An Innovative Ecological Step in the Cyclically Connected Pollution-Chain.

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ABSTRACT

Pollution and material degradation have some similarities in them, both being the cause and effect of each - other, in selected areas, as pollution makes the environment more aggressive, enhancing material degradation.

Ecological factors, like acid - rain, Ozone - depletion, caused by the pollution, Green - house gases, indiscriminate discharge of industrial wastes in rivers and seas, along with the enhanced level of U.V.B. radiation, make the environment more and more aggressive, showing the seeds of accelerated material degradation. In fact, it is meaningless, to try for any effective corrosion - control measure in a globally polluted environments, as pollution induced ecological mismatches may impose higher premium on the conventional corrosion - inhibition processes, till such time, the mismatches crosses the limit of reversibility, inflicting irreversible and non-elastic damages to the ecology.

This paper has discussed all these aspects, highlighting the correlation between industrial pollution, ecological imbalance and material degradation, along with the chain of events and their cyclic interactions and cumulative nature.

INTRODUCTION

This paper has discussed the aspects highlighting the correlations between the ecological imbalance, ecological pollution, material degradation, along with those of industrial pollution. It has highlighted the chain of events, their cyclic interconnected nature and their cumulative damage inflicted on the ecology, indicating the possibility of eco-materials, like ecometals, eco-barriers, non-metallic replacements and has hinted at the possibility of using eco-energies, like solar, wave, wind etc. in reducing the havoc from the fossil - fuel induced green house gases. Various remedial measures like, zero errosion technologies, recycling of wastes, utilization of wastes as by - products pollution control by using eco-materials, bacteria, gene - controlled plants and animals, algae, fungi, molecular traps of fullerine class compounds and the possible usages of bio -degradable consumables in both domestic and industrial applications, have been projected in proper perspective. It has been assumed that the use of various alternative pollution control measures, depending on the socio-economic status of a country, at a particular point of time. may solve this problem to a considerable extent, thereby minimizing the elastic ecological strains currently being sustained by the global environ. The aspect of holistic imbalances, touching on the socio-economic and socio-political planes has

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also been hinted. A concept of splitting to basic units and recombination as per the requirement of time and space, have been floated to redress the agonies of environmental pollution, Use of eco-materials and non-metallic replacements have been prescribed, for reducing the total anthropogenic activities for subsquent reduction of the emission of aggressive green-house gases, responsible for the extension of the ozone-hole.

TROPOSPHERIC - OZONE, LAYER, ECOLOGICAL POLLUTION AND MATERIAL DEGRADATION

In accordance with the provision of Montreal protocol on substances that deplete ozone-layer, the United Nation's environment programme (UNEP), developed as set of reports to provide an assessment of current knowledge of scientific, environmental, technical and economic matters, relevant to the implementation of the protocol. It has been confirmed that polluting industrial gases are responsible for the destruction of ozone-layer, Carbon-di-oxide (CO_2) being one of the major contributor in this process, a committee have been set up to restrict the emission of CO_2 to the 1990 levels, by the year 2000. But recent reports have confirmed a rise of 5% in CO_2 emission in developed countries U.S.A. appears to be a notable polluter of world environment, emitting 22.9% of the world's total emission, followed by China (13.3%), Russia (7.12%), Japan (5%), India (3.8%) and Germany (3.8%).

It has been stated that with depletion of ozone-layer, the atmosphere is becoming more and more transparent to solar ultra-violet radiations. Both the intensity and quality (wave length composition) of the ultra-violet - B (U-V-B) radiations, appear to be a salvage of urban domestic effluents and garbages, incineration of the domestic garbages and subsequent formation of useful composts and composities, is already picking up in a big way, both in the developed and developing countries.

Industrial gases, like CO_2 CO_2 NO_2 and chloroflurobrome compounds, also known as green house gases, have bee responsible for the formation of ozoneholes, over the arctic and Antarctic regions, enhacing the flux of the incident U-V-B radiations and hence cause overheating of the land-masses and terrestrial objects. Such overheating results in the oxidation of low melting metallic surfaces and in their degradation, along with the melting of the huge chunks of polar ice which extends the saline interface of the globe and increases the moisture content of the environment, both of which cause increased surface corrosion of the materials. It is argued that the massive Flichener Ronne and Ross (ice) shelves, for south of Antarctic peninsula, may eventually be affected, although the probability is very remote unless there is a huge rise in the atmospheric air temperature. In fact, the break up of the Antarctic peninsula ice-shelves, which are virtually the floating extension of the ground (ice street) has created a panic among the environmentalists, all around the globe. Scientists are scared about the huge ice-shelves, in and around the polar regions, to be succumbing to the same type of collapse, as on the Antarctic peninsular ice-shelves, resulting in the catastrophic annihilation and global submerging of our preciously nurtured human civilization. As such, the ecological imbalance in the tropospheric ozone layer is transmitted to the terrestrial material interfaces, through a series of interconnected events.

