Environmental Report
2020 *Digest Version*

This cover photo depicts Croatia's Plitvice Lakes National Park, a World Heritage Site that encompasses a massive 192-square-kilometer forest dotted with 16 emerald green lakes of various sizes that are linked by 92 waterfalls. A graduate student from our laboratory took this photo during a visit to the region. Although I have never visited this particular lake, I have visited Jiuzhaigou National Park in China, another stunningly scenic World Heritage Site. Both can fairly be called terrestrial miracles created by karsts.

Our laboratory studies the water cycles in Japan and the rest of the world. Some specific topics we are researching include water resource shortages and flooding disasters. While such stunning scenery in itself is not a direct subject of our research, we believe there is a need to zealously pursue our research activities to protect the relationship between beautiful bodies of water and humanity. Most people are aware that UNESCO administers World Heritages Sites, which is related to our research field, albeit in an unrelated context. UNESCO has four panels (or programs) in the fields of natural science. One of these is our research field, hydrology, with which the organization is involved in a number of ways, including international water research program planning.

Professor Shinjiro Kanae
Department of Civil and Environmental Engineering
School of Environment and Society

Tokyo Institute of Technology

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SUSTAINABLE DEVELOPMENT GOALS

Tokyo Tech is actively working on Sustainable Development Goals (SDGs).

President's Greeting

Striving to Lead Society to a New Future

Kazuya Masu
President, Tokyo Institute of Technology

The COVID-19 pandemic has been posing a serious global threat in the year 2020, and has greatly affected both social systems and peoples' lives. Educational institutes, too, have been forced to make major reforms. Universities, with education as one of their key missions, have had to create new educational styles and improve their educational environments. Another pressing issue for both our institute and academia as a whole is the matter of how to use science and technology to respond effectively to the crises the pandemic has created.

Meanwhile, global environmental problems such as environmental destruction and climate change grow more severe each year, and remain crucial issues demanding a solution. We are facing a challenging situation in which we must solve such environmental problems while at the same time fighting new crises.

In March 2018, the Minister of Education, Culture, Sports, Science and Technology selected Tokyo Institute of Technology as a Designated National University Corporation. Our proposal was "pioneering a new era through continuous dialogue with society and the discovery of hidden possibilities in science and technology." By pursuing talent development with an emphasis on an environmental curriculum as well as a number of other diverse initiatives, we strive to produce outstanding talents through more sophisticated education and research activities, and to contribute to solving social problems by giving our research results to society. Through these efforts, we will contribute to the society Tokyo Tech is a part of as well as human society as a whole. We seek to realize a rich future society and share it with generations to come.

In the realm of the environment in particular, we will continue to tackle diverse environmental problems while also considering new styles of education and research. We will do this in accordance with our basic principle on environmental policy, in which we see the problems as 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. At the same time, we will keep contributing to society through talent development and research activities.

This report was prepared in accordance with the Ministry of the Environment's environmental reporting guidelines, primarily focusing on environmental performance. It summarizes our environmental conservation activities, and includes but is not limited to initiatives to reduce the institute's own environmental impact, such as the waste generated by our education and research activities, measures to reduce energy consumption and CO_2 emissions and the reporting of the status of said measures, and the initiatives of students, faculty, and staff meant to solve environmental problems.

It is my hope that you will read the report and that Tokyo Tech's FY2020 activities will continue to earn your understanding and cooperation.

October 2020

Environmental Policy

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.

Cutting-Edge Environmental Research Topics

"Development of a Highly Selective Enzyme-Catalyzed Organic Synthesis Reaction"

Matsuda Research Group doctoral student Afifa Ayu Koesoema* (Left)

Associate Professor Tomoko Matsuda (Right)

Department of Life Science and Technology
School of Life Science and Technology
(*Specially appointed assistant professor at Okayama University since April 1, 2020)

Enzymes are environmentally friendly catalysts. They can be created in large amounts perpetually and continuously using microbiological cultures. Rare metal catalysts, meanwhile, are nonrenewable. In addition, the solvents and reagents used in enzymatic reactions are derived naturally and safe. For example, while the chemical industry uses organic solvents, enzymatic reactions use water. Another benefit of enzymatic reactions is that they occur at room temperature and atmospheric pressure. Many industrialized chemical reactions require high-temperature, high-pressure conditions and massive amounts of energy, increasing the impact on the environment. Enzymatic reactions, which progress in moderate conditions, are highly energy-efficient.

