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Science and Ecology

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Abstract:

Unfortunately we are witnessing today a deformed and distorted sight of mother nature, due to centuries of misuse, abuse, exploitation fuelled by crass ignorance, gross insensitivity and the deep selfishness of humans. In the past science and technology often used to be projected as the whipping boy of this tragic turn of affairs. This paper is an attempt to discuss briefly the role various factors, particularly science and technology, have played in bringing about this sad degradation, and how this can be reversed, particularly with the help of science and technology. The author argues that these ecological problems are too complex, and the agents involved too many and too diverse to be attributed to just one or a few causes. Accordingly, any solution to this mammoth challenge calls for a collaborative effort from various power centres. The author is hopeful that the dangerous trend can still be reversed, and the damages can be repaired, particularly with the application of the existing findings of science and technology, and by developing appropriate new ones. However, an all-pervasive issue like this cannot be efficiently and effectively handled by science alone. It affects everyone, and everyone has a share in finding effective remedies.

Keywords:

Ecosystem, energy cycles, ecological degradation, eco-sensitivity, science.

Introduction

Nature, in its original, un-tampered state, was perhaps the most impressive and imposing masterpiece of the Creator. Not only was it noted for its amazing immensity, awe-inspiring majesty, captivating beauty and breath-taking variety, it was also remarkable as a self-sustaining, self-maintaining, self-repairing, balanced and harmonious system. When many primitive peoples in practically all civilizations surrendered to this nature in worship, they were not giving vent to any irrational streak, but rather were recognizing their insignificance before this awesome grandeur and might. But today unfortunately we are witnessing a deformed and distorted sight of mother nature, thanks to centuries of misuse, abuse, exploitation fuelled by crass ignorance, gross insensitivity and deep selfishness of humans. In the past science and technology often used to be projected as the whipping boy of this tragic turn of affairs. This paper is an attempt to discuss briefly the role various factors, particularly science and technology, have played in bringing about this sad degradation, and how this can be reversed, particularly with the help of science and technology. I will argue that these ecological problems are too complex, and the agents involved too many and diverse to be attributed to just one or a few causes. Accordingly, any solution to this mammoth challenge calls for a collaborative effort from various power centres.

The Making of the Ecosystem: A Scientific Perspective

Nature as a Balanced, Harmonious System

In ancient times people were so impressed by the balance and harmony of nature that they looked upon it very much as a living organism. In the Middle Ages as well, this tradition persisted. As late as the end of the sixteenth century saw Johannes Kepler, one of the founders of modern science, in some of his writings occasionally referring to nature as a living organism. Although this obviously was an exaggeration, there is no doubt that nature can be considered a well-regulated system. By definition a system is an arrangement of matter so related as to form a whole unit. Our planet earth, with all its different parts and surroundings, constitutes one large unit or

system. In this paper we are concerned with the ecosystem. Scholars point out that "the living organisms of a habitat and their non-living environment function together as one unit called the ecological system or ecosystem."[1] Our study will focus on the earth as an ecosystem. It has been estimated that there are some five million species of plants, animals and micro-organisms, all forming a vast interrelated network in our ecosystem of the earth. Such a system has two principal parts: the abiotic and the biotic. The abiotic component includes the atmosphere (air), hydrosphere (water) and lithosphere (soil), whereas the biotic component includes all living organisms that interact with each other and with the abiotic part. Both these parts, each influencing the other, are necessary for an ecosystem. An organism tries to maintain a stable internal environment irrespective of the nature of its external environment. Ecology is the study of the relationship of living organisms among themselves and with the environment. More specifically, it deals with the principles of survival, adaptability and reproduction common to life on our planet earth.

The ecosystem of our planet has a number of special characteristics. Perhaps the most striking one is its unity in diversity. Despite the large diversity and variety, we see a beautiful unity underlying our ecosystem. Close interconnectedness of the different parts is another distinguishing mark. It is a dynamic system teeming with activity, and hence requires a delicate balancing between the different elements and between the diverse interactions among them. Such a balanced, dynamic and coordinated system has certain checks and balances built into it, and can tolerate changes and fluctuations as long as they remain moderate and within certain bounds. As we shall see, ecological degradation sets in when these natural Lakshman Rekhas are ignored, opening the door to strong outside intrusions. Although the close-knittedness and interlinking are a blessing, they have a reverse side as well: any problem in one part will have its chain reaction in the other parts as well; any breakdown in one region can prepare the way for the eventual collapse of the whole system.

