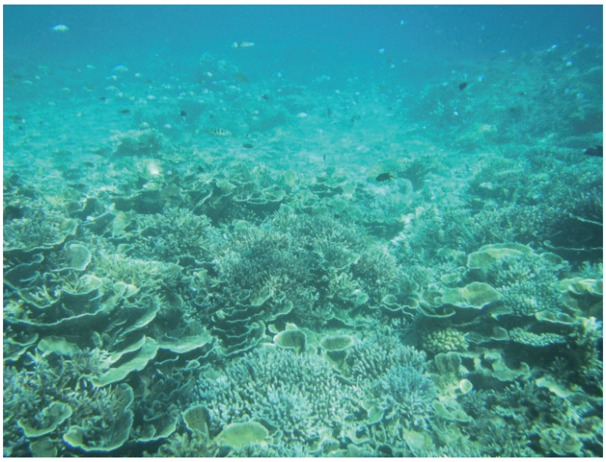
Environmental Report
2019 Digest Version

These photos show coral communities on the reefs in the Derawan Islands, Indonesia. The various colonies of corals and the schools of colorful fish swimming around them show the high level of biodiversity this area retains. Although not shown here, sea turtles, manta rays, dolphins, and other megafauna live in great numbers in the area. While there are still remaining precious pristine coral-reef ecosystems, I am concerned about how future tourism development in this region will change these beautiful underwater seascapes. Maintaining and using this ecosystem while supporting and improving the livelihoods of local people will require serious consideration about sustainable human-ecosystem relationships.



Associate Professor Takashi Nakamura
Department of Transdisciplinary Science and Engineering
School of Environment and Society

Tokyo Institute of Technology

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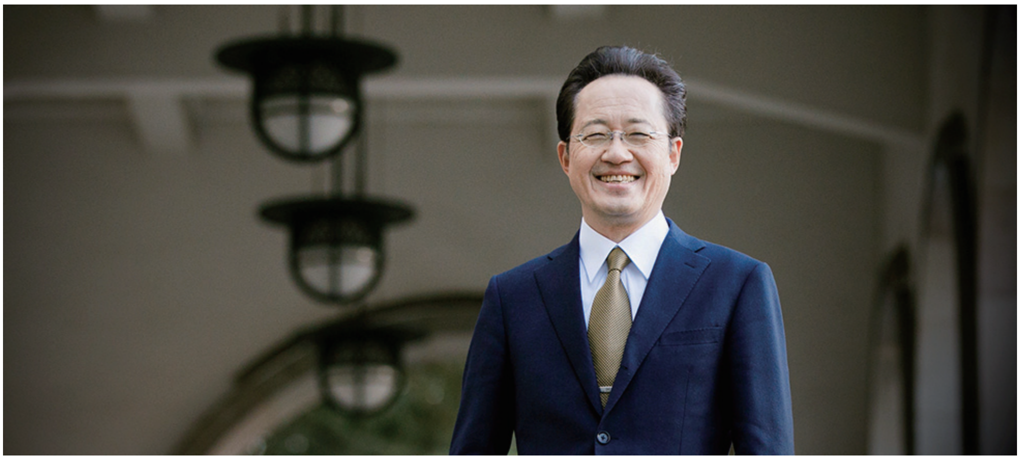


Working with Society to Design the Future

In the more than 130 years since its founding, Tokyo Institute of Technology has helped drive Japan forward by producing countless exceptional scientists and engineers and generating superior research results. In March 2018, the Minister of Education, Culture, Sports, Science and Technology named Tokyo Tech a Designated National University Corporation in recognition of our capability to carry out world-leading education and research.

We are pursuing our long-term goal of becoming one of the world's top science and engineering universities by 2030, shortly before Tokyo Tech's 150th anniversary. We have set achievement targets to realize this goal, one of which states: "Cultivate superior knowledge and develop talent in transdisciplinary fields that will solve global challenges such as producing green energy and taking measures on climate change and environmental issues." We are therefore emphasizing environment-related curriculums in line with this aim. In our bachelor's degree programs, for example, we offer lectures that highlight current problems with the global environment, raise student awareness of environmental safety, and help students acquire a sense of environmental ethics while stressing the importance of building circular economies and sustainable societies. We also offer a large number of multidisciplinary environment-related courses in our graduate programs.

Our duty as a national university is to strive to solve global issues such as environmental challenges and energy-related problems. We will fulfill this duty by producing brilliant, talented individuals through our excellent education and research activities, sending them out into society, and disseminating our research results to address society's needs. By doing so, we will help to realize a richer future society.

This report summarizes the environmental health and safety activities we have conducted over the last year in accordance with the basic principle of our environmental policy, which is "to share the global environment with future generations." It is my hope that you will read the report and that our university's activities will gain your understanding and cooperation.

September 2019

President, Tokyo Institute of Technology

Kazuya Masu

Tokyo Institute of Technology Environmental Policy

Enacted January 13, 2006

Basic Principle

As we strive to become the world's best science and engineering university, Tokyo Institute of Technology recognizes that environmental problems are not just issues for certain regions. They are major challenges on a global scale that pose an existential threat to all of humanity. To ensure that future generations have a viable global environment, Tokyo Tech will contribute to the creation of a sustainable society as it fulfills its mission as a research and education institute.

Basic Policies

In accordance with the basic principle "To share the global environment with future generations," Tokyo Tech will deal with the various problems facing the environment, based on the following policies, to create a twenty-first century civilization in which the earth and humanity coexist harmoniously.

Research Activities

We will further promote scientific and technological research that contributes to the creation of a sustainable society.

Talent Development

To foster the creation of a sustainable society, we will develop talented individuals with high environmental awareness, a rich knowledge base, and the potential to become leaders in various fields.

Social Contribution

We will contribute to Japan and the world through our research activities and talent development.

Environmental Management System

We will create an advanced environmental management system suitable for a world-leading science and engineering university, implement it effectively, and strive to continually improve it.

Reduce Our Environmental Footprint

We will establish environmental goals, develop plans based on those goals, and execute those plans to minimize our impact on the environment.

Promote Environmental Awareness

We will conduct environmental education and awareness-building activities that target every student and university employee, including executives, to increase their understanding of Tokyo Tech's environmental policies, etc. and the environmental awareness of everyone associated with the university.

Tokyo Tech's Cutting-Edge Environmental Research

"Seeking to Smoothly Incorporate Renewable Energy into Electric Power Systems"

Professor Toshiya Nanahara
Assistant Professor Kenichi Kawabe
Department of Electrical and Electronic Engineering
School of Engineering

Increasing awareness of global environmental problems — typified by the global warming that greenhouse gases such as carbon dioxide are largely responsible for — has led many countries to incorporate renewable energy sources such as solar and wind power into existing electric power grids. Because electricity makes our comfortable lives possible, providing highly reliable electrical power at a specified frequency and voltage is a necessity in modern society.

Solar and wind power's properties differ from those of traditional thermal, nuclear, and hydroelectric power sources. For example, solar and wind power output fluctuates depending on the weather. Since electric power systems must ensure that power demands are met with power generation from instant to instant, we need to compensate for output fluctuations in renewable electricity. Electric power systems must operate reliably even when unavoidable failures such as lightning strikes occur. However, renewable electricity sources behave quite differently to thermal, nuclear, and hydroelectric power when such events transpire, and we cannot allow blackouts caused by such differences.

Consequently, understanding any undesirable effects that a large-scale introduction of renewable electricity sources will have on electric power systems and clarifying solutions to them are important research subjects. Our laboratory engages in the following research initiatives aimed at solving various technical challenges we believe will arise in electric power systems (see Fig. 1) as the introduction of renewable electricity sources advances.

