Guest Forum

Global Environment and Environmental Monitoring Technologies

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Requirements over the Earth and Humans, and Approach to Their Limits

The 21st Century is referred to as the environmental century. Humankind (Homo sapiens) is the only species with unique classification in the animal kingdom. Its population is increasing at a 2% annually and may reach 10 billion in 2060. Not only do humans have a dominating influence on the planet but also they are altering nature and greatly transforming the earth's biosphere. Our predecessors have already stated their concerns that our activities would eventually lead us to ruin. For example, it has been said that Albert Schweitzer more than 100 years ago stated that, "Man has lost his capacity to foresee and forecast. He will end by destroying the earth." "The Limits to Growth," produced by the Club of Rome 30 years ago, has been very accurate in forecasting developments in our society and anticipates major social changes in the mid-21st Century.

Resources and energy are certain to run out. For example, seawater has begun to seep into oil in the Ghawar oil field in Saudi Arabia, the world's biggest oil-producing country, indicating that a giant oil field in the Middle East is in the process of drying up. Once oil is gone we will have to use other energy resources of lower quality. Depletion of natural gas is also just around the corner, while drilling for MethaneHydrate (methane gas trapped inside cage-like crystal structures made up of water molecules) is nowhere in sight. Rapid increase in population and the development of heavy industries in Asia, South America and Africa will continue over the next two decades, which will see those economies engaged in competition to consume global energy and resources. Liquid fuel such as petroleum is vital to internal-combustion engines, but changes in the composition of primary energy resources due to the lack of liquid fuel would lead a vast change in transportation vehicles, giving us another opportunity for technological innovation in the automobile, shipping, and air industries. New environmental problems, however, would arise with this innovation. The prices of energy and other resources have already been escalating. The skyrocketing of petroleum, coal and iron ore prices which happened at the end of 2004 is considered to be the beginning of this price escalation. This kind of escalation of raw material price will lead to the escalation of the prices of fertilizer and agricultural equipment, causing decreased food production in nations poor in resources and also negatively affecting people's living conditions in those countries.

Concerns over food production in the 1970s were allayed by improving agricultural production with an improvement in seeds called "Green Revolution," and in the 1990s grains were produced excessively, grain prices dropped, and more and more acreage reduction was implemented in advanced countries. There are two different forecasts for future food production in light of the approaching global population of 10 billion: the optimistic outlook, and the pessimistic outlook. Optimists see no problem for global food supply because they say we still have land to be developed for agricultural use and they foresee further improvement in agricultural technology. On the other hand, pessimists say that increases in food production will be limited because deteriorations in environmental conditions will decrease agricultural production and there will be only a limited amount of technological innovation. Coming petroleum shortages will decrease operating rates of agricultural machines and will escalate the price of nitrogen fertilizer. As a result there is a high possibility that, assisted by a shortage of phosphorus resources, agricultural productivity will decline. Declines in agricultural productivity will also occur due to soil runoff and low water-retention ability resulting from excessive deforestation. Meanwhile, if development of agricultural land for increased production of food continues, it will eventually lead to global environmental destruction as well.

It is not easy to quantitatively estimate the health impact of environmental pollution. In advanced countries, the impact of environmental pollution on the human body is not manifest as an acute illness, but rather it reveals itself as the effect of long-term exposure to trace pollutants, and as such may potentially occur in the future as a chronic symptom, or have an effect on later generations. On the other hand, environmental pollution in developing countries is more obvious; there is far more visible evidence of the effects of pollution over the short term. These countries also suffer from a shortage of water and the drinking water they do have is of poor quality. The Yellow River, which was once the cradle of Chinese civilization, now has a shortage of water and the water supply to the northern part of China, including Beijing, is becoming more difficult both qualitatively and quantitatively. In India and Bangladesh large amounts of arsenic pollution have also been caused by the overuse of ground water.

It is not possible to deal with the three elements of food, resources, and environment independently because they are closely related to each other. The existence of societies of increased longevity, like that which Japan currently enjoys, has been realized by our use of hitherto sufficient energy, resources and food. We have to think what would happen to our society if any of those three elements started to disappear. For the preservation of the natural environment, it is also necessary for us to recognize that the earth does not belong only to human beings. We should think about the earth's ecosystem and live our lives humbly, sharing our resources evenly and solving global problems of poverty.

Lake Baikal:The World's Oldest Lake with the World's Largest Storage Capacity of Freshwater(©Pacific Press Service (PPS))
Lake Baikal is home to more than 1,000 endemic water species such as the Baikal seal, but recently water pollution due to industrialization of the surroundings has become a serious problem.