The Different Cycles in Nature

The deep level interconnectedness as well as the balancing and self-maintaining mechanism of our ecosystem can be best illustrated by a brief discussion of the different cycles operating in our system. In fact, these cyclic phenomena are primarily responsible for rendering the system self-sustaining and self-maintaining. It is thanks to these cycles that our ecosystem is able to preserve itself and support and sustain life and life activities. A cyclic phenomenon is one that repeats itself after a certain period of time. It involves many and varied complex processes and interactions, but at the end of them all, the system is restored to its starting point to begin the processes anew. These cyclic processes are absolutely essential for the survival of the ecosystem since it allows the reuse of the essential elements, and hence the system can manage with a finite amount of these essential elements. Without such a reusable system, nature would have been forced to produce almost an infinite amount of each essential item.

The Energy Cycle

The sun is almost the exclusive source of energy for the biosphere since 99.98% of the energy comes from it. But this energy has to be rendered usable by transferring it to the molecules that make up the various beings in the system. These processes are called the photochemical processes of which photosynthesis is the most important one. Photosynthesis is the process by which plants prepare their vital food with the help of light energy from the sun, carbon dioxide from the atmosphere and water and minerals from the soil, producing carbohydrates and releasing oxygen. Plants retain carbohydrates as food and give out oxygen into the atmosphere. The carbohydrates are converted into energy and are stored up in the form of chemical bonds. When animals consume plants (vegetables), they take in precisely this stored-up energy of the plants. When they breathe, they take in oxygen and give out carbon dioxide to be used by the plants.

Not all energy produced is used up for life processes. Some is stored in dead matter. Certain bacteria convert dead matter into organic sediments, releasing carbon dioxide, water and heat into

the biosphere. Again, plants take in this carbon dioxide and water to restart the cycle.

Heat Cycle

This is closely linked to the energy cycle since heat is but one form of energy. Heat is also supplied by the sun. A small part of it is absorbed by the ozone layer. Atmospheric water vapour, carbon dioxide and dust particles in the atmosphere absorb another fraction. The earth actually gets about 47% of the total heat coming from the sun. It is important that the absorption and re-radiation of heat by the earth should ultimately balance, since any imbalance will upset the dynamic equilibrium maintained by a healthy ecosystem. This balancing is regulated mainly by water vapour in the atmosphere.

Carbon Cycle

This is also closely related to the energy cycle since photosynthesis plays the key role in this process. Carbon is the most fundamental element for all organic substances. In fact, organic chemistry is fundamentally the scientific study of carbon compounds. In this cycle carbon, that is vital for all forms of life, is circulated from animals to plants and back to animals through plants. Plants take in carbon dioxide and produce carbohydrates with the help of sunlight through the process of photosynthesis, releasing oxygen at the same time; animals, on the other hand, take in carbohydrates as well as oxygen, and release carbon dioxide.

Oxygen Cycle

After nitrogen, oxygen is the most abundant gas in our atmosphere, making up about 21% of the atmospheric gases. According to some astronomers, in the initial production of oxygen the sun played the principal role since they say that the ultraviolet rays from the sun split up the water vapour surrounding the earth, releasing a large quantity of oxygen. This life-saving oxygen also undergoes a cyclic process: The breathing of animals and the combustion of dead-matter both take in oxygen and give out carbon dioxide, whereas plants take in carbon dioxide and give out oxygen.

A coordinated, balanced interplay of these two processes is necessary to keep the ecosystem healthy.

Nitrogen Cycle

With an abundance of 78%, nitrogen is the most abundant gas in the atmosphere. However, nitrogen in this form is unusable, and so has to be rendered usable by a process known us "nitrogen fixing," i.e., incorporating it into a chemical compound. This is usually done by converting nitrogen into ammonia or amino acids which can be used by plants and animals. This fixing is carried out on land by diazotrophs, organisms having the genetic code for the synthesis of the enzyme nitrogenase which serves as a catalyst for nitrogen fixation. Nitrogen that is locked up in dead plants and animals is decomposed by bacteria producing carbon dioxide, water and ammonia. This ammonia returns to the atmosphere, where it gets dissolved in rain water and returns to the earth.

Water Cycle

The importance of water needs no explanation since all beings in our system are heavily water-dependent. Fortunately we are able to manage with a finite amount of water, thanks to the water cycle. Water from the sea and land sources evaporates and goes up to produce cloud and precipitation, which come down to the earth as rain and snow.

The Atmosphere

The atmosphere, which extends up to 50 kilometers from the earth, is really a built-in protective system, serving the earth and its inhabitants as an insulating blanket. Among its many salutary functions, it softens the scorching heat coming from the sun by absorbing a part of it. Its ozone layer absorbs the most deleterious ultraviolet radiation from the sun, thereby protecting living organisms from extinction.

There are many other components making up the ecosystem of our planet. All these show that our system was initially established as a self-sustaining and self-maintaining, balanced, harmonious life-friendly system. It would have continued to be so for ages to come.

However, unfortunately today the situation has changed drastically for the worse, and is moving towards alarming levels.