In a similar manner, quite a large number of other ecological interfaces may also be connected to industrial pollution and material degradation, through a number of cyclically interoven events. Acid-rain, caused by industrial pollution, aids in the destruction of plant life in land and aquatic domain in rivers and lakes, creating acidic interfaces, as a result of the decomposition of the destroyed organisms to low pH corrosive masses. This is added up to the already existing corrosive load due to acid-rain, making it synergistic and finally cumulative in time domain. The ecologically induced phenomena, like ozone - hole and acid-rain may thus be shown to be initiating the degradation of the environment and the materials therein of both metallic and non-metallic in nature. The possibility of depletion of the ground water level in the arid coastal land masses, affected by acid rain inviting the saline interfaces as a result of osmotic interactions, is another example of the interaction of the ecology and the materials. The saline interface may increase the salinity of the soil and affect degradation of the underground piping networks etc. in the region.

In its broadest sense, global changes is the study of the time dependant development, as a result of interaction between earth's geospheric, biospheric, hydrospheric, atmospheric and cryospheric systems. Much public and scientific interest stems from the possibility that significant manmade environmental changes may take place in future, over very short time scales, e.g., global - warming resulting from the burning of the fossil - fuels and degradation of tropical rain forests leading to partial polar ice-sheet-melting, sea-level rise and flooding of coastal region, including appearance of heavily polluted areas.

Time dependant global changes, like creation of new land-masses, melting of heavy ice-sheets, formation of larger inland - water bodies, glaciers, tundra - extension and spread of desert, along with the rapid quaternary climatic changes may however be brought under the broad spectrum of 'ecological 'changes' , although all of them cannot be termed as ecological imbalance or ecological pollution. Quite a good number of these changes are dependant on the ecological time and have helped the human civilization to consolidate their existence in this globe, in tune with the relevant dimensions of time and space. It is estimated that men started living in Europe, about 500,000 years, ago, while they started dispersing throughout the globe, 10,000 years ago. In fact, the global changes of geosphere, biosphere, hydrosphere, cryosphere and atmoshphere may be compared to the evolutionary changes, as observed in plant and animal -kingdom. Himan civilization has developed in different parts of this globe, adjusting themselves to these evolutionary changes of the ecology. The real problem of ecological imbalance have started very recently, due to the unabated pollution as a result of unplanned and uncared for industrial activities.

There had been three economic revolutions of global dimensions, namely, agricultural industrial and information and the mankind is on the verge of another revolution, which focuses on the environmental performance {1-3} and sustainability [1] as the primary necessities of economic growth and competitiveness. The recent environmental summit at Rio-De-Generio is only a manifestation of this global - trend. The earth summit's main achievement in 1992 was that it clearly established the inexeritable links between unsustainable growth pattern, environmental degradation and deepening poverty. Two legally binding protection norms have been highlighted in this summit, e.g. protection of biological diversity and protection of climatic changes. Convention on desertification, high sea fishing and setting up of a global environmental facility for the developing world, are the other off - shoots of this conference. It has been observed that one-quarter of the earth's surface is affected by desertification and about 300 million hectares of farm land have been spoiled by the use of presticides. It has been further observed that in spite of the world -wide increase of food production, about 800 million people suffer from hunger and mal-nutrition. Recent reports have indicated that 50,000 plants and animal species are expected to be lost every year. Of the 8,080 million hectares of forest cover in the world, 8000 years ago, only 3,044 million hectares remain today indicating an overall removal of two thirds of forest cover; the destruction being maximum over the last 5 years of urbanization. All these above statistics clearly indicate that poverty and dearth of fund are the two great polluters of this globe and what is required at this point of time, is the sustainable development of the potentialities of the people and of the mother nature, keeping in mind the basic needs of the people under poverty line, for food, shelter, water and energy. It appears further that the ecofriendly and environment friendly projects of the developing countries, should also take into account the sentimental and traditional interaction of the people with the environment.

