Anti-global warming technologies

Water and carbon dioxide are two key materials which govern the future of the global environment. The reason why this is so is because while both existence in abundance all over the planet, they circulate around the earth in many different forms, and their presence and form influence the global environment and determine whether or not the human race is capable of sustained development. AIST is involved in a program of research designed to learn about the behavior of such critical materials and discover ways of addressing the environmental problems which occur as a result of their movement.

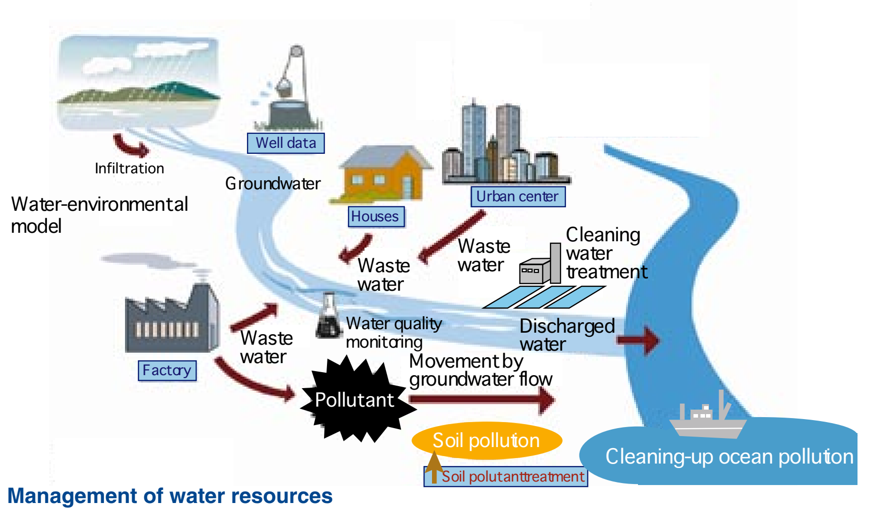
The twenty-first century as the century of water

It has been said that the twenty-first century will be the century of water. At the World Water Forum held in March 2003 in Kyoto, a statement was issued which said that the prioritization of water issues was an urgent global requirement because water is a driving force for sustainable development and the eradication of poverty and hunger and because it is indispensable for human health and welfare. The ministerial declaration issued at the WWF states that it is necessary to each country to act on its own in regards to the management of water resources and the sharing of benefits, ensuring safe drinking water and sanitation, providing water for food and rural development, preventing of water pollution and conserving local ecosystems, and disaster mitigation and crisis management.

The importance of developing forecasts of underground water resources in the Yellow River basin

As part of the Ministry of Education, Culture, Sports, Science and Technology's Kyousei Project, AIST has been assigned the task of constructing a model of the circulation of underground water in the Yellow River basin and developing forecasts of future underground water resources. In this project AIST will perform local hydrological surveys, construct models of underground water flows, and develop forecasts of future underground water resources to assess the role played by underground water basins in the circulation of water in this massive river system. The remarkable economic development of China which has made it come to be referred to as the world's factory, together with the movement of the population to urban centers, the transformation of the land, and the accompanying increase in the demand for water and the fragility of underground water resources are all such that when these factors are viewed in relation to their possible economic effects there is a danger that events in China could seriously affect Japan and eventually the entire world. Forecasting the future of underground water resources in the Yellow River basin is important as a basic element in considering global issues such as these.

One of the databases maintained at AIST is a database on underground water resources called the *Idojibiki*, or Well Database. This database has been constructed by collecting data on well water properties, boring cores, water quality and geological properties of bedrock formations and by creating links to databases of other organizations to provide a richer variety of data. AIST is also working together in conjunction with geological survey institutes and water resource authorities in Southeast Asia to create an underground water and hydrological database for the region which is expected to be completed in 2004. These basic research data could prove useful in addressing global environmental problems, managing water across national boundaries, evaluating the effects of urbanization, and infrastructure planning.