Ecological Degradation

As we have seen, a delicate, precarious balancing of the numerous components and activities is the characteristic mark of an ecosystem, and it will remain healthy and vibrant as long as the different elements are kept within moderate bounds. The system is also capable of handling variations and changes up to certain limits. Once these limits are exceeded, degradation sets in. This indeed has already happened to the ecosystem of our planet. Perhaps the most obvious part of this disturbing process is pollution. In general, pollution involves the addition of any substance or form of energy to the environment at a rate faster than it is equipped to deal with by dispersion, breakdown, recycling, or storage in some acceptable form. Depending on its source, pollution can be of different types: air pollution, ground pollution, water pollution, etc.

Air Pollution

Our environment is constituted of many gases in different proportions. Since it is a dynamic system, a certain degree of fluctuation in the proportion is natural, and the system readily handles it. Air pollution occurs when gases, fine particles of solids, or finely dispersed liquid aerosols are released into the atmosphere at rates higher than its capacity to accommodate them through dissipation or through incorporation into the biosphere. As we shall see below, this problem has given rise to a very dangerous phenomenon known as acid rain.

Ground Pollution

This refers to pollution on the land. Ordinarily land is able to deal with certain fluctuations in its composition, usually with the help of microorganisms. Ground pollution sets in when the ground is unable to dispose of the addition of materials like solid wastes that cannot be broken down fast or at all. This can come about because of the removal of top soil from the ground, which leads to destruction of the fertility of the land, on the one hand, and over-

silting or sedimentation of rivers and streams on the other. It also has serious consequences for agriculture.

Ground pollution can happen because of the excessive use of pesticides, plastics and other chemical products. These too are often resistant to the action of soil bacteria. Furthermore, pesticides are often rain-resistant, and so cannot be dissolved in water, and so can survive for long periods.

Water Pollution

Although water is a very good solvent and so can dissolve many products, many modern synthetic and chemical products are indissoluble in water. Other items are substances coming from acid rain, silt from soil erosion, runoff from septic tanks, chemical wastes from industrial plants, sewage, etc. When a water source receiving such products is unable to dispose of these items either by breaking them down or through recycling, water pollution results.

Usually water contains bacteria capable of disintegrating foreign substances added to it. But if the matter from outside exceeds the limit, algal water blooms may be formed. When these die, their remains become additional organic waste, thereby rendering the water deficient in oxygen. This can give rise to a surge in the activity of organisms that do not need oxygen. Foul and unhealthy gases like methane, hydrogen sulphide are emitted, and the water becomes a source of stench and diseases.

Greenhouse Effect and Global Warming

A part of the electromagnetic radiation coming from the earth heats up the surface of the earth, inducing infrared radiation. Left alone, this infrared radiation would pass into space and would not have any serious harmful impact on the environment. Nitrogen and oxygen are non-greenhouse gases and do not absorb infrared radiation. However, there are small amounts of greenhouse gases also in the atmosphere which do absorb this radiation. There are over 30 such gases, the principal ones being carbon dioxide, methane, nitrous oxide, black carbon aerosols, ozone, chlorofluorocarbons(CFCs), hydrofluoro-carbons(HFCs), perfluorocarbons(PFCs), sulphur hexafluoride, etc. The radiation

absorbed by them heats up the air and the earth's atmosphere, just like the hot gases inside a greenhouse heats up the air, plants and soil inside. This phenomenon is called the greenhouse effect.

Of course, a certain amount of heat is necessary to warm up the earth and make it habitable for humans and other living beings. But an excess does serious harm to the earth and its inhabitants. For instance, it can give rise to increased climate volatility, resulting in more extreme weather conditions producing severe heat waves, droughts, etc. It also causes excessive melting of snow and ice and shrinkage of ice sheets. As water gets heated up, it expands, raising the sea levels. This can also give rise to ecological and medical problems.

Acid Rain

When fossil fuels like coal are burnt, sulphur dioxide and nitrogen oxides (nitrous and nitric oxides) are produced as waste. In the atmosphere these gases combine with oxygen and water vapour to form sulphuric and nitric acids. Furthermore, carbon dioxide in the atmosphere combines with moisture to form carbonic acid. These acids floating in the atmosphere get mixed with rain, snow, moisture, etc., and come down to the earth. This phenomenon is known as acid rain.

This acid rain has several harmful effects. It increases soil acidity and changes the chemistry of the soil. It can also increase the acidity of the water in lakes, rivers, etc., thereby making water unsuitable for fish and other wild life.