Attention of scientists and technologists have recently been diverted to clean production processes, clean products, energy -efficiency, co-generation and pollution control measures. All these measures, require the modification of the existing process cycles for zero -waste, while the aspect of co-generation and pollution control methods. remain manipulative. As such, it is necessary to examine in deep and an objective manner the various environmental factors and their impacts on human civilization , so as to suggest possible remedies and adopt suitable interdisciplinary aproaches to the problem of environmental management for reducing the deleterious effects of man's activities in this century.

Waste - management and recyling of industrial wastes fall within broad category of prevention and control measures, although pollution prevention is pretty expensive. Pollution control processes are sometimes less expensive than the pollution prevention schemes. Prevention of polllution, particularly in industries, may be achieved by reducing the polllution load of the manufacturing processes to zero state, by following alternative eco-friendly route. Alternatively, it can also be achieved by efficient management of waste products by 100% recyling and generation of 100% eco-friendly by - products. On the contrary pollution control measures may be organized by the establishment of pollution control plants, attached to the existing industrial units, for release of nontoxic wastes to the environments.

Metallic degradation appears to have a direct cause and effect relationship with pollution, environmental pollution enhances the various factors, responsible for metallic corrosion. Ecological imbalances like, deforestation, irregular rainfall, ozone-depletion and green house effects enhances material degradation, as the polluted and imbalanced environments have a predominant component of in-built corrosivity in them., In fact, industrial pollution and metallic corrosion, may also be connected by a number of direct and indirect link, such that the inbuilt corrosivity of the industrially polluted environment and the metallic corrosion are well revealed. The same may be assumed to be applicable to the cycles of ecological - imbalance, ecological pollution, material degradation, industrial pollution and metallic corrosion, all of which appear to be connected to each other, through some well-knit cause and effect sequence. In fact, it is meaningless to try for an efficient inhibition-programme for metallic corrosion in an industrially polluted and ecologically degraded environment.

In this context, mention should also be made of the role of chemical engineers and their firms, who also have considerable responsibilities in the tackling of this socioeconomic global-menace, particularly in providing economical answers to cleaning of yesterday's wastes and tomorrow's pollution, by innovations like catalytic converters. reformulated gasoline, smoke-stack scrubbers, etc. for keeping this world clean, along with other calculated steps, like, synthetic replacements for rare depleted materials, more efficient processing and new recyling technologies.

This paper has highlighted, all these aspects in a systematic way, using some tailor made technological examples and events and also some selected experimental data.

Table -1 reveals the composition and ecological linkages of eco materials. eco-coatings and non-metallic replacements. Considering the huge quantities of materials being in use in this globe even a low rate of corrosion of these surfaces, may reduce thousands of tons of corrosion debris, a good part of which is toxic. Stainless steel and super alloys, being resistant to normal, modernately aggressive and highly aggressive environments. may be the preferred eco-materials, which may incidentally substitute the conventional carbon and low alloy steel materials. referred eco-coating may be cited as .V.D. C.V.D. ion-lated and laser torched over layers of transitional metals and refractory oxides and carbides. Non-metallic replacements specifically mean superior polymeric formulations, highly resistant to degradation and cable of replacing depleted and rare materials of strategic importance.

Fig.1 reveals the cumulative relationship between the industrial pollution, ecological imbalance and metallic corrosion. Industrial gases like CO_2 NO_2 SO_2 CO_2 and chloro, fluoro compounds, also known as green house gases extends ozone hole, thereby enhancing the incident flux of UVB radiation. The acidic gases also condense to form acid rain. Enhanced U-V-B radiation, not only cuases overheating and melting of polar-ice, causing an effective increase of saline interface, but also results in enhanced oxidation of polymeric materials and low melting metals and alloys.

Table-1
Eco-materials, eco-coatings and nonmetallic replacements

Sl. No.	Name of material	Composition of the material	Ecological-linkage
1.	a) Medium alloyed super alloy: Durimet 20.	Ni29 Cr20 MO2 Cu3 Mn 1.5 Si 1.5 Co. 7 Fe 42.4	Recommended for engineering and structural applications in aggressive environment, for reduced corrosion debris at substrate environment interface.
2.	Metallic coating (a) P.V.D. (b) C.V.D. (c) Ion-plating (d) Laser surfacing	(a) N_2, Ti, Al_2O_3 (b) TiC, Ti N (c) Ni, Cr (d) Ni, Cr, Ti, Ta, Zr	The eco-coatings generate very low extent of corrosion debris at metal-electrolyte interface and requires minimum number of replacements.
3.	Non-metallic coating Replacements (a) Polyeurathene (b) Epoxy-tar with MiO (c) Chlorinated rubber with Acrylic resin	(a) Iso cyanate based (b) Eposides with coal-tar bitumen (c) Chloroprene-class elastomeric compounds with acrylic-class polymeric resin.	Poly eurathane may be considered a pore free barrier, followed by that of the interpenetrating type chlorinated rubber with acrylic. These barriers produce very low corrosion debris.