Enzymes are also outstanding catalysts for organic synthesis reactions. Their most notable characteristic is their high selectivity. They can control the generation of byproducts as well as synthesize optically active compounds, which are needed as medical and agrochemical intermediates. As medical and agrochemical intermediates, there is a need for both *S*-isomers and *R*-isomers, which are left-hand and right-hand mirror images of the same molecule. However, when the difference between left-hand and right-hand versions is small, it is difficult to selectively synthesize one or the other. In addition, few enzymes are capable of reducing bulky aliphatic ketones — an area requiring research and development.

We are researching enzymatic reductions using *Geotrichum candidum*-derived acetophenone reductase (*Gc*APRD), a durable enzyme. By using a wild type of *Gc*APRD to reduce a diverse array of ketones such as acetophenone derivatives, tetralone derivatives and aliphatic ketones, we obtained their corresponding *S*-isomer alcohols with extremely high stereoselectivity. For example, in a 3-hexanone (ethyl propyl ketone) reduction reaction, we obtained its corresponding *S*-isomer alcohol with an enantiomeric excess (ee) of 99+ percent. In other words, this enzyme has the ability to distinguish between ethyl group and propyl group. Its mechanism was revealed through X-ray crystallography and docking simulations between substrates and the enzyme. The interaction between Trp288 and the substrate stabilizes the pro-*S* binding pose (Fig. 1).

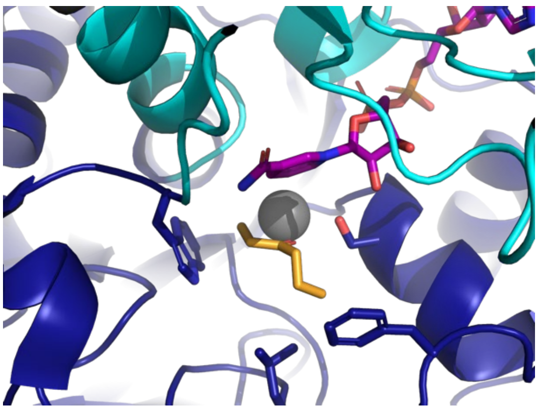


Fig. 1 Docking simulation of *Geotrichum candidum*-derived acetophenone reductase (*Gc*APRD (wild type)) and 3-hexanone

However, wild-type *Gc*APRD has a weakness — it cannot synthesize *R*-isomers. To solve that problem, we tried mutating one amino acid (Trp288) of the wild type, a *S*-isomer synthesizing enzymes, that exist abundantly in nature . We were able to modify it into a highly valuable enzyme that can synthesize *R*-isomers. We also succeeded in reducing more challenging bulky aliphatic ketones. For example, we reduced 4-octanone (propyl butyl ketone) using the mutant (Trp288Val), and obtained corresponding *R*-isomer alcohol with an ee of 87 percent.

Our study will clarify an expression mechanism of strict stereoselectivity. We expect this enzymatic reaction to have applications as an environmentally friendly synthesis method for medical and agrochemical intermediates. Further, it will be possible to apply the mechanism to the study of interactions between biopolymers and organic compounds, leading to the development of pharmaceuticals with high selectivity and minimized side effects.

Reference Literature: A. A. Koesoema, D. M. Standley, K. T. Sriwong, M. Tamura, T. Matsuda, Tetrahedron Lett. 2020, 61, 151682. A. A. Koesoema, Y. Sugiyama, K. T. Sriwong, Z. Xu, S. Verina, D. M. Standley, M. Senda, T. Senda, T. Matsuda, Appl. Microbiol. Biotechnol. 2019, 103, 9529. A. A. Koesoema, Y. Sugiyama, Z. Xu, D. M. Standley, M. Senda, T. Senda, T. Matsuda, Appl. Microbiol. Biotechnol. 2019, 103, 9543.

Matsuda Lab: http://www.matsuda.bio.titech.ac.jp/

“Geologic Storage of Carbon Dioxide”

Professor Tetsuya Suekane
Department of Mechanical Engineering
School of Engineering

