symbol of humanity's ability to achieve a clean energy future and a leitmotif for ever higher ambition as nations prepare to conclude a universal climate agreement in Paris at the end of the year above all today's take-off provides a launch pad for the ultimate aim of the Paris agreement, namely, a long-term goal of climate neutrality in the second half of the century."

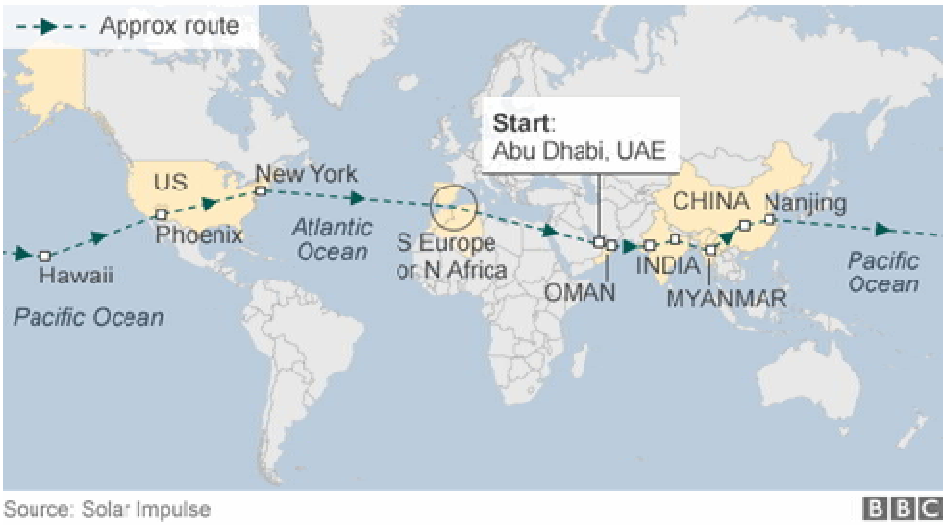
Solar Impulse Completes Longest Leg of Flight around the World

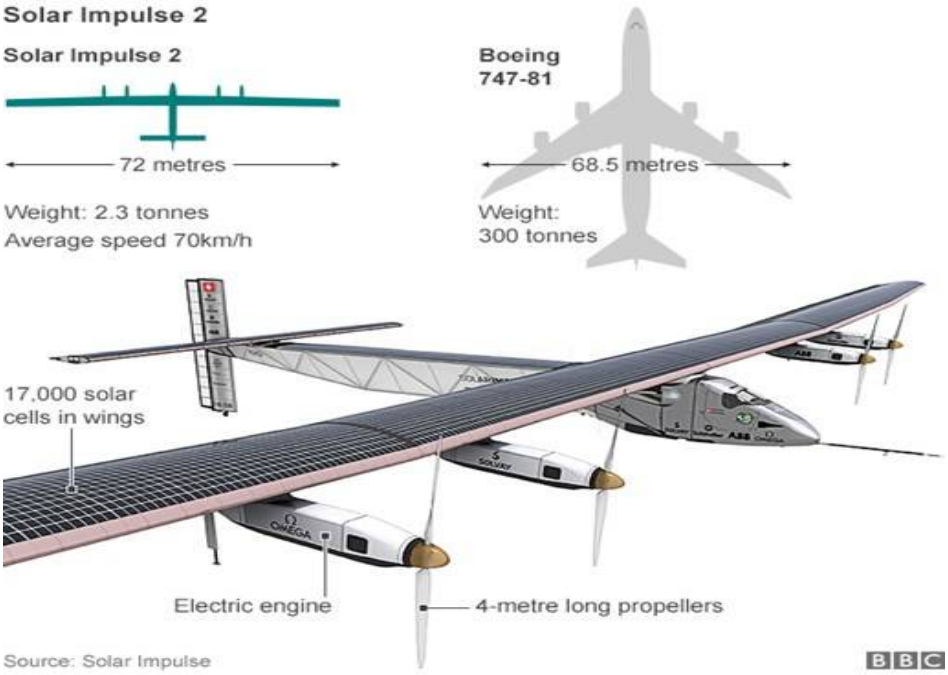
Solar Impulse, the only airplane of perpetual endurance able to fly day and night on solar power without a drop of fuel, has completed the longest leg of its flight around the world. On Friday, the aircraft touched down in Hawaii after crossing the Pacific Ocean from Nagoya, Japan, covering a distance of more than 8000 kilometers in five days and nights.