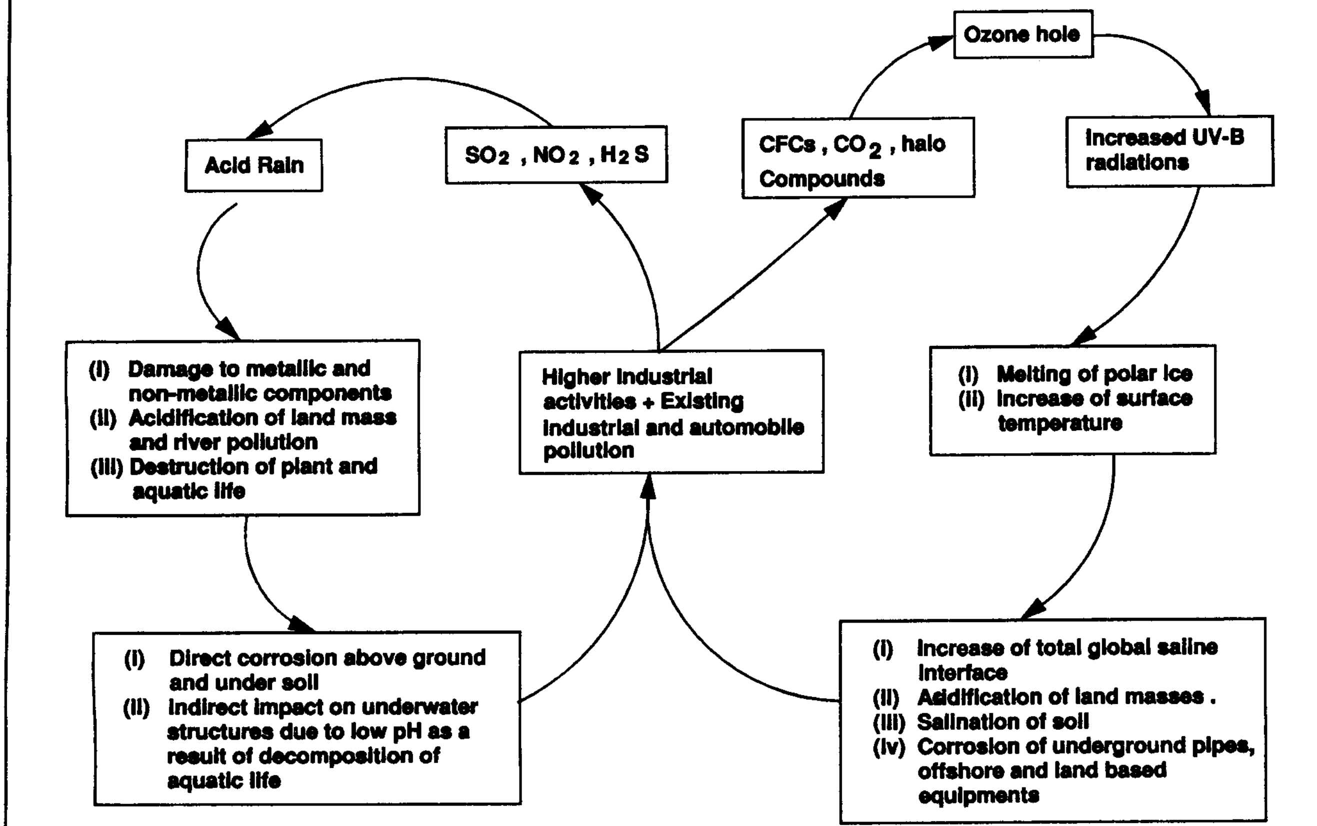

FIG.1 . CYCLICALLY CONNECTED EVENTS IN POLLUTION

It reveals the ecologically connected events and factors, related to pollution, corrosion and ecology. It is seen that corrosive industrial gases and emissions from the fossil-fuels, also known as green house, gases cause ozone-hole, which inturn resuts in the melting of polar - ice and increase of ground temperature. This results in an effective increase of the total global saline interface, acidification of land masses and salination of the soil, due to sea water ingress within the deleted water tables of the arid zones. All these combinedly result in the corrosion of underground pipes etc. in land and offshore based structures in sea. Higher industrial activities are to be resorted to replenish the damaged underground and offshore structures, generating fresh environmental load of CO_2 M_2O_2 SO_2 Cl_2 $F\text{-}B_2$ etc. Which indirectly assists in the extension of ozone - hole . This process continues more or less cyclically and may be termed as the viscous environmental cycle. Similar cyclic pattern may also be identified for acid-rain. formed due to the stratospheric condensation of the industrial green house gases. Acidic precipitation causes the dissolution of the metallic surfaces of the industrial equipments and components, exposed in environment, along with the acidification of land-masses. Pollution of river, destruction to plant-life and damage to aquatic life. There is also disordered rain fall pattern due to the destruction of the forest - cover, aiding in the process of acidification of land masses. As such, there is an overall intensification of the process of metallic corrosion, above ground, under soil and under water. There is also a synergistic interaction of the low pH acid rain, acidic decomposition of the plant and aquatic life and the elevated temperature of the arid- land-masses, in the overall process of material degradation. It again results in higher industrial acitivities for the replenishment of the damaged materials and subsequent emission of green house gases, which results in the further extension of ozone hole, creating another viscous cycle. Many other cycles of similar nature may be identified and recorded. Emissions of green house gases, appear to be the rate determining factor for such cycles. There is another slow step concealed in these process-cycles, which comprises of usage of eco-materials, eco-coatings and non-metallic replacements in place of conventional materials and coatings, such that fresh industrial activities may be kept to minimum for the frequent replenishment of damaged materials equipments. This will cause a break in the cycle and their cummulative interaction.

Use of super-alloy in pulp and paper industry, may actually usher in the solicited eco-step, such that generation of newer pollutants, will be checked. This remedy is not readily visualized, as the conventional system, allows the production of mild steel, carbon st eel and low alloy steel in a continuous stream generating millions of cubic meters of toxic manufacturing exhaust gases and considerable heavy metal particulates mixed with particulated iron-oxide rust.