Ozone Layer Fracturing

The ozone concentration in the stratosphere (17-50 kilometers above the earth) forms a rather thin layer called the ozone layer which absorbs the ultraviolet radiation from the sun and protects the earth and living beings on it. In the stratosphere there are both ordinary oxygen and its isotope ozone. Until the middle of the 20th century the ozone layer remained intact, performing its function smoothly. An equilibrium condition existed, with the concentrations of both forms of oxygen remaining relatively constant. However, certain developments since then led to the destruction of a part of

the ozone collection and consequent thinning of the layer. A number of anthropogenic gases like nitric oxide from exhausts of aeroplanes, nitrogen fertilizers, industrial chemicals like chlorofluorocarbons, etc., can destroy ozone. Among these the role of CFC, invented in the 1930s as a substitute for ammonia in refrigerators, is very serious. Although in the lower atmosphere it remains stable, in the stratosphere it breaks down because of ultraviolet radiation, and chlorine is produced. This chlorine reacts with ozone to produce chlorine monoxide and oxygen. Thus ozone is converted into ordinary oxygen, thereby reducing the ozone concentration. The damage does not stop here. The chlorine monoxide is further broken down by ultraviolet radiation into chlorine and oxygen, to begin another round of breakdown of ozone. It has been estimated that, thanks to this chain reaction, a single chlorine atom trapped in the stratosphere can destroy 100,000 ozone molecules.

The rupturing of the ozone layer has serious consequences for us humans. For instance, it increases the incidence of skin cancer; it can increase the rate of eye diseases, etc.

Some Examples of Actual Environmental Pollution

All these different forms of pollution are rampant in our environment today, some having taken alarming proportions. For instance, it was reported in 2000 that the Chinese Shenyang Smeltry discharged 74,000 tons of sulphur dioxide and 67 tons of heavy metals annually. Fortunately, in June 2000 this monster was shut down. The US, the most industrialized nation in the world is also the world leader in the production of hazardous carbon dioxide, and it is projected that China may overtake the US in 2025 if it continues in its current state. In the year 2000 a study by Jonathan Levy and John D. Spengler reported that the emissions from a power station in Massachusetts could be linked to 43,000 asthma attacks and an estimated 159 premature deaths each year. The US uses 27-32 million kilograms of atrazine each year, thereby making it the most widely used weed killer. This chemical is reported to cause sexual abnormalities in frogs. Coming to India, deforestation due to tremendous pressure on land is a serious threat to ecology. It has been reported that in Orissa the Similipal Tiger Reservation Area

has suffered heavy deforestation due to the shifting cultivation of the tribals in that area. In Madhya Pradesh, it has been reported that the discharge of industrial waste from Brajarajnagar paper mill and from two others into the Mahanadi has increased the salinity of the water, and has given rise to cracks in the Hirakud Dam.

The Living Planet Report, published on October 1, 1998, by the World Wide Fund for Nature, the New Economic Foundation and the World Conservations Monitoring Centre at Cambridge, England, gives a number of revealing facts.[2] According to it, since 1960 the use of fresh water has doubled, thereby noting a sharp decline in the store of freshwater. Also carbon dioxide emission has doubled during this period. It also says that consumption of wood and paper has increased by two thirds. Side by side, consumption of sea fish has more than doubled. It also points out that few forests were managed sustainably. These statistics should serve as a serous eye-opener for anyone concerned about our ecosystem.

Causes of Ecological Degradation

What is the cause of ecological degradation? What factors have led our one time beautiful and healthy nature - praised for its beauty and grandeur, revered for its immensity and power – to degrade into a polluted and risk-ridden world? Ecology and related issues are too complex to be limited to any particular source or cause. Any simplified solution runs the risk of either missing the actual culprits or getting only a partial answer. Failure to diagnose the root cause(s) correctly is a sure path to the perpetuation of the problem.

Two extremes need to be steered clear of in this context: 1). Framing science as the whipping boy of ecological degradation, 2) Claiming that science is value-neutral and hence it has to be exonerated from all responsibility. When these two extremes are avoided and the matter is subjected to a fair and balanced reflection, one finds that a whole cluster of factors were responsible for this tragic state of our planet, and the real remedy rests in a concerted and coordinated effort of all these sectors.

The Principal Causes of Ecological Degradation

According to a recent study, "Environmental degradation is the result of the dynamic interplay of socio-economic, institutional and technological activities."[3] Obviously, technology which is closely linked to science is only one of the causes.

Social Factors

Over-population, pathetic poverty and fast urbanization are some of the primary social factors driving our environment to a crisis point. There has to be a healthy balance between population growth and the life support system. Any explosive growth in population forces people to exploit nature indiscriminately for their survival. A recent study shows that India supports 17% of the world population on just 2.4% of the world land area. Not only that, the population is growing at a high rate of 1.85%. Naturally, there is tremendous strain on the natural resources available.

Poverty is another key player in this tragedy. The linkage between poverty and abuse of nature is too well known to need any detailed discussion. In fact, poverty is both the cause and effect of ecological degradation: Poverty forces the poor to squeeze out every thing available in nature to meet the immediate need of survival, without any regard for the long-term consequences. Conversely, a depleted environment becomes unhealthy and becomes a source of sickness and more poverty.