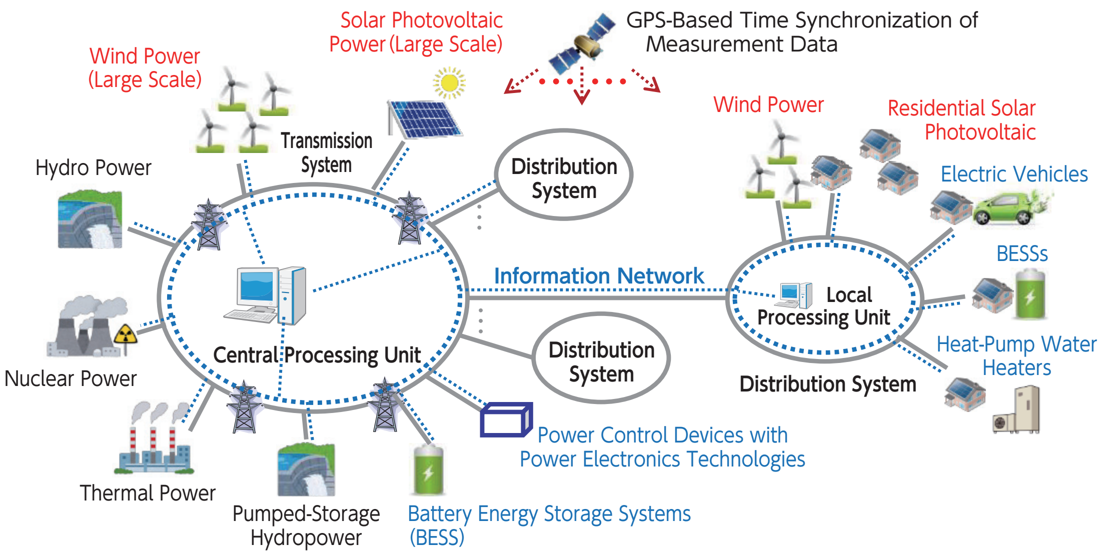


Fig. 1 Possible future electric power system

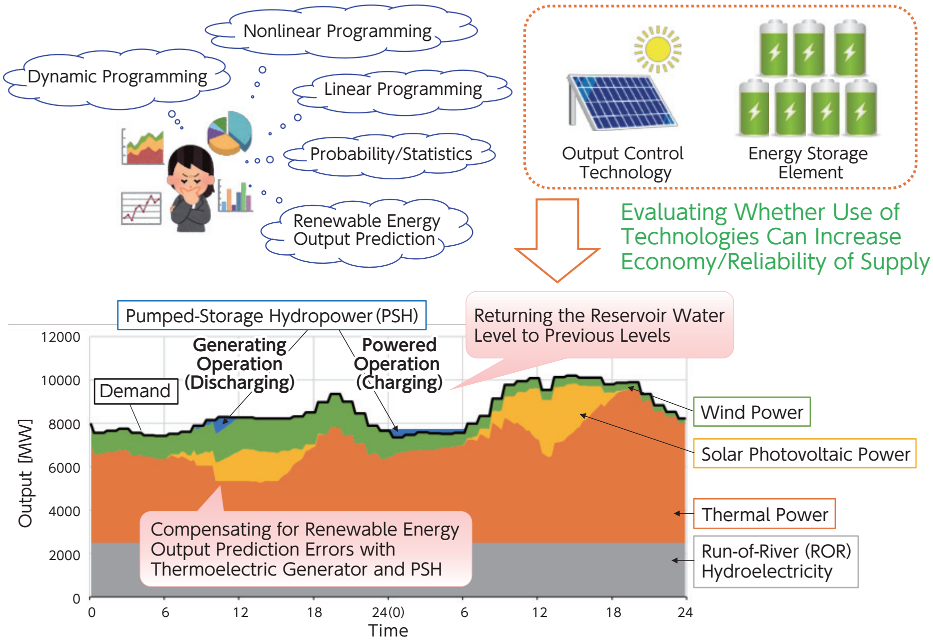


Fig. 2 Sample simulation of supply-demand management incorporating renewable energy

(1) How to maintain the balance of supply and demand in electric power systems efficiently

We can maintain the balance of supply and demand in electric power systems by controlling various power sources with different properties such as renewable electricity, thermal power, and hydroelectric power. In the future, we will be able to use new technologies such as battery energy storage systems. We conduct research on measures to efficiently maintain supply and demand balance during normal operation, after accidents (such as when a power source is suddenly interrupted), and other situations. Fig. 2 shows one aspect of our research.

(2) How to ensure that electric power systems operate stably even after severe failures and events such as lightning strikes occur

The large-scale introduction of renewable electricity sources may cause the flow of electricity in the power grid to deviate from the expected state due to changes in the response characteristics of power sources.

One of our research topics involves looking into technologies that utilize advanced communications technology to collect information not previously available, and to control power generators based on that data.

Nanahara Lab: http://www.pwrsys.ee.titech.ac.jp/ index_E.html
(Japanese) http://www.pwrsys.ee.titech.ac.jp/

“Rare Earth -Molybdenum Complex Oxides with Antibacterial and Antiviral Properties”

Professor Akira Nakajima

Department of Materials Science and Engineering

School of Materials and Chemical Technology

A wide range of viruses that includes new strains of influenza, MERS, SARS, and Ebola with the potential to threaten humanity’s very survival have recently and repeatedly spread around the planet at breathtaking speeds. Because the vast majority of people have no immunity to these viruses, a worldwide pandemic would create severe health hazards and social disruption.

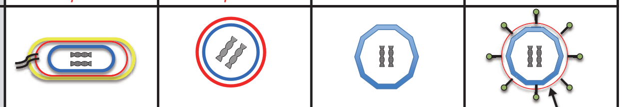
Research into treatments for viral infections is primarily conducted in the medical field, **and research into the prevention of such infection and the control of its spread is extremely limited. Once a viral pandemic occurs, however, people in the affected areas must hold on for a month or more — the time it takes to make and distribute a vaccine.**

Until now, a number of antibacterial and antiviral materials, including antibacterial metals such as silver (Ag) and copper (Cu), as well as photocatalysts such as TiO_2 have been identified and put to practical use. Ag is expensive, however, and elements such as chlorine ion hinder its effectiveness. Cu is inexpensive, but its antibacterial properties are inferior to those of Ag. The antibacterial properties of photocatalysts do not activate in environments without light. Considering the above, we investigated the possibility of creating a completely new oxide material with antibacterial and antiviral properties.

For this study, we focused our attention on $La_2Mo_2O_9$ (LMO), a complex oxide that combines a rare-earth oxide and molybdenum oxide. Although this material is reportedly an ion conductor, it had not been investigated as a potential antibacterial or antiviral material. We used a method called citric acid polymerization to manufacture a fine single-phase LMO powder.

Bacteria are broadly classified into gram-positive bacteria, which have peptidoglycan layers and cell membranes, and gram-negative bacteria, which have lipopolysaccharide around their peptidoglycan layers. We conducted our antibacterial properties testing in accordance with ISO 17094 (JIS R 1752) using *Staphylococcus aureus* (*S. aureus*) as our gram-positive bacteria and *Escherichia coli* (*E. coli*) as our gram-negative bacteria.

	Bacteria		Bacteriophage	
Bacteria・Virus name	*Escherichia coli*	*Staphylococcus aureus*	*Bacteriophage Qβ**	*Bacteriophage Φ6**
Classification	Gram negative bacteria	Gram positive bacteria	Alternative of *Norovirus*	Alternative of *Influenza virus*
Size	3 μm	1 μm	20nm	30nm
Structure				



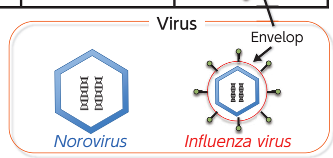


Fig. 1 Schematic Diagram of Pathogen Sizes and Structures

The structures of viruses are broadly classified into two types: influenza virus-like structures with an envelope over a capsid, and norovirus-like structures with only a capsid. For our evaluation of antiviral properties, we used bacteriophage Qβ and bacteriophage Φ6. Qβ stands in for norovirus, while Φ6 stands in for influenza virus. The two substitutes have similar structures to their respective originals (**Fig. 1**), and their activity has also been reported to match up as well.