Chlorine appear to be a key pollutant in paper-pulp industries. Use of eco-friendly bleaching agents, and utilization of electrolytic processes, for the insitu generation of H_2O_2 for the bleaching purposes may open up newer pastures in this field. Statistics indicate intensive chlorine related metallic degradation inside the paper mill and extensive chlorine pollution in the adjoining environment.

Application of newer chemical compounds of fluorine - class, may also be utilized for trapping hazardous wastes, utilizing their typical trap-like molecular structure. This may work efficiently, where bio-scanvengers do not work, as in the case of hazardous nuclear-wastes. Studies, conducted on pore-quality refractory oxides, like silica, have indicated that porous matrices may be doped with markepto - propylsilane, followed by thiogroup tagging, such that one end covalently bonds with metals like, Hg, As, Pb etc.

Pollution by thrown out plastic, polythene bags, containers etc. poses another problem,, as production of these materials cannot be fothwith stopped, in view of the fact that they are inexpensive, highly formidable and some are also very much inert. However introduction of protein -class and starchy materials in their formulation may usher in the age of bio-degradable plastics. There is also the probability of the food materials, being affected by the solubilization products of polymeric substances, except in the case of highly inert and stable materials, like teflon. Similar is the story of abondoned tyres, which can only be salvaged by making suitable composites, of them. Rubberizion of hard plastics and sofeting of hard elasto meric materials are other directions. Where considerable activities are being continued, using the technique of misalignment of molecular chain length. Proper utilization of the degraded and polluted materials, will not only improve the overall health of the ecology, but also create a more sustainable environment for the materials, reducing their degradation and overall rate of deterioration in a less polluted environment, which is inherently less corrosive.

Last but not the least, sustainable development of this globe may well reduce its comulative degradation by considering the human being as a part of this globe and not an outside entity and also keeping it fit for habitation for our children and the citizens of tomorrow. Better science and technology, rapid industrial development and higher standard of living, are definitely not a curse to the humanity, provided one does not allow the effluent societies, to create more of effluents. Sustainable development , holistic approach waste-management and ecofriendly technologies can not only reduce the degradation of this globe, but also the interconnected deteriorations of the materials, contained in it.

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