Fast and reckless urbanization is another cause of ecological degradation. Drastic demographic changes are taking place in India and other countries in favour of urbanization. The village population is fast shrinking and the urban population swelling. This transformation has its ripple effect on ecology since this stretches the land and other resources in the urban areas to the maximum and leads to serious deterioration of living conditions. For instance, unsanitary slums are increasing both in number and volume. There has been an eightfold increase in urban population during the period 1901-1991. In India in 1971 the urban population was only 109 million; but by 2000 it has grown to over 300 million – an almost threefold increase![4]

Economic Factors

The role of economic factors in bringing about ecological problems is obvious and well known. A significant part of the problem has come from reckless and law-flouting industrial plants and projects. Many countries, including India, have good laws to prevent and remedy pollution. But enforcing these measures is expensive, and cuts deep into the profit margins of the owners. Profit-hungry entrepreneurs hardly care about implementing these regulations.

Again, poverty forces the poor to look for immediate gain and forget about the long-term consequences. Indiscriminate felling of trees, shifting cultivation on an extensive scale, etc., are some typical instances of this problem. Furthermore, lack of adequate funds prevents agencies from enforcing some of the measures necessary for environmental health.

Perhaps a very apt illustration of the role of economics in ecological degradation is the response of the United States and United Kingdom to the Kyoto Protocol, widely considered a landmark in the efforts of the international community to reverse ecological degradation. In December 1997, representatives from 160 signatory nations of the United Nations Framework Convention on Climate Change attended a meeting at Kyoto, Japan, and reached an agreement, called the Kyoto Protocol, to reduce global emission by about 5.2% for 2012. The European Union agreed to reduce it by an average 8% below the 1990 level and Japan by 6%. Initially the US agreed to reduce it by 7%. But later on it began dragging its feet on the matter, and finally went back on it. On September 25, 2005, UK also followed the US example. In both cases it was the economic factors that led them to make the wrong decision. The US said that "caps on energy use would damage its economy."[5]According to a study done by Wharton Econometric Forecasting Associates, "Kyoto Treaty would cost 2.4 million jobs; our country's Gross Domestic Product (GDP) would be reduced by 3.2%; prices would rise for food, housing, and heating."[6] Similar reasons were given by Mr.Tony Blair, the Prime Minister of UK. It may be noted that the United States is the world's largest carbon dioxide emitter. This fact flies in the face of Jack M. Hollander's principal thesis in his book, *The*

Real Environmental Crisis: Why Poverty, Not Affluence, Is the Environment's Number One Enemy, that "the rich can afford to preserve their environment, the poor have to exploit their environment ruinously to survive."[7]

Institutional Factors

In the building up and maintaining of a healthy environment individual attention and cooperation are vital, but not sufficient. Strong and sustained institutional effort and support are necessary. Most countries have ministers and departments to take care of these matters. In India, for instance, The Ministry of Environment and Forests is responsible for this job. However, often the efficiency and effectiveness of such governmental agencies are questionable. Besides, very frequently the enforcement capabilities of these agencies leave much to be desired. It has been reported that "the weakness of the existing system lies in the enforcement capabilities of environmental institutions, both at the centre and the state. There is no effective coordination amongst various Ministries/Institutions regarding integration of environmental concerns at the inception/ planning stage of the project."[8]

Science and Its Role in Ecological Degradation

The interface between science and ecology, particularly its role in precipitating the ecological crisis, is highly complex involving many aspects and defying any simple, straightforward analysis. That the linkage between science and ecology is complex becomes evident from the fact that science has both a positive and negative impact on ecological harmony and health.

Reference has already been made to the extreme and one-sided view of considering science as the whipping boy of the contemporary crisis in ecology. Such a view betrays a sheer lack of perception of the gravity and complexity of the problem. Often such a view has its genesis in the mistaken identification of science with technology. Technology is closely related to science, but the two are not identical. Technology is the practical application of science; technology is science's attempt to touch and transform the world around. However,

one can be an outstanding scientist without being a technocrat or technologist. Albert Einstein, for instance, made hardly any direct contribution to technology; yet he is considered one of the greatest scientists who ever lived. Furthermore, in the case of the ecological crisis more than technology is involved. Industry and industrialists play a crucial role in determining how technology is applied and for what purpose. Often monetary profit is the prime factor in their decisions. When this happens, ecological considerations become the casualty. The illustrative instances mentioned above bear this fact out.

The Positive Impact of Science on Ecology

1. Science and Its Positive Attitude towards Nature

A positive attitude towards nature is a necessary requirement for a healthy and balanced concern for the environment or ecology. This is obvious from the fact that all eco-friendly religions are marked by a positive and reverential attitude to nature. In fact, eco-friendly religions like Hinduism, Buddhism, etc., observe many customs and traditions to express this positive attitude and reverence. For instance, the bhumipujan (the ground-breaking ceremony for constructing a new building) ceremony in the Indian tradition has as one of its principal parts a prayer asking pardon for hurting mother earth. Kissing the ground on arrival to a new place is another custom along the same line.