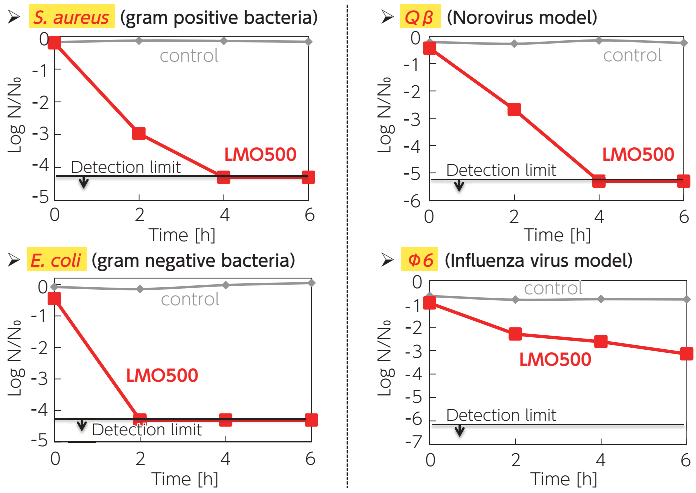


Fig. 2 LMO Antibacterial/Antiviral Activity

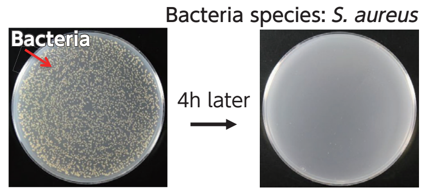


Fig. 3 Decrease of Bacteria (S. aureus)

Figures 2 and 3 show the results. The logarithmic vertical axis shows the number of *S. aureus, E. coli*, Qβ, and Φ6 over time. Being logarithmic, this means 99 percent of the microorganisms in question have been killed when the number on the vertical axis falls to -2. In our testing, we saw that the use of LMO led to a reduction of more than 99.9 percent in the numbers of each bacteria and virus within six hours, indicating excellent antibacterial and antiviral properties. As a result of our detailed investigation, it also became clear that both the molybdenum and lanthanum contributed to LMO's antibacterial and antiviral properties.

Nakajima & Matsushita Lab: http://www.rmat.ceram.titech.ac.jp/index_e.html
(Japanese) http://www.rmat.ceram.titech.ac.jp/

“Building Indoor Environments and Indoor Air Quality”

Associate Professor Naoki Kagi

Department of Architecture and Building Engineering

School of Environment and Society

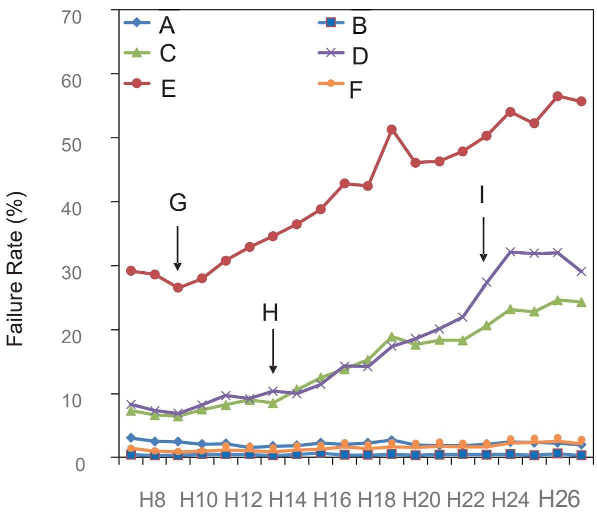
We usually feel that most buildings in Japan are well-constructed, safe, healthy, and comfortable. Is that true? To improve their energy efficiency of buildings during the oil crises of the 1970s, improving the thermal insulation and airtightness of buildings had led to preventing from escaping air-conditioned air in indoor environments. Therefore, any pollutants that are generated in indoors are easy to accumulate in buildings. This contaminated air in buildings caused building occupants to harm health problems such as fatigue, dizziness, headaches, eczema, sore throat, and respiratory conditions. This is generally called as “sick building syndrome.”

To prevent the sick building syndrome, the Japanese government established the Act on Maintenance of Sanitation in Buildings (Building Sanitation Act), which includes building environment sanitation management standards for indoor environments. As shown in Table 1, the building environmental standards are concentrations of suspended particle matter, carbon monoxide, carbon dioxide, and formaldehyde as air qualities, and temperature, relative humidity, and airflow as thermal environments. These environmental standards for buildings can improve indoor environments, and the sick building syndrome have been well controlled in Japan rather than Western countries.

Table 1 Building Environment Sanitation Management Standards Related to Indoor Air Environment

Suspended Particle Matter	≤0.15 mg/m^3
Carbon Monoxide	≤10 ppm
Carbon Dioxide	≤1000 ppm
Temperature	17℃ – 28℃
Relative Humidity	40% – 70%
Airflow Rate	≤0.5 m/s
Formaldehyde	≤0.1 mg/m^3(≤0.08 ppm)

But what percentage of buildings actually conforms to these standards? This statistical data on the buildings in Japan on the Building Sanitation Act is publicly available. We can learn the state of indoor environments from the nonconformity rates for each standard, which are based on the number of nonconforming buildings that did not meet the relevant standard among the buildings investigated for each standard. Fig. 1 shows the yearly trends of nonconformity rates, meaning the percentage of buildings that did not meet the standards listed in Table 1.



A	Suspended Particle Matter Concentration
B	Carbon Monoxide Concentration
C	Carbon Dioxide Concentration
D	Temperature
E	Relative Humidity
F	Airflow Rate
G	1998 Amendment to the Energy Conservation Act
H	2020 Amendment to the Building Sanitation Act
I	2011 Great East Japan Earthquake

Fig. 1 Trends in nonconformity rates for Air Environment Standards

The nonconformity rates for suspended particle matter, carbon monoxide, and airflow rate have been at a low level of just a few percent, indicating that an appropriate environment is being maintained with the standards. On the other hand, the nonconformity rates for carbon dioxide, temperature, and relative humidity are trending to increase each year. One possible reason for the increase of the nonconformity rates of carbon dioxide concentration is that ventilation volumes in the buildings are insufficient to save energy for air conditioning. As you can see in Fig. 1, the increases in nonconformity rates for temperature and relative humidity standards coincide with amendments to environment-related laws and the Great East Japan Earthquake, which may have resulted in the excessive energy conservation. Whether can their occupants in the buildings that do not meet the indoor environmental standards stay healthy while inside them?

Because the occupants cannot see or feel these indoor air pollutants, they will continue to breathe in this air even after its air quality becomes worsen. There are other air pollutants in addition to those listed in the table in indoor environments. For this reason, we are conducting our research from the viewpoints of three approaches: 1) grasping the current situation by measuring with devices that detect $PM_{2.5}$ (fine particles with a diameter of 2.5 μm or less) and even finer particles such as nanoparticles, and analyzing chemical compounds using GC/MS to identify new indoor pollutants; 2) revealing the relationship between indoor air pollutants and the health of occupants of indoor spaces; and 3) understanding the causes of indoor air quality deterioration and finding countermeasures.

Kagi Lab: http://www.create.mei.titech.ac.jp/

“Eight Years Since the Disaster — Aiding in Fukushima’s Recovery and Environmental Remediation: Human Resource Development and Creation of Revitalizics”

Associate Professor Hiroshige Kikura

Assistant Professor Hideharu Takahashi

Laboratory for Advanced Nuclear Energy

Institute of Innovative Research

The earthquake that occurred on March 11, 2011 off Japan’s Pacific coast and devastated the Tohoku region shook all of eastern Japan and triggered a tsunami that inundated coastal areas, bringing destruction on a massive scale. The impact of the earthquake and tsunami caused Tokyo Electric Power’s Fukushima Daiichi nuclear power plant to lose all power, which in turn caused a meltdown of the plant’s reactor fuel and released radioactive material into the environment.

In 2019, eight years after the disaster, evacuation orders have been lifted for most of the affected regions other than the “difficult to return” zones. The national government’s efforts to assist Fukushima’s recovery are in full swing. One such initiative is the Fukushima Innovation Coast Framework, a national project aimed at creating a new industrial base in and around Fukushima Prefecture’s Hamadori coastal region. Another involves using the 2020 Tokyo Olympics and Paralympics to show people how the prefecture has recovered. A third is aimed at preserving the memories of the disaster as well as the lessons learned from it.