Preservation of the Environment: Strategies and Science/ Technologies

Preservation of the environment is a key issue to sustaining the human race. Is our hope that philosophy, religion and people's consciousness (which all question the ideal state of human beings) along with international politics, domestic politics and economics, have all begun to move toward an idea of environmental preservation.

It was the US state of California which took the initiative in environment policies in 1980s. The California still continues to implement its pioneering work, but since moving into the 1990s it has been the EU which has started taking the initiative at a bigger, federal-union level. The policy decision-makers' basic idea is that necessary technologies will be developed and realized when a new regulation or policy activity target is indicated. This can be considered as an appropriate strategy because thus far events have been unfolding in line with this idea. Precautionary principles towards suspected toxicants, the idea of "Mottainai" (too precious to waste), Zero Emission, and Best Available Technology continue to be adopted by society. Through legal regulations and internalization of environmental costs, social and economic approaches to environment preservation have been showing some effects. Practically, however, scientific and technological follow-up is required for this approach. The science for recognizing and forecasting future environmental issues and technologies to prevent environment pollution, such as environmental measurement, monitoring technology, and pollution control/remedy, should be synergistically combined and applied. The following shows some example issues in Japan.

Development of Science for Recognition of Environmental Issues

Classical environmental pollution reached its peak before 1970 and was dramatically reduced via implementation of measures against sources of pollution focusing on heavy and chemical industries. Concerns raised in the 1980s were air pollution in cities caused by transportation such as cars, and pollution in closed water areas caused by agriculture and dairy farming. Though these issues are slowly being resolved, there are some remaining problems such as that of particulate matter contained in exhaust gas from diesel vehicles and most recently nanometric particles. To alleviate problems with materials such as these we need not only to accumulate scientific knowledge about their physicochemical characteristics but also look into their biological impact on the environment.

Environmental pollution, which has a negative impact on health, is a top-priority issue. In the 1970s, the main issue was the outbreak of diseases referred to as "pollution-caused diseases," caused by high-level exposure of humans to toxic substances. In 1980s the issue of potential health risks caused by long-term low-level exposure arose. One of risks is that of carcinogens. Carcinogenesis is a disease caused by genetic damage; the disease develops following the build up of genetic damage through long-term exposure. Although the carcinogenic potential of asbestos was recognized around 1980, cases of specific mesothelioma with poor prognosis have begun to increase recently, 25 years later. In response to these carcinogenic substances, in the 1990s the Clean Water Act and Clean Air Act were revised, opening the way to exposure prevention for certain substances. With the proliferation of chemical industries it is thought that more than 100,000 different kinds of chemical products are currently on the market, and it is no easy task to keep them under control. Under the Water Pollution Prevention Law and Clean Air Act there are more than 100 kinds of substances to be regulated and/or monitored, and there are still another 300 kinds of substances listed as items to be investigated at the preliminary level; efficient measurement systems for investigating these substances are still required.

What has been receiving people's attention since mid-1990s in relation to dioxin issues is the need to prevent negative effects on reproduction and the health of the next generation. An example is the issue of what we call "environmental endocrine disrupters." It has been pointed out that a small amount of a chemical substance acting on a highly-sensitive mother, unborn baby, or infant, could possibly cause damage, such as a reduction in reproductive ability, abnormal immunity and reduction in intelligence, which would then affect the next generation. For example, some people are concerned about the influence of mass-produced chemicals such as bisphenol-A, phthalate esters and alkyl phenols, based on what has been learned from certain animal study data that shows even a slight amount of those chemicals produce reactions in animals. However there are also other people who disagree on the issue of toxic potential. The progress of science towards measurement as well as toxic evaluation is a necessity, as is always keeping in mind the precautionary principle, and the building up of an early-warning system. As new toxicological approaches, focusing on toxicogenomics[*1] and receptor binding, are developed, it is desirable to use them for preliminary toxic evaluation.

***1**:A word coined from combining "toxicology" and "genomics." Toxicogenomics is a toxicity evaluation method in which a database is created of gene-expression patterns for substances that have a history of side effects in human or animal tissue. This database is then used as a reference point when comparing gene-expression patterns to predict potential side effects in substances whose side effects are as yet unknown. It has been developed as a new method to understand hazardous effects and their mechanism of various chemical substances.

It is not only the effect on humans we must consider - the effects on wildlife are extremely important. We have been losing precious living species from the earth at a very rapid rate. Habitat loss is posited as the major cause of this, but the effects of hazardous materials are also to blame. There is a distinct role for science in the preservation of living species.