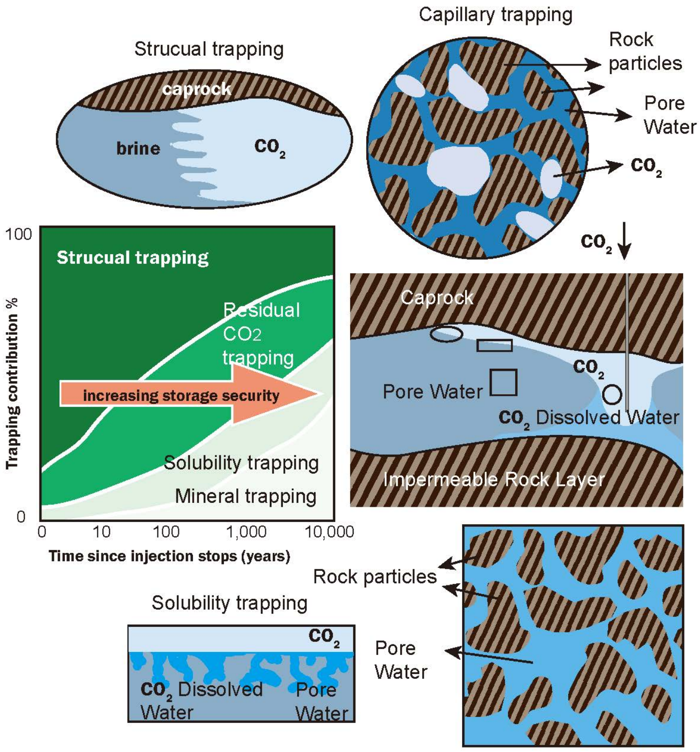
Reducing the emission of greenhouse gases such as carbon dioxide (CO_2) to mitigate climate change has become a global agreement. The Paris Agreement have set a target of keeping global temperature rise to within 2 ºC with respect to pre-industrial levels. To achieve this goal all schemes should be implemented sush as the replacement of fossil fuels with renewable energy, improvement in energy conversion efficiency, energy sources changes, nuclear power, tree planting and so on. Japan emits approximately 1.19 billion tons of CO_2 per year. If you were to compressively liquefy (under approx. 57 bar) that much CO_2, it would have a volume equivalent to around 1,246 Tokyo Domes. Over eighteen years, it would rival the volume of water in Lake Biwa.

Carbon capture and storage (CCS) is a technology used to separate and recover CO_2 emitted by coal-fired power stations and other carbon emitters and then store the enormous recovered volume of CO_2 underground. CCS was first implemented in the 1990s at the Sleipner gas field in Norway, where around a million tons of CO_2 per year is stored by injecting it into a geological formation located approximately 1,000 meters below the Earth’s surface. In Japan, a CCS demonstrator project is currently being conducted utilizing an undersea geographical formation offshore from Tomakomai, Hokkaido. The density of CO_2 grows quite high due to the high-temperature, high-pressure conditions underground. However, since CO_2 is lighter than water (with a specific gravity between 0.2 and 0.8), its buoyancy could cause it to move inside rock. As such, there is a need to know the security of the storage place and to predict the long-term behavior of CO_2.

CO_2 injected into a geological formation (reservoir) is initially physically trapped by a dense impermeable rock layer. This is the same mechanism that allows crude oil and natural gas to remain within a geographical formation for millions of years. Next, the movement of the CO_2 divides it into bubbles, which are then trapped by capillary pressure. Bubbles naturally assume a round shape due to surface tension. Because the force of the surface tension is stronger than the buoyancy of the bubble, the bubbles are unable to change their form and are trapped within the rock. In fact, this is the same mechanism that can reduce the oil recovery rate in oil recovery, where avoiding capillary trapping is a major challenge. CO_2 is known to exhibit detergent-like properties in the high-temperature, high-pressure conditions that exist underground. CO_2 injection has been used in American and Canadian oilfields to enhance oil recovery since the 1980s.

Next, the CO_2 dissolves into the groundwater. Because carbonated water is slightly heavier than freshwater, this causes natural convection within the reservoir, which further dissolves CO_2. To estimate the time required to shift more stable dissolution trapping, we should accurately predict how much time is required for natural convection to occur. Although it is impossible to look directly inside rock, figure 2 shows the results of visualizing natural convection inside of a porous material using X-ray computed tomography. According to this result, we can predict that natural convection will occur in the Sleipner gas field in Norway in around eighty years. The CO_2

will eventually react with the minerals that comprise the rock and turn into carbonates such as limestone, a process referred to as mineralization.