A temperature condition became stable in 2011 at the Fukushima Daiichi nuclear power plant after the accident. All spent nuclear fuel was removed from Reactor No. 4 by 2014, and treatment of RO-concentrated saltwater (highly contaminated water) using a multi-nuclide removal facility was completed in 2015. Robotic surveys are being conducted as part of efforts to remove fuel debris from the reactor. That debris formed as the reactor’s nuclear fuel melted together with surrounding structures inside the containment vessel and then solidified. These surveys are gradually shedding light on the situation inside the power plant.

Given this situation, Tokyo Tech and other academic institutions selected the three research themes outlined below and are vigorously pursuing transdisciplinary research to quickly advance the Fukushima Innovation Coast Framework as well as the environmental remediation of regions the earthquake affected (Fig. 1):

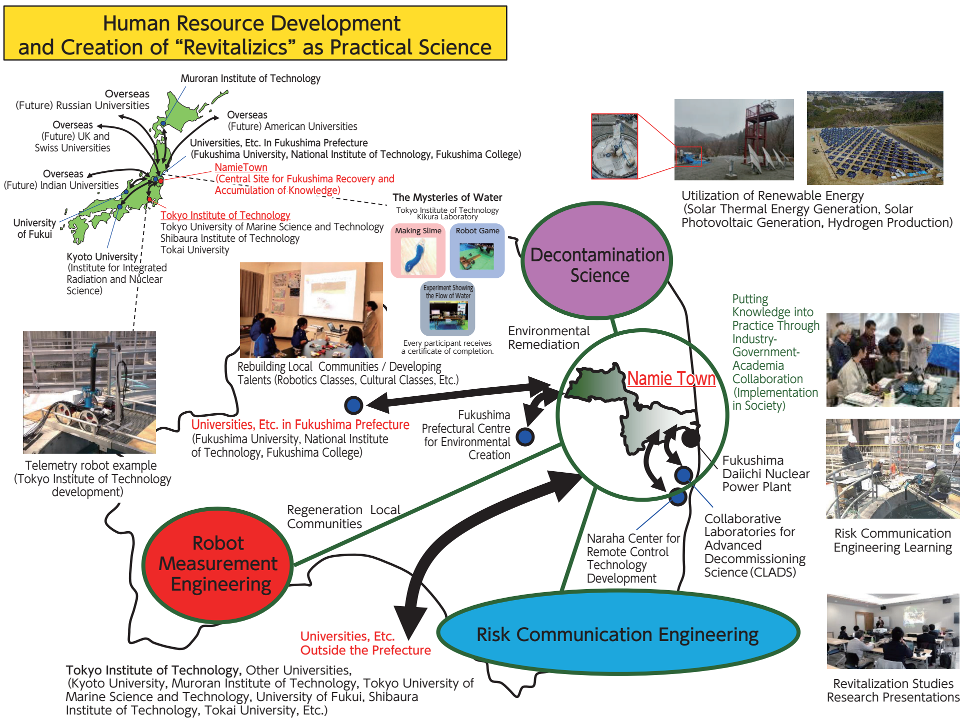


Fig. 1 Initiatives Aimed at Promoting Fukushima’s Recovery and Environmental Remediation

1. Initiatives designed to remediate the soil, etc. contaminated by the nuclear accident (decontamination science)
2. Initiatives to accelerate nuclear decommissioning through robot measurement (robot measurement engineering)
3. Initiatives aimed at sharing responsibility for risks and building trust (risk communication engineering)

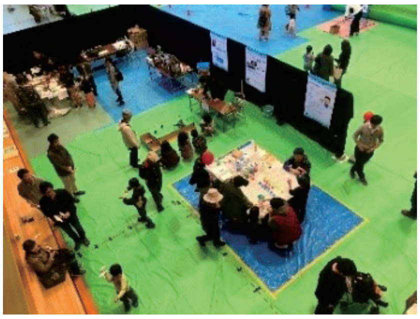


Fig. 2 Science education support activities targeted at elementary and junior high students, etc. in Namie Town, Futaba District, Fukushima Prefecture

On the first research theme, we are looking into a technology to separate cesium from the soil, incinerated ash, etc. that has adsorbed it and then stabilizing and solidifying it. This will reduce a region's air contamination and greatly limit the volume of final waste (Laboratory for Advanced Nuclear Energy, Takeshita et al.).

For the second research theme, we are devising remote measuring technologies and robotic technologies aimed at reducing the risks when removing debris from nuclear reactors being decommissioned (Kikura and Takahashi; Department of Mechanical Engineering, Endo et al.).

On the third theme, we are developing risk communication engineering methods based on engineering certainty. We hope this will establish a safe and reliable risk management system that gives local residents peace of mind (Kikura and Takahashi; School of Environment and Society, Murayama et al.).

We are also trying to create a new field of study — "Revitalizics" — as a practical science that systematizes the results of such research projects. We are also instituting human resource development initiatives that include providing opportunities for practical experience for graduate students and science education support activities targeted at elementary and junior high school students and other individuals in Namie, a town in Fukushima Prefecture's Futaba district (Fig. 2). Through these activities, we hope to contribute to the recovery of industry there in cooperation with companies, municipalities, and other entities in the region. We want to contribute to the early realization of the Innovation Coast Framework as well as pass on the skills, knowledge, and experience needed to recover from an unprecedented nuclear disaster to future generations.

Kikura Laboratory: http://www.lane.iir.titech.ac.jp/~kikura/

Environmental Education and Talent Development

Seeking to contribute to the world through the power of science and technology, Tokyo Tech established six new schools in April 2016 that integrate undergraduate and graduate education, allowing students to plan and individualize their academic path and producing graduates with superior expertise and leadership in science and engineering fields. Our enhanced educational system enables students to pursue independent learning and develop aspirations powered by their own efforts.

As part of this upgrade process, we also debuted an academic quarter system, a new course-numbering system, and other fresh elements. The updated educational system emphasizes studying a broad range of fields comprehensively and systematically based on the student's individual interests and intellectual curiosity. Our new system also emphasizes environment-related curriculums that foster a strong sense of ethics.

Here we introduce some key environment-related courses that our undergraduate and graduate programs offer.

Bachelor's Program: In the first year, we offer lectures that highlight current problems with the global environment, raise student awareness of environmental safety, and help students acquire a sense of environmental ethics while stressing the importance of building circular economies and sustainable societies. In their second to fourth years, students are offered curriculums suited to their specialized undergraduate major. Some courses are taught in English.

"Introduction to Global and Local Ecology"

Bachelor's program, Department of Transdisciplinary Science and Engineering, School of Environment and Society

Associate Professor Takashi Nakamura
Department of Transdisciplinary Science and Engineering
School of Environment and Society

The Department of Transdisciplinary Science and Engineering offers a course on the subject of ecosystems entitled "Introduction to Global and Local Ecology." The term "ecosystem" refers to a system that includes a biological community and the environment around it. There is an inextricable relationship between biological activity — which includes human activity — and the environment.

The first half of the course is in a lecture format, in which students comprehensively learn about a variety of subjects.


"Introduction to Global and Local Ecology" lecture

The lectures cover both macroscopic and microscopic topics such as global environmental systems, the planet-wide circulation of matter and the role of global ecosystems, as well as local-scale ecosystems and the environmental problems they face. The lectures are designed to promote discussions on the sustainable use of ecosystems, which include humans and our social systems. In the second half of the course, students work in small groups.

This academic year, we covered examples of projects designed to protect coastal environments and ecosystems, either as a stated goal or as a precondition for the success of another goal. One objective of the course was to promote in-class discussions about the characteristics of such projects as well as the problems associated with them. At the end of the course, each group gave a presentation about what they had discussed.

During the groupwork portion of the course, I had students evaluate a project's framework and then ponder in depth the structure of the conflict that arises among stakeholders when implementing that project. Based on that analysis, I guided students to consider various problems that must be solved to realize the project.

I believe this groupwork was a good opportunity for students to perceive the structure of the problems at hand from multiple perspectives and to understand that solving them will require broad-based, integrated initiatives. The structure I hope to use for groupwork during the next academic year is to create environmental education materials. I plan to have students create games that people can enjoy playing while learning about coral ecosystems and the environmental problems affecting them. I always look for new ideas for the course so that students can have fun while independently learning about subjects such as ecosystems and environmental problems through group work.