It is important to underline the often forgotten fact of history that the birth of modern science was based on a positive understanding and appreciation of nature or the material universe. Although most of the founders of science openly expressed this point, Nicolas Copernicus and Johannes Kepler have expressed it most vividly. For instance, Copernicus writes about an almost divine-like status of the sun in his revolution-making *De Revolutionibus*: "The sun is not inappropriately called by some people the lantern of the universe, its mind by some others, and its ruler by still others. [Hermes] the Thrice Greatest labels it a visible god, and Sophocles's Electra, the all-seeing. Thus indeed, as though seated on a royal throne, the sun governs the family of planets revolving around it."[9] Kepler is even

more explicit. For him the material universe is something sacred since it is the "bright temple of God."[10] In his letter to David Fabricius, he stated: "For me nature aspires to divinity."[11] Indeed for him the material universe was truly the image of God, just as the human soul is: "The world is the corporeal image of God, whereas the soul is the incorporeal, though created image of God."[12] In his view God had ordained that the universe act and operate by the same laws as God's: "As God the Creator played, so he also taught nature, as his image, to play; and to play the very same game he played for her first."[13] That the positive attitude towards the material universe was an integral part of Kepler's life and thought was made unmistakably clear in his heated exchange with his friend Johannes Pistorius, a pious, traditional Jesuit priest who had a negative outlook towards the universe and life in it. Pistorius referred to life and activities in the present world as "inanities of the world." To this Kepler gave uncharacteristically a merciless and sharply-worded response. He went to the extent of saying that such an attitude was at the root of "the passionate factional fights, the views about personal beatitude, the roman claims about religious supremacy, the abuse of power, etc."[14] In some ways Isaac Newton also shared a similar positive view insofar as he believed that nature was the revelation of God, and we could go to God through the study and reflection on it. Thus most of the founders of modern science, if not all, had, in varying degrees, a very positive attitude towards the material universe. In fact, this is what motivated them to invest their valuable time and energy in the study of nature, although at that time the reward available was, in most cases, meagre and unattractive.

Since this positive attitude is at the root of both modern science and ecology, it is incorrect to look upon science as the villain of the environmental degradation today, as many often do. Science, one may say, was born to assist environmental concern, rather than resist it.

2. Recent Scientific Developments Should Promote Eco-Sensitivity

Many recent findings tell us that we are intimately inter-linked with the rest of the universe. We are all webbed together with a real bond of a common origin and common heritage. In a true sense we can join Francis of Assisi and say "Brother Sun, Sister Moon!" Science tells us that every atom in our body was in the womb of a sun-like star at some time in the past. Atoms like carbon, oxygen, phosphorus, etc., in our body could be manufactured only inside a star. Every material part of our body was inside some star some time ago. Francis of Assisi was right to call "Brother Sun." If he had known a bit more science, he would have called "Mother Sun, rather than brother sun."

Furthermore, evolution tells us that all living beings have a common origin from some primeval stuff. The developments in the genetic revolution reveal an even deeper bond. The Human Genome Project tells us that the DNA of all living beings is made up of the same 4 chemical base units: [Adenine(A), Guanine(G), Cytosine(C), Thymine(T)]. More interestingly, the genomes of living beings show very close similarity. For instance, the chimpanzee share 98.4% of the human genome;[15] Cows 90%, Mice 75%, Yeast 30%, E. Coli bacteria 15%. Indeed, all living beings are linked together closely. All are brothers and sisters in a real way. We cannot ignore or ill-treat other living beings. We need to have genuine concern for the rest of the living world. This is exactly what eco-sensitivity is all about. If science is taken seriously, if we go by scientific findings, we should become more concerned about the world around us.

3. Science as a Restorer of Eco-Health

There is no doubt that science and technology should own up some of the responsibility for ecological degradation. But this is only just one side of the issue. There is an often forgotten side: Science can and does play an important role in repairing the damage done to nature and restoring it to good health.

Ignorance is at the root of all ecological abuses, be it among the tribal and rural population or among the urban and literate societies.

Science goes a long way in remedying this serious deficiency. Proper knowledge and timely information are the necessary prerequisites for ensuring healthy environmental conditions. Science is making substantial contribution in this area. Thanks to science, today we know the seriousness of air pollution and other types of pollution, the importance of the ozone layer and our need to preserve it intact, etc. Scientific research can expose the possible dangers of seemingly harmless products. To cite one recent example, it has been found that MXC (Methoxychlor), a common pesticide developed as a safe alternative to DDT, has serious undesirable effects. A research team at the Yale School of Medicine found that MXC suppressed the expression of HOXA 10, an oestrogen-regulated gene, by up to 70%, thereby reducing the ability of the uterus to support pregnancy. Science needs to intensify its research in this field and share the findings with the public.