Management of water resources

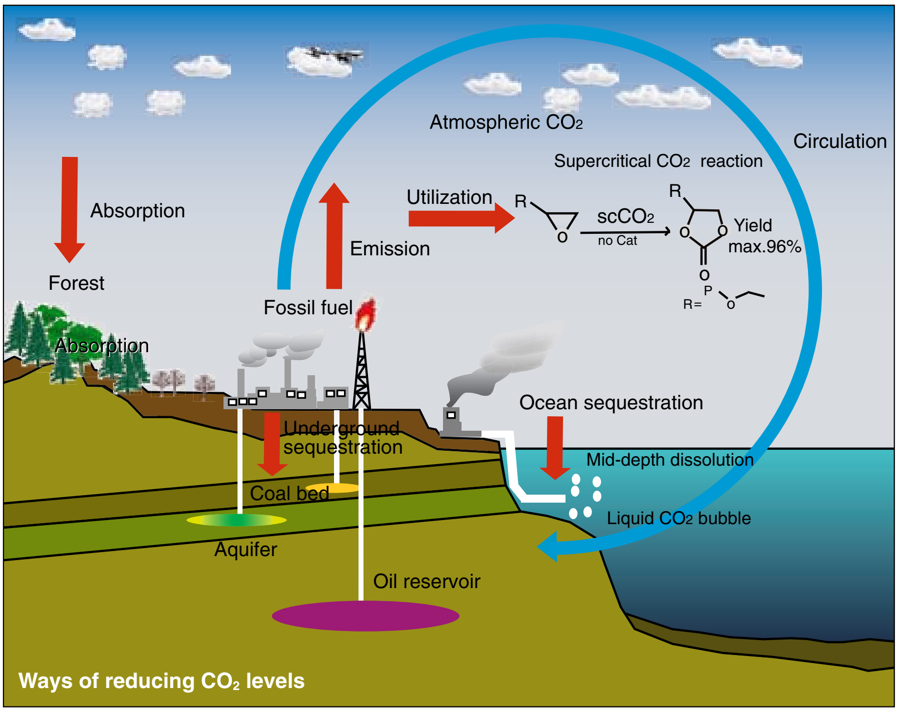
Water quality monitoring as a means of learning about watersheds

Water quality monitoring is an basic and central method for use in learning about changes in watersheds. To develop more advanced monitoring technologies for use in monitoring the ionic water contaminants which serve as indices of water pollution, we are developing a water quality monitoring system which uses new dissolution methods together with an on-site ion chromatography system to identify hydrogen ions, anions(e.g., sulfur, nitric acid, nitrous acid, phosphoric acid, chloride, fluoride, silicic acid, and hydrogen carbonate ions), cations (e.g., sodium, ammonium, potassium, magnesium, and calcium ions), and organic acid ions. Current plans call for this system to be put to use in monitoring watersheds in Japan and abroad to prove its effectiveness and for the system to be introduced as part of JIS, ISO, and other official standards.

Cleaning up water pollution

To maintain our rich and comfortable lifestyle, we continue to release large amounts of persistent pollutants into the environment, and these pollutants result in the pollution of underground water systems and many other water environment problems. Ozone has the ability to transform materials into a form which makes it possible for living organisms to easily decompose such pollutants, and by making use of this property together with bio-processing, we have found that it is possible to efficiently decompose persistent pollutants in waste water containing dyes to remove its total organic carbon (TOC) content. This technology is a promising one which might make it possible one day to purify and restore watersheds throughout the world.

Mention has been made about the major effects that the trace chemical pollutants that have been a subject of wide concern could have on ecosystems, and many different methods for reducing the quantities of such pollutants in the environment have been studied. While biologically based methods of decomposition are known to place less of a burden on the environment than physical chemistry methods, in recent years particularly strong attention has come to be given to methods which make use of biocatalysts found in living organisms. One example of such an effort can be seen at AIST, where we developed a new ceramic catalyst carrier with nanoscale pores to hold catalysts and where we are now working to develop ways in which this could be put to actual use in a minimally compact advanced water treatment system which would be more sustainable and provide higher levels of efficiency than previous such systems. This in turn would make it possible to develop systems which use oxygen to improve



the circulation of water.

Cleaning up ocean pollution is also an important part of global environmental preservation. The coast along the Ariake Sea in Kyushu is one of Japan's major sources of seaweed. Although the ocean water used in the production of seaweed products is polluted in many ways, it is released back into the sea without being treated in any way, and this has resulted in major environmental problems in the regions surrounding production centers. To address this problem, we are currently working to develop a complete treatment system for use in the treatment of seawater used in processing seaweed products based on technologies for the production of environmental cleaning agents which have already been developed. If this system can be completed, we believe that it could be used in other applications as well and prove useful in treating water in many applications.