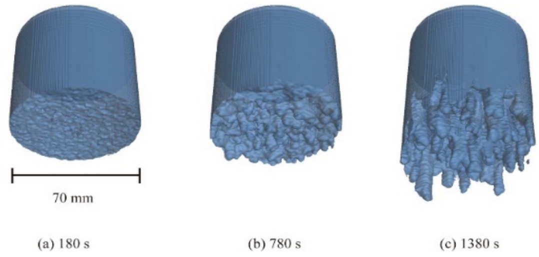


Figure 1 (Left):
Progress of CO_2 trap mechanisms in carbon capture and storage process

Figure 2 (Above):
Visualization of Natural Convection Within a Porous Medium, Convection of Salt Water (Blue) and Fresh Water

Most scientists expected that mineralization requires periods on the scale of millions of years. However, it was discovered during a demonstrator in Iceland that mineralization occurred in only two years. Although the technology poses challenges in how to dissolve CO_2 in water and inject it underground, the basalt and serpentinite formations in which the abovementioned quick mineral fixation was observed to occur are widely distributed in Japan. We believe we need to consider using this storage technique in Japan as well.

Suekane Lab : http://www.suekane.mech.e.titech.ac.jp/

Improving Environmental Education

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 will introduce the main environment-related courses we offer in our bachelor's and graduate degree programs (data below are as of AY2019).

[Environment-Related Courses in Bachelor's Degree Program]

Note: Numbers in parentheses are the number of courses offered in their respective series.

First Year	We offer course(s) that describe current global environmental problems. They are intended to get students to think about the formation of a sound material-cycle society/sustainable society, increase their awareness of safety, and help them acquire a sense of environmental ethics. 100-series course (1)
	"Environment and Safety"
Years Two to Four	We offer curriculums suited to the specializations of each department. A number of our 200-series (7) and 300-series courses (16) are offered in English.

[Environment-Related Courses in Graduate Degree Program]

Note: The numbers in parentheses are the numbers of courses offered in their respective series.

We offered courses suited to the specialization of each graduate major: 400-series courses (38), 500-series courses (14), and a 600-series course (1)
In addition to the course presented below, our interdisciplinary 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 — offer a large number of environment-related courses.
Lectures for all specialized courses in our graduate degree programs are offered in English, making each curriculum suitable for international students seeking an education on environmental topics.

Course-numbering system: Every course is assigned a course code that indicates its academic discipline, level of specialization, relationship with other courses, as well as its order relative to related courses and other information. This system, which makes it easy to understand the progression of an educational program, is referred to as a course-numbering system.

Features of a Tokyo Tech Education (in Japanese): https://admissions.titech.ac.jp/school/features/

【Biochemistry II]

Undergraduate Course: School of Life Science and Technology Department of Life Science and Technology

Associate Professor Yoh-ichi Tagawa
Department of Life Science and Technology
School of Life Science and Technology

Cells are composed of a wide variety of biomolecules that control various cell functions. Animals break down the glucose, fatty acids and amino acids in food to synthesize adenosine triphosphate (ATP) and use the energy gained through the hydrolysis of ATP to synthesize biomolecules and perform a variety of life activities (energy metabolism). Living organisms are never in a state of equilibrium; they only reach an equilibrium state when they die. This means living organisms are constantly in a state of metabolization while they live.

The objective of this lecture course is to clearly show the relationship between the vital mechanisms of life: the mechanisms that cells use to synthesize ATP, the mechanisms cells and individual animals use to regulate their level of ATP synthesis, and the mechanism they use to maintain homeostasis on the level of individual animals and its relation to metabolism.

Microorganisms can be found everywhere on the planet, and our lives are closely connected with them. An adult human's intestines are home to approximately thirty trillion gut flora. Meanwhile, around 100,000 normal flora live on the skin. The countless bacteria that live in rivers, oceans and soil maintain the planet's environment. While it is of course essential for us to understand the biochemistry of humans, the biochemistry of microorganisms is also incredibly important. When our physical condition changes, the variety of gut flora that live inside of us also change significantly, which in turn greatly affects us. The Earth is the same. If the environment changes, the kinds of microorganisms on the planet may also greatly change. There is a high probability that this would not only affect the environment but also greatly affect the ecosystem.