Science gives the knowledge and technology acts on it. Science not only.traces the source of the problem, but also points out how it can be counteracted, and technology makes this counteraction possible. It is no exaggeration to say that today science and technology are becoming the principal agents for nursing and restoring nature back to good health. For instance, with the help of science, many steps have been taken to reduce the pollution level, and the results are very encouraging. A NASA-funded study showed in December 2001 that the rate of growth of greenhouse emission slowed during the 20 years from 1980. In the reduction of CFCs also science is reported to have done laudable service. Currently technology-driven measures can reduce pollutants like methane cheaply and swiftly.

Fuel economy cars and other means of transportation are other ways in which science can contribute to the restoration of eco-health. Recently the Honda and Toyota companies have come up with remarkably fuel-efficient cars. Honda's Insight gives 61 miles per gallon, while Toyota's Prius gives 68 miles per gallon. It has been estimated that Insight produces only 3.1 tons of GGEC greenhouse gases for 15,000 annual miles, compared to 13.6 tons of Dodge Ram and 20.4 tons of Ferrari Enzo. We can expect even better results as science and technology make further advances.

Furthermore science helps in identifying cheap and naturally occurring alternatives. For instance, a recent study in India has revealed that the Vedic Indian plant Sanjivani has many salubrious effects. The findings of a team headed by Nand K. Sah of Madhav Institute of Technology, Gwalior, have shown that a bioactive compound extracted from it triggered biochemical reactants that can arrest genetic damage and produce longevity-giving anti-oxidants.

The Negative Impact of Science on Ecology

Although the negative impact of science on ecology comes mostly through technology, other factors also contribute to science's involvement in ecological degradation. As we have seen already, science began in an atmosphere of eco-friendliness. But in course of time certain developments in science, particularly during the period of classical science, poisoned this atmosphere, allowing vested interests to use science to advance their greed-driven agenda by indiscriminately exploiting nature.

1. Mechanical Philosophy of Nature

This was the official philosophy of science of classical science, according to which the universe was looked upon as a gigantic machine, governed by the laws, rules and methodology of the science of mechanics. Since mathematics was an integral part of Newton's mechanics, the rules and laws of mechanics were characterized by mathematical exactness, precision and objectivity. This universe was governed by blind and rigid laws of mechanics. Not only the material universe, but also the living world, including the human body, was reduced to lifeless machines. In the bargain nature lost its liveliness, dynamism and creativity.

2. Objectification of Nature

A natural consequence of this mechanical view was that nature was reduced to a mere object, detached from all relations to humans and human activities. Humans got alienated from nature. Science, the paradigm of human activity, too got alienated from nature. Once nature was turned into a mere unrelated object, all respect for nature began to wane and disappear. Nature became something that could

be used at will to gratify one's desires and needs, without feeling any qualms of conscience.

3. Technological Advances

It was at this time that many technological advances began to surface, allowing science to produce many new and attractive things people could use. Technology began expanding to practically all fields of human life and activity, offering new and easy means of comfort and convenience. Since these items added to the comfort and convenience of people, they became highly desirable, and the demand for them saw a sudden quantum jump. Such heavy demands put severe strains on nature's resources, leading the producers to do violence to nature. Denaturing of nature was the inevitable outcome. But since nature had already been reduced to a mere object, hardly anyone felt upset by this turn of events.

4. The Industrial Revolution

Industrial Revolution usually refers to the social and economic organization arising from the replacement of hand tools by machine and power tools, small-scale production by large-scale industrial production. It originated in England around 1760, but later spread swiftly to other nations as well. The Industrial Revolution came in at the nick of time to meet the burgeoning demand for commodities. For profit-hungry, principles-flouting industrialists this became a golden opportunity to promote their selfish agenda. Many important laws for the protection of nature and the environment were enacted, but this unscrupulous business world always found a way out. Natural resources were mercilessly exploited, with hardly any concern for the future of nature.

5. The Moral Responsibility of Science

Some scholars believe that science is value-neutral and hence cannot be held morally responsible for any harmful consequences. Their argument is based on the claim that the harmful effects, if any, are due to the misuse of science by human agents, and so those responsible for the misuse should be held accountable. It seems to me that science cannot be exonerated so easily. If science were to

be considered to be pure knowledge, perhaps this justification would be defensible. But science is far more than pure knowledge, it is an activity. It involves human activity that has impact on other humans and other beings. Also human activity involves intention or motive. Given all these, science cannot be considered amoral or morality-free.

It is often said that science is not responsible for the environmental degradation; technology is responsible, and science and technology are different. It is true that technology is the application of science, and hence the two are not the same. Still, science and scientists have to bear some responsibility for the application to which their work is put. Science and scientists cannot simply wash their hands of all the harm technology brings about. It is true however that their responsibility is limited and the actions they can take are also limited. This limited responsibility they need to accept with all its consequences.