In this first round-the-world solar flight, pilots Bertrand Piccard, André Borschberg, and their team have set themselves the challenge to demonstrate how pioneering spirit, innovation and clean technologies can change the world.

The team also wants to draw attention to the need for an ambitious new, international climate change agreement this year, before they set out, the Solar Impulse-235,000 km journey around the world.

Solar Impulse 2: 35,000 km journey around the world





Electric Solar Sail to Be Used to Mine Water from Asteroids, Make Fuel

As appeared in London news, electric solar wind sail makes continuous bidirectional manned mars flight possible utilizing water mined from the asteroids. The electric solar wind sail provides propellant less transportation within the solar system, thus enabling economical asteroid mining. The e-sail invented first in Finland in 2006, utilizes long-charged tethers to convert natural solar wind momentum flux into spacecraft thrust.

After finding a suitable water-bearing asteroid, a mining unit could be sent by email to extract the water from asteroid soil. This can be done by heating the material and letting the evolving water vapor condense in a cool container. When the container is full, it is separated from the mining unit and transported with an email to the orbit of the Mars or Earth, where it splits into hydrogen and oxygen and liquefied. The liquid hydrogen/ oxygen (LH2/ LOX) fuel can be used to fill the tanks of manned vehicles travelling between Earth and Mars, researchers said.

Due to exponential nature of the rocket equation, intermediate tanking reduces the launch mass dramatically. During the trip, asteroid water could also be used as radiation shielding of the manned module to reduce the launch mass further.

ISRO's Lunar Manned Missions and View of Dr. VK Goswami

In the author's view, the above studies can be used by ISRO in future manned lunar missions, i.e., electric solar sail to be used to mine water from asteroids, make fuel. Also, water can be produced by the above techniques from asteroids. Next, LiH_2/LiOx be used to react with GHG, viz., CO_2 to convert into non-toxic and CH_4 be converted to ethanol fuel in the atmosphere and thus, control of global warming through chemical reactions and inhibit climate variability and environmental pollution.

Solar Powered Air Conditioning System

K Krishnaraj, an Engineering student of B. Tec. final year, Kerala, India, has developed an environment-friendly solar-powered device that will double up as an air conditioner in summer and a refrigeration system during winter. This technology is believed to reduce at least 40% of electricity bills.

He says, "The AC, like other solar-operated devices does not operate on panels. Instead of solar panels, the machine is fitted with parabolic trough, which is a solar concentrator, complete with methanol and activated carbon attached on the top. The benefit of this system is that methanol and activated carbon minimizes greenhouse effect, thereby increasing the cooling process.

"In a conventional system, a compressor driven by electricity is used to pump the refrigerant and then a solar panel converts solar energy into electricity. This drives the compressor that has lesser efficiency owing to loss of power during conversion. To overcome the maximum possible heat loss, we integrate a component called heat pipe. The carbon inside the bed absorbs the refrigerant (methanol) when it is at low temperature and releases it at high temperature. This principle is used to run the system."

Harnessing of lunar energy and lunar cooling: Based on the above Krishnaraj Studies (*Hindustan Times* 20th Sep 2015), the author is of the view that lunar energy can be harnessed and used for cooling and production of lunar AC and refrigeration as well.

Lunar cooling can be generated by either harnessing the lunar energy through lunar panes like solar panels or developing the lunar concentrator by using a parabolic trough like machine, perhaps complete with methanol and activated carbon attached on the top.

In all probability, this proposed system of lunar concentrator comprising methanol and activated carbon should minimize greenhouse effect, thereby increasing the cooling process.