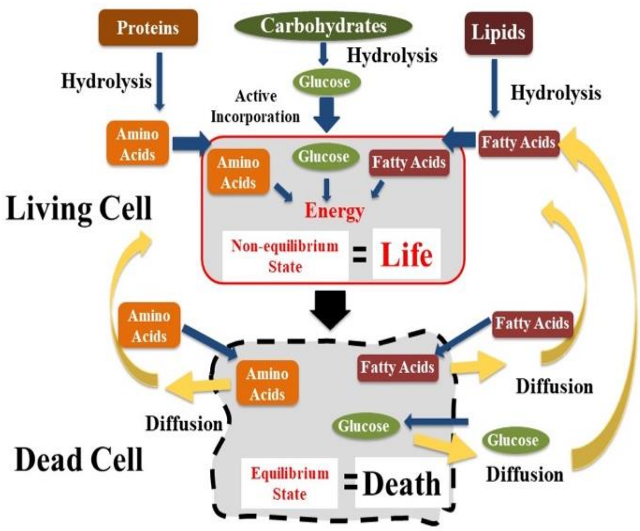


Fig. What is life? What is death?
An Approach from Biochemistry

This lecture course aims to give students the fundamentals of biochemistry, get them to ponder the nature of life, and gain the ability to investigate subjects related to microorganisms and humanity as well as microorganisms and the global environment from a biochemical perspective.

Tagawa Lab：http://www.tagawa-lab.bio.titech.ac.jp/

【Environmental Impact Assessment】

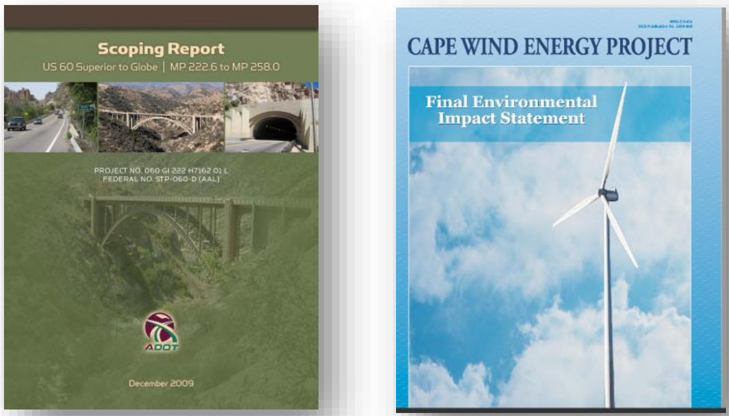
Graduate-Level Course: Department of Transdisciplinary Science and Engineering, School of Environment and Society

Associate Professor Shigeo Nishikizawa
Department of Transdisciplinary Science and Engineering
School of Environment and Society

Dealing with environmental problems will require more than just technical solutions. We will need to build systems that push economic activity and our own lifestyles and behaviors in a more environmentally considerate direction. Pursuing this goal is the subject of fields such as environmental planning and environmental policy. The Department of Transdisciplinary Science and Engineering's "Environmental Impact Assessment" course (instructed by Professor Takehiko Murayama and myself) tells students about these fields.

Environmental impact assessment (EIA) is a tool used to put the necessary measures in place through communication with the parties involved in projects that affect the environment. This is done by providing results obtained through investigating and predicting the environmental impact of relatively large development projects such as construction of roads, solid waste disposal facilities, and power stations. This course will first outline basic EIA concepts and procedures, and then explain both technical and social aspects of EIA. That includes techniques used in investigations/surveys and the prediction/evaluation of the results obtained, as well as social angles such as public participation and communication.

This graduate-level lecture course is taught in English, and international students account for about half of the course participants. Time is set aside during classes for students to form groups of about five, each comprised of both Japanese and international students. They read and compare EIA reports from Japan and the United States, discuss their different characteristics, and present their findings.



Examples of EIA reports used in class
(Left: Road construction; right: Wind farm (both in the US)

The aim of this lecture course is not merely to have students gain an understanding of EIA. It is also to shine a light on the negative aspects of technological development and scientific progress so that students can gain an understanding of the impact these things have on society, how to handle that impact, and the roles of environmental policy and planning.

Nishikizawa Lab: http://www.nishikiz.depe.titech.ac.jp/index.html

Environmental Education at the Tokyo Tech High School of Science and Technology

At Tokyo Tech High School, which specializes in science and technology, environmental education is provided through courses that have the objective of helping students understand the relationship between the environment and science and technology. Students are encouraged to develop a willingness and desire to explore the environment from a scientific point of view.

1. Research Project Initiatives

The research project is a third-year course in which students in AY2019 energetically explored a wide variety of themes related to the environment, energy and so on in our five fields of study. The table below shows some of such themes.