This point can be seen from another perspective too. Today science and scientific institutions are well funded and highly respected. This was not always the case. Kepler died in utter poverty; so did many other scientists, particularly before the technological revolution. One principal reason why scientific institutions and scientists are well taken care of is that technology brings in huge amounts of money. If science and scientists get a share in the good technology produces, should they not also accept a share in the harm technology causes? It is true that once a scientific idea has moved into the hands of technologists, scientists cannot take it back or stop them from doing what they want. Yet I think that they have a responsibility to protest any harmful use made of their ideas, and since scientists are highly respected in our society, their voice will be heard.

It may be noted that many scientists have carried out admirably this duty of theirs, and quite effectively too. For instance, in 1992 more than 1700 scientists, including 102 Nobel laureates, from across the globe, assembled in the US to point out the breadth and depth of the environmental degradation that is taking place around us. The joint statement they put out had a profound impact on the world community. Many other instances can be given. Such activism and

awareness campaigns must continue and become stronger and firmer in the days to come.

Conclusion

The level of ecological degradation is serious and alarming, but it is not irredeemable. The dangerous trend can still be reversed, and the damages can be repaired, particularly with the application of the existing findings of science and technology, and by developing appropriate new ones. However, an all-pervasive issue like this cannot be efficiently and effectively handled by science alone. It affects everyone, and everyone has a share in creating this predicament. There needs to be an international collaboration and effort to meet this serious challenge. Fortunately many agencies, particularly the UN, are already seized of this situation, and are doing admirable work in this field. This should continue unabated, and needs to be intensified and expanded. Science and scientists cannot take an "I know nothing" attitude in this context, but have to be deeply and creatively involved in this necessary and noble task. Certainly we do not want to go back to the pre-modern science era of considering nature as a living organism like humans and animals. But we need to keep in mind that nature has a life of its own, a life that demands respect and care from all of us. We also need to remember, as our sages of old have taught us and as contemporary science confirms, we humans and nature are so intimately linked with each other that in this case of eco-struggle all stand to win or lose. If nature loses out, we too stand to suffer from it; if nature wins we too stand to profit from it. If we take appropriate care of nature, we will find a healthier and richer home in nature.

Notes

1. M.C. Dash, *Fundamentals of Ecology* (New Delhi: Tata McGraw-Hill Publication Co., 1996), p.27.
2. See *Britannica Book of the Year 1999* (Chicago: Encyclopedia Britannica Inc., 1999), p.213.
3. "The Underlying Causes of Environmental Degradation," http://indiabudget.nic.in/es98-99/chap1104.pdf
4. See *Ibid.*

5. David Adam, "Climate Change Talks Open a New Front," *The Hindu*, November 3, 2005, p.16.
6. Paul M. Weyrich, "Environmental Degradation and Evangelicals," in http://www. cnsnews.com/ViewCommentary.asp? Page=%5 Commentary%5Carchive%5C2005511%5CCOM20051118c.html
7. http://www.culturewars.org.uk/2003-02/hollander.htm
8. *Ibid.*
9. N. Copernicus, *On the Revolutions*, tr. Edward Rosen, ed. Jerzy Dobrzycki (Baltimore: Johns Hopkins University Press, 1978), p.22.
10. Carola Baumhardt (ed.), *Johannes Kepler: Life and Letters* (New York: Philosophical Library, 1951), p.32.
11. Kepler's letter to Fabricius, dated July 4, 1603, in Gesammelte Werke, ed. W. von Dyck, Max Casper, F. Hammer, M. List and Volker Bialas (Munich, 1937-), Vol. XIV, nr. 262, ll.495-496.
12. *Ibid.*, Vol. XIII, nr. 117: ll.295-296.
13. *Ibid.*, Vol. IV, p.246: ll. 23-24.
14. Job Kozhamthadam, *The Discovery of Kepler's Laws: The Interaction of Science, Philosophy and Religion* (Notre Dame: University of Notre Dame Press, 1994), p.38.
15. This figure seems to have been modified recently; some studies put the difference as much as 4%.

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Ahimsa: The Ecophilic Vision of Gandhi

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Abstract:

The author studies the profound notion of Ahimsa as the ecophilic vision of Gandhi and points to its role in dealing with the ecological crisis of today. He visualizes a new world of healthy individuals in a healthy community on a healthy planet, sharing with one another the bounty of the one Father and Mother of all. This is part of Gandhi's quest, his concern for *loka-sangraha*, his *seva* to *hari-jana*, his worship of Hari (God), his search for Truth, his faith in *advaita*. The Gandhian ashram embodies this search and anticipates in some way the goal of that search. Only when ecophilia is part of a greater search will it be truly effective. Only when our concern for ecology shapes our life-style will it be credible and transformative.

Keywords:

Ecophilia, M. K. Gandhi, Advaita, inter-relatedness, personal commitment, ashram, satyagraha, Mother Nature.