Graduate Program: Our graduate courses offer students specialized curriculums for their majors. Since those classes are taught in English, international students also benefit from our environmental education. Students in our transdisciplinary graduate majors — Energy Science and Engineering, Engineering Sciences and Design, Human Centered Science and Biomedical Engineering, Nuclear Engineering, Artificial Intelligence, and Urban Design and Built Environment — have their pick of a range of environment-related curriculums.

"Environmental Microbiology" Graduate Major in Life Science and Technology

Associate Professor Rie Yatsunami
Department of Life Science and Technology
School of Life Science and Technology

The earth is home to countless varieties of microorganisms. These microorganisms are directly involved in the world's matter cycles and energy cycles. One lecture series the School of Life Science and Technology offers in its Graduate Major in Life Science and Technology is "Environmental Microbiology." The content of the series includes:

1) Investigating the influence that matter cycles and energy cycles on the earth's surface have on the environment
2) Analyzing how the life processes of microorganisms can be used in environmental cleanup, agricultural production, and material production
3) Evaluating the life processes of microorganisms that thrive in extreme environments and finding ways of using them
4) Investigating the structures and functions of microorganism colonies in the environment, and the methods used to analyze them

Hirondellea gigas inhabits deep ocean beds

Plastic trash found in the deep sea

For the third topic above, we invited Dr. Chiaki Kato, a former Japan Agency for Marine-Earth Science and Technology senior researcher and current chief engineer of the incorporated NPO Team Kujirago, to give a talk about piezophiles, which are pressure-loving creatures that live in the deep sea (see the photo above). His talk covered aspects such as their biology and ecology, the mechanisms they use to resist pressure, and the characteristics of the proteins they produce.

In the second half of his lecture, Dr. Kato described his public activities. For example, he runs a natural sciences education program geared for all school-age children that promotes the sound development of the earth's future stewards. During his talk, Dr. Kato spoke about the program as it related to the subject of marine environmental issues and their countermeasures. Specifically, he spoke about the plastic trash polluting the deep oceans, a current global news topic. Dr. Kato used photos and experimental data to teach students about the plastic trash found in the deep sea (see the photo above), the creatures it has harmed, how plastic that ends up in the ocean becomes microplastics, and more. He also talked about research on microorganisms that can break down plastic. The talk was a good opportunity for students to learn about an environmental problem that must be tackled on a global scale as well as the unlimited potential of microorganisms.

The students listened with great interest from start to finish. Many even stayed to ask Dr. Kato questions after his presentation. I hope that Tokyo Tech students will make great contributions to society after completing our graduate program. I would also like to continue offering classes that pass down knowledge but also demonstrate how the subject at hand connects with society.

"Analysis of the Stomach Acid Resistance System of Pathogenic *Escherichia coli*"

Takeshi Kanda
Wachi Laboratory Second-Year Doctoral Student
Graduate Major in Life Science and Technology
Department of Life Science and Technology
School of Life Science and Technology

We drink water every day as a matter of course. Water makes up more than 60 percent of the human body, and is essential to sustaining life. While Japan has no shortage of potable water, it can be scarce in regions with poor sanitary environments such as developing countries. People in these places are sometimes forced to drink from sources such as rivers, ponds, and exposed wells. That water is often unsafe to drink due to contamination with bacteria capable of causing food poisoning.

One of the most dangerous of these bacteria is pathogenic *Escherichia coli* (*E. coli*), which is typified by enterohemorrhagic *Escherichia coli* O157. Its infections cause stomach pain and diarrhea, with severe cases also leading to dehydration. Children in developing countries who are immunologically compromised due to malnutrition are often hit especially hard, and fatalities are not uncommon. Highly virulent strains of *E. coli* such as O157 also have the potential to cause serious complications beyond stomach pain. Efforts are therefore being made to prevent infections even in developed countries such as Japan. Despite this, there are around 4000 cases of infection (including asymptomatic carriers) reported in Japan each year, and mass infections with fatalities also occur with some frequency.

Given these circumstances, preventing pathogenic *E. coli* infections has become a matter of increasing importance in recent years, so our laboratory is conducting research on the stomach acid resistance system pathogenic *E. coli* possesses. The primary route of infection of pathogenic *E. coli* is oral — when someone consumes food or drink contaminated with the bacteria. However, this exposes pathogenic *E. coli* to stomach acid. While exposure to stomach acid kills the vast majority of microorganisms, pathogenic *E. coli* unfortunately has a stomach acid resistance system that allows it to survive a journey through the stomach. This system only manifests when the surrounding pH turns acidic, such as when the bacteria are exposed to stomach acid.

I'm especially interested in the way this stomach acid resistance system manifests in reaction to the surrounding pH levels, so I'm trying to understand the mechanisms behind this phenomenon. In our research so far, we have analyzed all 4,600 of *E. coli*'s gene expression patterns and found particular genes that change their expression depending on the surrounding pH (Fig. 1).

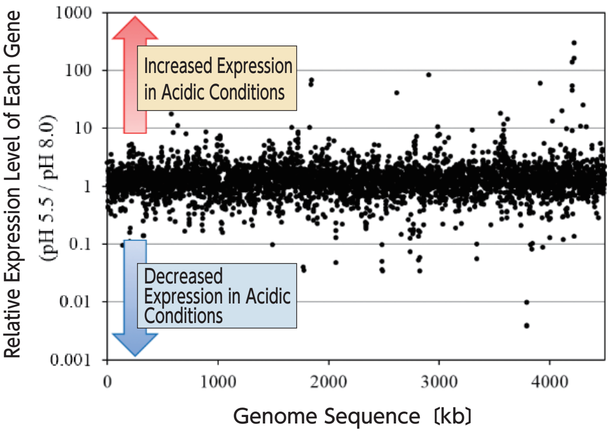


Fig. 1 Analysis on *E. coli* gene expression patterns associated with changes in the surrounding pH levels

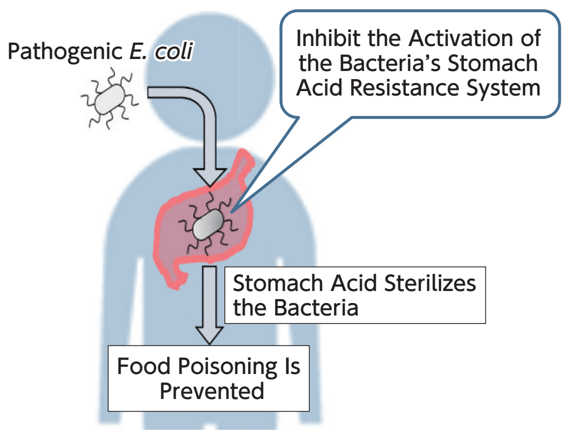


Fig. 2 The new pathogenic *E. coli* infection prevention measure that we expect will result from this research

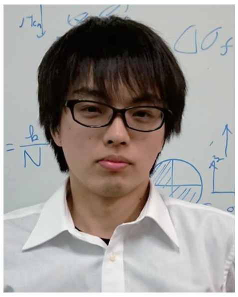
From there, we discovered the genes we believe to be responsible for controlling the manifestation of the bacteria's stomach acid resistance system. We are now on the verge of solving part of the mystery of how *E. coli* gains its resistance.

If we are able to artificially inhibit the manifestation of the stomach acid resistance system of pathogenic *E. coli*, it may be possible to use stomach acid to prevent infection by sterilizing this harmful bacteria (Fig. 2).

Wachi Lab : http://www.celltech.bio.titech.ac.jp/

“Using Seismic Waves to Look Inside the Earth”

Hirokazu Kashiwagi
Nakajima Laboratory Second-Year Master’s Student
Graduate Major in Earth and Planetary Sciences
Department of Earth and Planetary Sciences
School of Science



Earthquakes occur every day in the Japanese archipelago, the place we call home. While most of these tremors are too small to feel, large earthquakes that cause massive damage occur frequently. The 2011 earthquake off the Pacific coast of the Tohoku region and the 2016 Kumamoto earthquakes are likely still fresh in your memory. The Japanese archipelago also has 111 active volcanoes, and eruptions that result in the loss of human life such as the 2014 Mount Ontake eruption often occur as well. Volcanic ash ejected during an eruption also has the potential to paralyze transportation networks, damage precision equipment, cause respiratory conditions, and produce a number of other negative effects. Seismic activity and volcanic eruptions are natural phenomena that directly influence our living environment. Given our current knowledge, however, we cannot predict their occurrence on a practical level. To be able to accurately predict these phenomena, we need to deepen our understanding of the underground structures in which seismic activity takes place and through which magma passes and accumulates. Unfortunately, we aren’t able to directly look under the ground. While it is possible in astronomy, for example, to observe distant celestial bodies using visible light or radio waves, we can’t observe what is underneath our feet using similar methods.