Carbon dioxide released into the oceans

Since the time of the Industrial Revolution, the production and consumption of energy which has accompanied human activity has resulted in the release of vast amounts of carbon dioxide into the atmosphere. A variety of different data and calculations made using models indicate that roughly 25 percent of the total amount of carbon dioxide released has been absorbed into the oceans. In order to quantitatively investigate this behavior, we have used models of ocean flows and carbon circulation to calculate the distribution of anthropogenic carbon dioxide in the oceans. From these distributions we have learned that the anthropogenic carbon dioxide which has been absorbed into the oceans is transported and concentrated by ocean currents into the subtropical regions where ocean currents converge. Because the behavior of carbon dioxide which has been absorbed into the oceans plays a major role in determining the concentration of carbon dioxide in the atmosphere, these calculations should prove useful in predicting future concentrations of carbon dioxide in the atmosphere.

Ways of reducing carbon dioxide levels Methods of carbon dioxide sequestration

Carbon dioxide in the atmosphere is absorbed by forests through photosynthesis. Methods have already been developed capable of continuously and quantitatively measuring over long periods of time the capacity of forests in severe climactic environments such as those found in the tropics to absorb carbon dioxide. Based on outdoor tower observations performed using these methods, we are working to investigate the relationships which exist between climactic conditions and the net volume of carbon dioxide exchange (i.e., carbon absorption capacity) between the atmosphere and forest ecosystems and to learn about seasonal and year-by-year changes in carbon absorption capacity. From observations of some representative forest ecosystems in East Asia performed in cooperation with different research institutions and universities, we have found that forest ecosystems have a capacity to absorb from the atmosphere as much as from 1.3 to 5.7 tons of carbon per hectare per year, or an average of 3.2 tc/ha/yr. In addition to having made it possible to identify actual conditions, these results may also be used as basic data for use in the trading of carbon dioxide emissions rights between Japan and other Asian nations.

Sequestration is one method which might be used to reduce the amount of carbon dioxide in the atmosphere. Broadly speaking, there are two ways in which carbon dioxide could be sequestered: through underground storage or through ocean sequestration. The two main methods being considered for underground storage are a method whereby carbon dioxide would be stored under pressure in aquifers covered by caps of rock to prevent the carbon dioxide from escaping and a method whereby carbon dioxide would be stored under pressure in coal beds, which have a high degree of adsorption with respect to carbon dioxide. The first method would make use of technologies developed for the underground storage of natural gas or for improved oil recovery, and the second method would have the advantage of making it possible to recover methane at the same time that carbon dioxide is injected underground. If either one of these methods could be made practical, it would serve as a tremendous contribution towards directly reducing carbon dioxide levels.

The mid-depth and deep areas of the oceans are also viewed as a promising place for the sequestration of source-reclaimed carbon dioxide. However, because the waters of the oceans circulate these waters eventually come into contact with the atmosphere and it is feared that any sequestered carbon dioxide would be released into the atmosphere or that sequestered carbon dioxide could have a serious effect on the marine environment which would alter its ecosystems. Moreover, our knowledge of the oceans at intermediate and extreme depths is poor, and no predictions have been made about the effects or the behavior of carbon dioxide after ocean sequestration. To address these questions, using data from on-site observations and indoors testing obtained using methods developed over the past few years, we are working to develop ways to identify the dynamics of carbon dioxide after sequestration and to develop methods of predicting the environmental effects of sequestering carbon dioxide in the oceans. The ability to make such predictions should make it possible to determine whether ocean sequestration can be made feasible.

Making use of organic synthesis to consume carbon dioxide

We are also trying to find ways of actively using carbon dioxide as a way of reducing its effects on the environment. Some of the technologies now being developed which have gained the greatest amount of attention in this area include technologies for phenol and other selective hydrogenation reactions which use supercritical carbon dioxide as a substitute for toxic organic solvents and technologies which use carbon dioxide fixation as a means of synthesizing carbonates. Multi-phase systems which use combinations of solid catalysts which accelerate reactions with supercritical carbon dioxide not only improve reaction efficiencies but also perform both reaction and separation in the same step, thus making this a pioneering new process which makes it possible to reduce overall process times. This method is accordingly viewed as both an environmentally friendly and economically attractive organic synthesis technology with a promising future.