Applied Chemistry	"Red Colored Glass Manufactured without Containing Any Harmful substances" "Producing Cellulose Nanofiber from Weeds" "Extraction of Cellulose from Rice Husks and Synthesis of a Bioplastic Using the Acetylated Cellulose" "Ethanol Produced from Decomposition of Cellulose by Microorganisms"
Information Systems	"Development of Electronic Medical Record Sharing System Using Blockchain" "Improvement of Exercise from Using Motion Capture and Myoelectric Sensor" "The Research of an Automatic Transport Vehicle to Compensate for Decreasing Labor Force"
Mechanical Systems Engineering	"Wireless Power Supply by Using Laser Module" "Production and Evaluation of a Swing Generator Using Double One-way Clutch Mechanism" "Developing of Generator Position Information System and Production of Rear Car for Transportation"
Electrical and Electronics	"Clothes Drying Assisting Machine: Automatically Spreads and Pulls Together Laundry" "All Day Sitting Stopper: Production of a Device to Detect and Notify a Long Sitting Position" "Development of System Prevent Glass Scattering by Earthquake Early Warning Production of Curtain Control Device"
Architectural Design	"Calculation of Amount of Dismantling of Tokyo Tech High School of Science and Technology Experimental Building" "The Study on the Strength of the Concrete Poles Reinforced with Carbon Fiber Sheet" "Rainwater/Sunlight: Design and Review of a Public Facility Created to Connect with Nature" "The Present Situation and Countermeasures of Unoccupied Houses in Setagaya-ku, Tokyo"

2. Initiatives in Global Society and Technology

The school-designated course Global Society and Technology provides first-year students the chance to explore the theme “the Environment and Humanity.” Through class sessions titled “The Environment as Viewed from PET Bottles” and “The Environment as Seen from The Earth’s Energy Balance,” students strive to develop the scientific and technological problem-solving skills needed to create a sustainable society.

3. Initiatives in Introduction to Advanced Science and Technology

A tour of DHC Tokyo Co., Ltd.’s Tamachi Station East Gate District Heating and Cooling (DHC) Center was conducted as part of the class. In addition to seeing a working DHC system in person, students also deepened their understanding of subjects such as cogeneration, smart energy networks, and other topics.

Touring the DHC Center
February 10, 2020

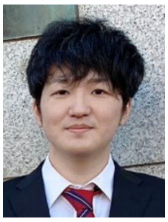
Tokyo Tech High School of Science and Technology
http://www.hst.titech.ac.jp/

Student Environmental Conservation Activities

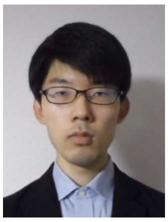
Initiatives Related to Fukushima's Revitalization and Environmental Problems, and Activities on Science Education Support

Kikura Laboratory
Department of Mechanical Engineering, School of Engineering / Department of Transdisciplinary Science and Engineering, School of Environment and Society

First-year master's student Yuki Iijima



First-year doctoral student Ryo Ikeda



Second-year doctoral student Naruki Shoji

Third-year doctoral student Zhang Weichen

Around nine years have passed since the Great East Japan Earthquake and the Fukushima Daiichi Nuclear Power Plant accident. Evacuation orders have been lifted for most of the regions other than the "difficult to return" zones in Fukushima Prefecture. Over the last few years, the national government's efforts on Fukushima's recovery and revitalization have entered high gear. One example of this is the Fukushima Innovation Coast Framework, a national project aimed at building new industrial infrastructure in the prefecture's coastal Hamadori region and other areas. Given the situation, Kikura Laboratory members selected a variety of research topics aimed at speeding the realization of the Fukushima Innovation Coast Framework and are energetically engaged in related activities. This included forming "Revitalizics," a new practical science discipline.

As examples of our activities, we will introduce two of our efforts. One is an investigation of reputational damage that Fukushima Prefecture's fishing and agricultural industries suffered. The other concerns the children's science classes we offered to the public. Both activities were conducted as part of our social contribution and environmental conservation activities.

Commercial distribution of seafood from Fukushima Prefecture has yet to recover to pre-earthquake levels. We hypothesized that reputational damage is the cause of this problem, and conducted a hands-on field investigation spanning the entire distribution route from producers to brokers to retailers to consumers. We went on a fishing vessel working in the waters off Fukushima to confirm the safety of its seafood through radioactivity measurements and other means. We then conducted interviews with producers, brokers and retailers. After that, we sold the fish we had caught in Fukushima at a supermarket outside the prefecture and surveyed the attitudes of consumers. From these results, we were able to draw a better picture of the reality of the reputational damage the prefecture has suffered.