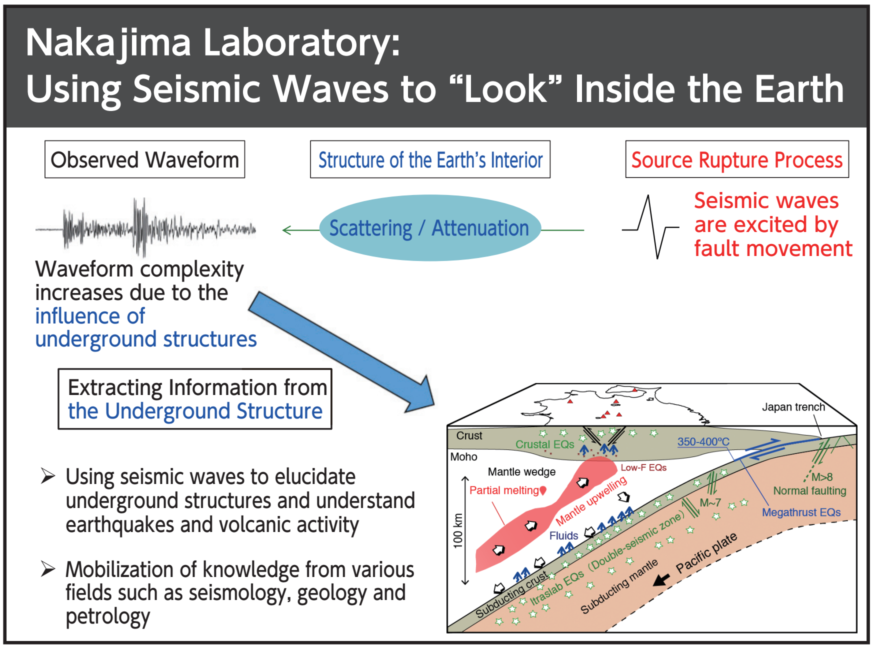


Fig. 1 Research by Nakajima Laboratory

For this reason, our laboratory is probing the earth using seismic waves instead of radio waves to look inside its underground structures. An extensive observation network has been created by placing more than a thousand seismographs across Japan, covering nearly the entire Japanese archipelago. The seismic waveforms these seismographs track contain information about the path, or medium, that seismic waves have passed through (Fig. 1).The seismic waveforms you may have seen in science textbooks are the result of the simple waves emitted by a fault movement due to a variety of influences that affect the propagation process. By analyzing these seismic waveforms with computers to extract information about the medium, we can clarify details of the earth’s interior.

Of all the information that can be gained from seismic waveforms, my research focuses on seismic attenuation, which is the phenomenon of vibrational energy being absorbed by the medium during the propagation of seismic waves. It is one key indicator of the temperatures and presence of fluids underground.

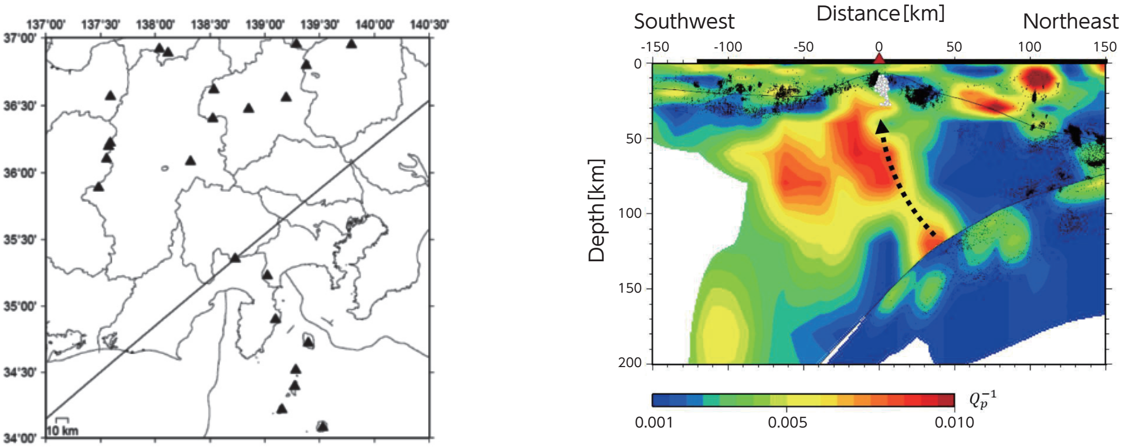


Fig. 2 Seismic attenuating structures along a traverse line through Mt. Fuji.
Warmer colors indicate regions with higher attenuation

For example, any seismic waves that pass through underground high-temperature magma will be strongly attenuated. By analyzing vast numbers of seismic waveforms, we can estimate the locations and shapes of underground three-dimensional attenuation structures. From this estimation, we have learned that there is a region with high attenuation, indicating a magma accumulation, deep underground, and that the region is connected to a spot directly below a volcano (Fig. 2). In the future, we will likely be able to use imaging technology with increased spatial resolution to analyze attenuation structures, therefore allowing us to gain more details about them. We believe that diligently advancing research like this will increase our knowledge and reduce uncertainty about earthquakes and volcanic eruptions, changing our living environment for the better.

Nakajima Lab: http://www.geo.titech.ac.jp/lab/nakajima/index1.html
(Japanese)http://www.geo.titech.ac.jp/lab/nakajima/index.html

Message from a Graduate

“From Student Researcher to Industry Professional”

Keita Azechi

Wind Power, Hydroelectric, and Biomass Business Unit

Shizen Energy Inc.

Profile

Mar. 2015 Earned doctoral degree from the Department of Environmental Science and Technology, Interdisciplinary Graduate School of Science and Engineering, Tokyo Institute of Technology.

Mar. 2015–Present Shizen Energy Inc.

My impetus for joining Shizen Energy Inc. was the research I did in Germany while working toward my PhD. Because I was researching renewable energy policy, I felt compelled to go to Germany, one of the world’s renewable energy pioneers. Once there, I made appointments to visit and interview countless administrative agencies, environmental NGOs, and renewable energy companies as part of my research. One of the companies that most readily agreed to my requests was juwi, a world-class renewable energy company. They told me they had a partner in Japan called Shizen Energy, which is how I first heard about the company (Shizen Energy and juwi have launched two joint ventures). Perhaps this was fate.

Shizen Energy’s Whole Group Workshop (June 2018)

Shizen Energy, which has set forth “co-create a 100% renewable-powered planet” as its message, is an integrated provider of renewable energy-related services. Those services range from the development of renewable energy projects — including photovoltaic power, wind power, and small hydroelectric power plants — to fundraising, EPC (engineering, procurement, and construction), O&M (operations and maintenance), and the sale of renewable electricity. As its partnership with juwi suggests, one of Shizen Energy’s most notable traits is its diversity. This comes from a corporate culture of strengthening the organization through diversity of nationality, gender, age, and background. Take nationality for example. People from twenty countries have worked at Shizen Energy Group, including interns from overseas. In the last two years, the company has taken on about 40 interns on a full-year basis from over 10 countries. I believe that diversity is one of Shizen Energy’s strengths, and will drive the organization’s growth.

Shizen Energy’s message over a photo of Karatsu Minato Wind Power Plant in Saga Prefecture, which Azechi helped develop

I’m involved in wind power plant project development. More specifically, I’m in charge of tasks such as gaining consent from landowners and the community, conducting environmental assessments, overseeing procedures for getting authorization and licenses, fundraising, and so on.