There are many issues that science has yet to solve, such as global warming and accompanying climate change, depletion of the ozone layer, marine pollution, and the mysteries of the deep subterranean. Our knowledge and understanding on our own planet is far from sufficient.

Environmental Measurement and Monitoring Technologies

Technologies for environmental measurement and monitoring have been progressed dramatically over the past 30 years. We have seen the development of gas analysis methods as part of air pollution measures, and various sensors for monitoring water quality. In addition, analytical atomic spectrometry and mass spectrometry (associated with heavy-metal contamination), as well as gas chromatograph mass spectrometry and liquid chromatography mass spectrometry (associated with organic contamination) have been supporting the development of early detection/warning systems. As part of the UN Environmental Program (UNEP) which was aimed at expanding local-level monitoring to the global level, the GEMS Plan (Global Environmental Monitoring System) was proposed back in the 1970s and implemented as GEMS-AIR, GEMS-WATER, and HEAL (Human Exposure Assessment Location). Recently, the program has been expanding its area of influence to cover, amongst other things, global warming and depletion of the ozone layer, acid rain monitoring and marine pollution from land-based sources. Persistent organic pollutants (POPs) have become subject to international treaty and we are now on the path to the implementation of worldwide emission limitation and monitoring standards.

Along with the development of information technology, on-site real-time monitoring has also been advancing and soon it will no longer be a dream to both carry out measurements and communicate using cell-phones. Source-monitoring technology by FT/IR, etc., such as for monitoring the emissions from a running diesel vehicle or an industrial waste incinerator chimney using the laser light back scattering method will also become possible. Remote sensing with satellite has shown position resolution of less than 1 m, and optical spectral

analysis has made it possible to analyze the planet's surface material qualitatively and quantitatively. For example, the imaging of vegetation has been carried out using chlorophyll absorption in visible bands. Using spectroscopy with sunlight as a light source we can obtain information on the atmospheric distribution of molecular species in terrestrial airspace.
Environmental monitoring is essential for prevention of environmental pollution, as well as for studying countermeasure effectiveness. Moreover, the monitoring must develop constantly, always taking into account that new environmental issues are going to arise along with the development of nanotechnology and other new technologies.

Pollution Prevention Technology and Pollution Remedy Technology

The measures taken to deal with and reduce pollution at the source have improved through the development of technologies for exhaust gas emission processing and wastewater treatment, and have regaled in such names as "The Solution to Pollution is Dilution" and "End of Pipe." Currently the range of environment technologies we need to consider has become wider, from prevention of environment pollution to environment remedies and environment-creating technologies. With regard to toxic substances for example, we have been developing not only leak prevention and analysis/processing technologies but also replacement goods and replacement technologies. As a global environment measure, technology is being applied to allow the generation of energy with increased efficiency and no carbon dioxide emission.

Although landfill disposal of waste to segregate pollutants seems to be a kind of postponement of the problem, it has opened the way toward permanent treatment and recycling. In a sense, it can be said that the joint problem resolution process of "the entrance" fossil fuels and "the exit" waste issue is the right way to look at the problem. At the same time, persistent technology development is needed to reduce the effects on the environment.
On the other hand, treatment of negative products from the past, i.e. POPs such as PCB, old military chemical weapons, and heavy metals in soil and oil contamination is also becoming important. There is an issue of how much money should be spent to deal with this negative legacy, but we must implement the process in order to be able to expect sufficient effectiveness in regeneration of the environment. The recognition of dioxin as a social problem in mid-1990s has produced, in Japan, the world's most advanced incineration technology. Though some people complain, saying it is too costly; it is probably the only option for a country with limited land and high population density.
The market scale of Japan's environmental industry is considered as approximately 5% of Gross National Product (GNP), but this is a very worthwhile investment when one considers that technologies produced in this industry can help the improvement of the world environment.

Anmon Waterfall in the Shirakami Mountain Range (©Pacific Press Service (PPS))
Covered by a vast beech forest, the Shirakami mountain range remains almost unchanged from how it was in ancient times.

Conclusion

We need comprehensive solutions to resource, energy and food issues as well as environmental issues at the global and local level. Because many of these issues are the result of movement - humans transporting substances, or themselves - an approach that monitors and controls this movement is likely to be effective. It may be possible to solve environmental problems systematically by inputting all kinds of information - such as information about the usage cycle of resources and energy, data gained from observation of the earth by satellite as well as microanalysis, information concerning the impact (including toxic effects) on humans and other creatures, and geographical information - into a supercomputer. It should be noted that in a large number of cases, tragedies occur during the transitional stage of problem-resolution technology development. Utilization of new energies also has a risk of causing unexpected major environmental problems at the same time, so vigilance is paramount.