Left: Collecting Fukushima seafood
Right: Conducting interviews
Field Investigation in Fukushima Prefecture's Coastal Fishing Grounds
(Source: NHK program *Miraijuku*, airdate July 7, 2019)

Revitalize Namie Tokaichi Festival

Eco Festa Wonderland in Rokugo

According to our investigation, while around 80 percent of consumers were interested in buying fish from Fukushima, some 90 percent of retailers and other distributors thought the opposite: they supposed that around 80 percent of consumers do not want to purchase Fukushima seafood.

This large gap in understanding was the reason that distributors were not handling seafood from Fukushima, which of course resulted in poor sales. We then engaged in activities aimed at helping Fukushima's fishery environment recover, including presenting the results of our investigation to supermarkets. Our activities were even featured on an episode of the NHK program *Miraijuku* (Lectures for the Future, airdate July 7, 2019). We also conducted similar activities regarding Fukushima's fishing and agricultural industries in collaboration with individuals in the nuclear field from Taiwan.

The purpose of our children's science classes was twofold. The first goal was to explain the advanced technology cultivated through our nuclear-related research in an easy-to-understand way. The second was to increase awareness about how the Tokyo Institute of Technology is contributing to Fukushima's recovery and revitalization and helping to solve environmental problems. In FY2019, we conducted the classes at the Revitalize Namie Tokaichi Festival in Namie Town, Fukushima Prefecture on November 23 and 24, as well as at the Eco Festa Wonderland in Rokugo event held in Ota City, Tokyo on February 16.

Children got to change the viscosity of water through making slime, visualizing the flow of a fluid using an ultrasonic velocity profiler, and operating a remote-control robot. Both science sessions were major successes. We are sure that these activities helped the children understand the nuclear power field and Fukushima's recovery and revitalization better. We also believe they have a greater awareness of and interest in environmental problems, and more intellectual creativity as well. We believe these efforts expand the base of future human resources with a passion for manufacturing.

The members of the Kikura Laboratory hope to continue contributing to Fukushima's recovery and revitalization and coming up with solutions to environmental problems through our activities.

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

Tokyo Tech VG Environmental Conservation Activities

Tomoki Ichimura
Fourth-year undergraduate student
Department of Architecture and Building Engineering
School of Environment and Society

The Tokyo Tech VG is a student volunteer group created out of a desire to support the recovery and revitalization of regions affected by the Great East Japan Earthquake. Taking what we learned from the Fukushima Study Tour on January 19, 2019, we again visited Minamisanriku Town in Miyagi Prefecture and the Fukushima Daiichi Nuclear Power Plant in October and November 2019, respectively, to take another look at what the group could do to help.

In Minamisanriku, we participated in a two-day study tour organized by the Minamisanriku Town Tourist Association. On the first day, we went on a walking tour in the town's coastal area before staying the night with local host families. There, we had a chance to ask our host families about their lives following the disaster in great detail. This was an opportunity to gain an understanding of the realities of disaster-affected areas. We were able to hear unfiltered talk from local residents unlikely to be shown up in the news. For example, while the deep-rooted nature of the region's community did result in people independently engaging in mutual aid, it also made it possible for residents to know the level of damage that other families in the region had suffered. As a result, casual remarks or small differences in thinking occasionally led to major discord. In addition, some residents found it unsettling that the newly developed high ground and seawalls blocked their view of the ocean.

On our second day there, we attended a workshop. Based on the previous day's interviews of local residents regarding how they spent their days at the time of the disaster, we discussed what the best course of action would be if a massive near-field earthquake (earthquakes that occur near a fault) occurred in a major city. After the workshop, we once again visited the town's high ground where we had spent the previous night with local residents. The view from there gave us a visceral feel for the technology and the massive amount of energy invested in the area's reconstruction and recovery. We pondered the awesome power of nature by imagining the onslaught of a massive tsunami that could swallow us up where we stood. We also reflected on the actual damage suffered, as the disaster had destroyed an entire town's scenery, community, and livelihoods such as the fishing in an instant. Through the study tour, we were able to understand and empathize with the feelings of many different people regarding the environmental problems that accompany post-earthquake reconstruction and recovery.

Left: Walking tour in Minamisanriku Town (starting from the seawall being rebuilt)
Right: Disaster prevention workshop in Minamisanriku Town (discussing the best courses of action for each period of time following a near-field earthquake in a major city)

At the Fukushima Daiichi Nuclear Power Plant, we attended a workshop organized by Mirai Kaigi (Future Meeting).