Although I began my involvement with renewable energy as a researcher objectively examining projects and suggesting better policies and plans, I'm now a frontline industry professional tasked with thinking about and implementing better projects. While this change came with many challenges, I learn a great deal every day from my new perspective.

One Shizen Energy initiative aimed at implementing better projects is the "1% for Community®" concept. For example, the wind power plant I was involved in developing in Karatsu City, Saga Prefecture has a business plan that includes giving one percent of its electricity revenues to regional agriculture. We refer to this policy as energy design — thinking not just about building a power plant but also the system for maintaining the plant as well as the regional community and industry. This is the mission of Shizen Energy.

Started in June 2011 by three founders, the Shizen Energy Group team now has more than two hundred members, each bringing their own experience and skills to their diverse jobs. As both a single renewable energy professional and member of the Shizen Energy team, I will continue working hard to improve my skills and abilities so I can contribute to ever-better projects and the invigoration of industry and regional society.

Shizen Energy Inc. http://www.shizenenergy.net/
Shizen Energy no Denki https://shizendenryoku.jp/

Student Environmental Conservation Activities

Activities of the Sweet Sorghum Research Group
— Taking on Regional and Energy Issues through Rural Resource Recycling —

Yasufumi Ono,
Murayama Laboratory Second-Year Master's Student
Ken Takayama
Nishikizawa Laboratory Second-Year Master's Student
Graduate Major in Global Engineering for Development, Environment, and Society
Department of Transdisciplinary Science and Engineering School of Environment and Society

The Sweet Sorghum Research Group was established in 2014 primarily to conduct policy research. We believe that agriculture and energy form the foundation of our industries and lives. The goal of our research group is to help solve issues such as how to revitalize agriculture and supplement Japan's energy supplies.

Sweet sorghum is a plant originating in South Africa that contains high amounts of sugar in its stalks. Fermenting and repeatedly distilling this sugar will produce ethanol. Sorghum is not a major food crop. In Japan it was used as animal fodder until the early 1980s, but today is primarily used as green manure. In addition, sorghum was considered one solution for Japan's abandoned farmland problem because we can grow it on unattended land.

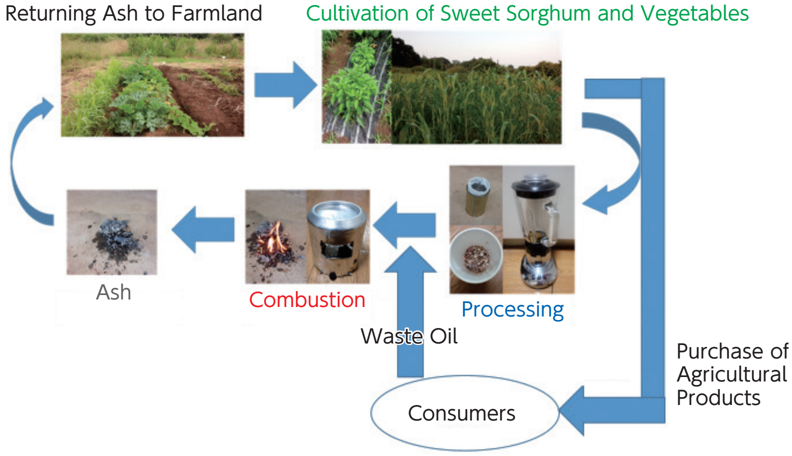
The Bush administration in the United States showed strong interest in the production of bioethanol from plants such as rice and corn. The global attention focused on these crops led to a steep rise in their prices in 2008. Since sorghum is not frequently used as food, its use in biofuel is not likely to affect the food economy.

Working in the experimental farm field

Manufacturing bioethanol is more difficult in Japan than in other countries, however. One reason is that the production of ethanol requires a permit under the Liquor Tax Act. Another issue is that the maximum percentage of bioethanol that can be mixed with gasoline is lower than in bioethanol leaders like Brazil, due in part to resistance from the Petroleum Association of Japan. Yet another issue is the size of the capital investment required to mass-produce bioethanol. Due to such factors, bioethanol manufacture has not become widespread in Japan.

For this reason, we thought about ways that farmers who grow sorghum could process it themselves and easily use it as a source of energy. We came up with the idea of oiled chips, made by pulverizing thoroughly dried sorghum chips and combining the result with waste cooking oil, which every household produces and is a pain to dispose of. Farmers can easily use these chips as fuel, and make use of waste cooking oil. In our experiments we generated enough heat from burning these oiled chips to boil water.

Oiled chips produced by mixing waste cooking oil and sorg
chips (left)
Burning oiled chips (right)



Model of the sweet sorghum resource cycle

A paper written by our members about this effort, incorporating chemistry and economics perspectives, was awarded the Excellence Prize in the student essay contest by Yanmar Co. Ltd.

Another paper our members wrote dealt with the use of abandoned land for rural revitalization. There are plans to build solar power plants on abandoned farmland and in unmanaged forests. In some regions, residents voiced concerns about the potential for fires and low-frequency noise from such facilities. The paper discussed using revenues etc. from these facilities to revitalize a rural community. It won an Encouragement Prize in the Nomura Research Institute’s student essay contest.

Yet another paper about a policy study aimed at using biomass produced from resources other than sorghum won the Award of Excellence in the FY2018 Kumiai Chemical Industry student essay contest.

Workshop in Kasama City

Visiting a biomass utilization site

The Sweet Sorghum Research Group collaborates with farmers, NPOs, and others on the frontlines, intent on promoting agriculture that utilizes sorghum and contributes to the revitalization of local communities. We conducted a workshop and a discussion about renewable energy last year in Kasama City, Ibaraki Prefecture. This year, we are proposing a project that will explore the fusion of ultrasonic technology with agriculture and the use of sorghum as a material for various purposes.

Rather than allowing these initiatives to become short-lived activities, we hope to explore new activities and new possibilities involving sorghum and agriculture by leveraging the flexible thinking of young people.

Tokyo Tech VG Environmental Conservation Activities

Tokyo Tech VG is a student volunteer group founded to support the recovery of areas affected by the Great East Japan Earthquake. In FY2018, we planned and carried out the Fukushima Study Tour, which involved twenty-five Tokyo Tech students and faculty and staff members. We also organized a beautification campaign on the Ookayama Campus.

Study tour participants visited Hisanohamamachi, Iwaki City — which suffered extensive damage when inundated by the tsunami the Great East Japan Earthquake caused — as well as Futaba District, which still has many areas designated as “difficult to return” regions. They were able to see the current state of affected areas, listen to stories by an earthquake storyteller about the disaster, and study at museums and archives such as Reprun Fukushima (the information center for specific waste burial processing) and the TEPCO Decommissioning Archive Center. This was a good opportunity to think about how to face environmental issues in terms of both the damage caused by the earthquake and the devastation of radioactive contamination. We believe this was a meaningful experience for Tokyo Tech students, who are expected to become drivers of the sustainable growth of humanity and society.

Tokyo Tech VG hopes to continue implementing a wide variety of environmental conservation activities in 2019, including our continuing campaign to beautify our campuses.



Study tour participants listen to a story about the catastrophe at the Iwaki City Regional Disaster Prevention and Exchange Center (left)
Inspecting the current state of a “difficult to return” region (Tomioka Town, Futaba District) to which access is restricted (center)
Visiting the TEPCO Decommissioning Archive Center (right)

Masari Watanabe
Tanaka Laboratory Second-Year Master’s Student
Graduate Major in Physics
Department of Physics
School of Science

Tokyo Tech VG (Student Volunteer Group)
https://www.facebook.com/TitechVG/

The Importance of Environmental Data Seen through the Activities of Tokyo Tech's iGEM Team


Tokyo Tech's iGEM team

We are a team of mostly undergraduate students who represent Tokyo Tech at iGEM, the International Genetically Engineered Machine competition. Our team has earned medals at twelve consecutive competitions up through last year's competition.

For our project last year, which was titled "Finding Flavi — Establishment of dengue virus serotype prediction and detection systems," we developed a system that uses data on the number of infected persons already identifed to predict the serotype of dengue fever that will be prevalent the following year and beyond. Although it was possible to make such predictions with a certain level of accuracy by comparing past data, we saw some discrepancies related to the height and location of peaks, etc.

To solve this problem, we investigated the correlations between prediction factors and a variety of field data. We were able to establish that environmental factors such as rainfall levels and especially temperature had a powerful influence. This is quite understandable, given that mosquitoes transmit dengue fever. In recent years, big data-based simulations have become crucial. As our case suggests, collecting and analyzing detailed environmental data will also become essential in such simulations.

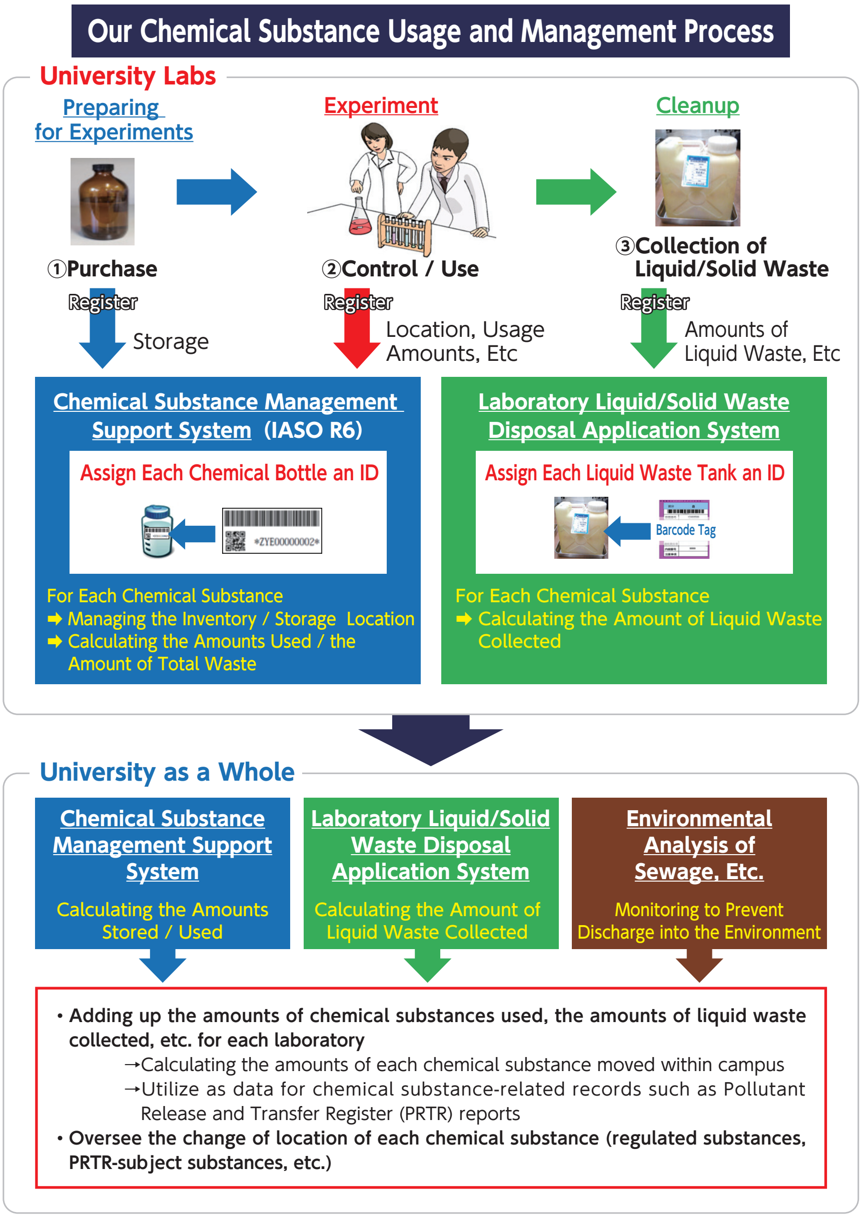
Synthetic biology is a technology that poses risks to the environment. In addition to participating in iGEM, our team also organizes a symposium focused on assessing these risks. Genetic engineering technology is essential to the advancement of synthetic biology, and the ethical issues inherent in this field are one more aspect that will require continued consideration.

Moe Takahashi, iGEM Tokyo Tech 2019 Team Leader
Third-Year Undergraduate Student
Department of Life Science and Technology
School of Life Science and Technology

Initiatives to Reduce the Environmental Footprint of Chemical Substances

To ensure that we manage chemical substances properly, we have introduced IASO R6 (also known as the Tokyo Tech Chemical Substance Management Support System), which allows us to determine the inventory and use of chemical substances at the university in real time. We also have two ways to reduce the environmental footprint of the chemical substances we use. The first is an Laboratory Liquid/Solid Waste Disposal Application System that allows us to grasp the quantities of liquid/solid waste material generated during experiments. The second is to conduct environmental analyses and chemical analyses of waste material for chemical substances to ensure that they are not released into the environment.

● Our Chemical Substance Control Process



Note: All laboratories that use chemical substances must register with IASO R6 and the laboratory liquid/solid waste disposal application system.

● Our Laboratory Liquid/Solid Waste Disposal Process (from pickup requested by a laboratory to disposal by a contracted company)

Our laboratories use the Laboratory Liquid/Solid Waste Disposal Application System to manage waste according to the type of waste material, and identify the waste with tags on the tanks. Data on the composition and chemical analysis of the liquid waste logged in the system is then used to prepare waste data sheets (WDSs). Because the handling of experimental waste requires accurate information, WDSs are used to convey key details about the waste materials to the contractors tasked with their disposal.

Environmental Performance

Tokyo Tech's activities consume a great deal of energy and a wide range of materials. Most of the energy we consume is in the form of electricity and gas. The primary materials we use are chemical substances, paper, and water. While we need to use these to conduct our cutting-edge research activities and education/talent development activities, we're also engaged in minimizing the environmental footprint of our operations.
The following chart shows the amount of input needed for our research and education activities and other operations for fiscal 2018, as well as the emissions and waste generated. Inputs include energy and materials consumed, while outputs include waste and environmentally hazardous substances discharged outside.

INPUT

Energy

Electricity : 68,369,000 kWh

City Gas : 625,000 m^3

Fuel Oil : 0.97 kl

Gasoline : 0.3 kl

Material

Chemical Substances (2,798 types) : 85.4 t

Pollutant release and transfer register (PRTR) related Substances : 35.8 t

Paper : 58.4 t

Water : 256,800 m^3

Recycling

Paper : 348 t

Other Recycled Materials : 319 t

Graywater Reuse : 64,000 m^3

OUTPUT

Atmospheric Emissions

Greenhouse Gas Emissions : 33,383 t CO_2

Purchased Electricity : 31,800 t CO_2

Fossil Fuels : 1,403 t CO_2

Water and Sewage : 180 t CO_2

Waste

General Waste : 168.6 t

Industrial Waste : 559.0 t

Water Discharged

Total Sewage Discharged : 263,700 m^3

Pollutant Emissions
BOD : 11.6 t Nitrogen : 6.3 t
Phosphorus : 0.8 t

● FY2018 Environmental Performance Viewed from the Perspective of Laws and Ordinances Related to Energy Conservation

Law / Regulation	Standard Value	Achieved Value	Rate of Reduction	Result
Energy Conservation Act (*1)	0.04130 (kl/m^2)	0.04011 (kl/m^2)	-2.9%	Achieved (*4)
Tokyo Ordinance (*2)	119,288 (t/four years)	87,138 (t/four years)	-27.0%	Achieved
Yokohama Ordinance (*3)	82.36 (t/1000 m^2)	77.20 (t/1000 m^2)	-6.3%	Achieved

*1 We reduced our crude oil equivalent energy consumption per square meter of floor space (kl/m^2).

*2 This is our total tonnage of CO_2 emissions for four years compared to the standard emission level for four years (five-year compliance period).

*3 We reduced our tonnage of CO_2 emissions per 1000 square meters of floor space (t/1000 m^2).

*4 Our average reduction rate of -1.7% for the past five years met the nonbinding target set in the Energy Conservation Act.

Use the QR codes below to see the full version and digest of the Tokyo Institute of Technology Environmental Report 2019 (both in Japanese).

Environmental Report 2019
(Japanese)

Digest Version
(Japanese)

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古紙パルプ配合率70%再生紙を使用