In the morning, we observed the power plant's premises from a bus. Although the scene gave the impression that things were being properly maintained, the buildings housing reactors No. 1 and 2 — which are being decommissioned — were in the same terrible state as the day of the accident. In the afternoon, around forty people (including us) with diverse backgrounds from all across the country gathered to discuss their thoughts on the tour, their activities, their feelings about the future, and other topics. After returning to campus, we each prepared a report on the tour while also sharing our feelings and exchanging ideas and opinions. This was a great opportunity for group members to consider the importance of our activities as we related to the nuclear accident, which has had a major impact on our living environment.

Active dialogue between participants of the workshop organized by Mirai Kaigi (Future Meeting)

The numerous problems brought on by the Great East Japan Earthquake span many environmental aspects. For example, there are global environmental issues such as the radioactive contamination the nuclear accident produced, as well as the increased energy consumption required for post-disaster reconstruction and recovery activities. There are also social environmental issues, such as the local communities the disaster destroyed and when it came to light that Fukushima Daiichi Nuclear Power Plant, provided electrical power for Tokyo. The Tokyo Tech VG hopes to continue holding study tours in AY2020 and beyond, to broadly solicit participation by more Tokyo Tech students, and engage in activities that confront environmental issues of all kinds from diverse aspects.

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

Energy Conservation and CO_2 Reduction Initiatives

Tokyo Tech conducts a great deal of experimental research. For this reason, the combined energy consumption of our Ookayama, Suzukakedai and Tamachi campuses is about the same as that of 20,000 typical homes. This results in high CO_2 emissions for an enterprise that does not make any products. With that in mind, Tokyo Tech has set numerical goals related to energy efficiency and is pursuing initiatives to achieve them.

Activities of the Energy Conservation Section

To promote energy conservation at Tokyo Tech, we established our Energy Conservation Promotion Office in October 2010. This office was renamed the Energy Conservation Section and became part of the Office of Campus Management in April 2017 to further conserve energy. This new organization is in charge of matters including proposing, planning and carrying out policies related to the promotion of energy conservation as well as information collection.

The primary energy consumption-related laws and ordinances Tokyo Tech is currently subject to are the national Act on the Rational Use of Energy, Tokyo Metropolitan Government ordinances, and Yokohama City ordinances. In accordance with these laws and ordinances, we need to reduce energy consumption (electricity and natural gas) as a medium- to long-term initiative. To further promote energy conservation, we devised the Tokyo Institute of Technology Energy Conservation Action Plan in FY2018. Since 95 percent of the energy we use comes from electricity, the Energy Conservation Section primarily pursues management activities related to lowering the use of electricity.

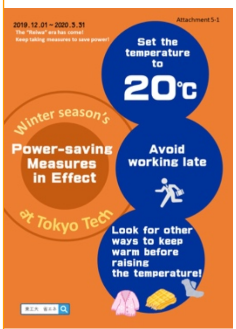
Implementation of Cool Biz / Warm Biz

We used posters and other means to proactively call for cutting electrical usage during high-usage seasons.

Implementation of Cool Biz
(March 1 to October 31)

We requested faculty, staff and students to cooperate with targeting a room temperature of 28°C, and to work in light clothing.

Implementation of Warm Biz
(December 1 to March 31)



We called for faculty, staff and students to target a room temperature of 20°C, and to wear clothing that is warm and easy to move around in.

We created an energy efficiency and conservation manual to promote energy conservation.

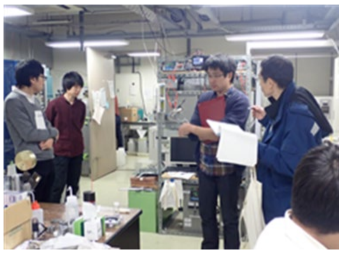
The target room temperatures of 28°C during the Cool Biz period and 20°C during the Warm Biz period were guidelines, not designated thermostat settings. Please keep room temperatures at a reasonable level in consideration of factors such as location, the situation and your physical condition.

Proactive Introduction of High-Efficiency Devices and Systems

Tokyo Tech has set the goal of making its campuses low-carbon, environmentally friendly places, and every fiscal year we formulate a plan for implementing improvements. That includes transitioning to LED lighting and installing high-efficiency air-conditioning systems. We have also worked to boost energy conservation through energy management measures such as installing a centralized air-conditioning control system and a centralized power meter reading system. We even started an electric power consumption visualization project to make faculty, staff and students aware of energy conservation. Since 2010, we began installing renewable energy equipment such as solar power systems and fuel cells.

Implementation of Energy Conservation Inspections

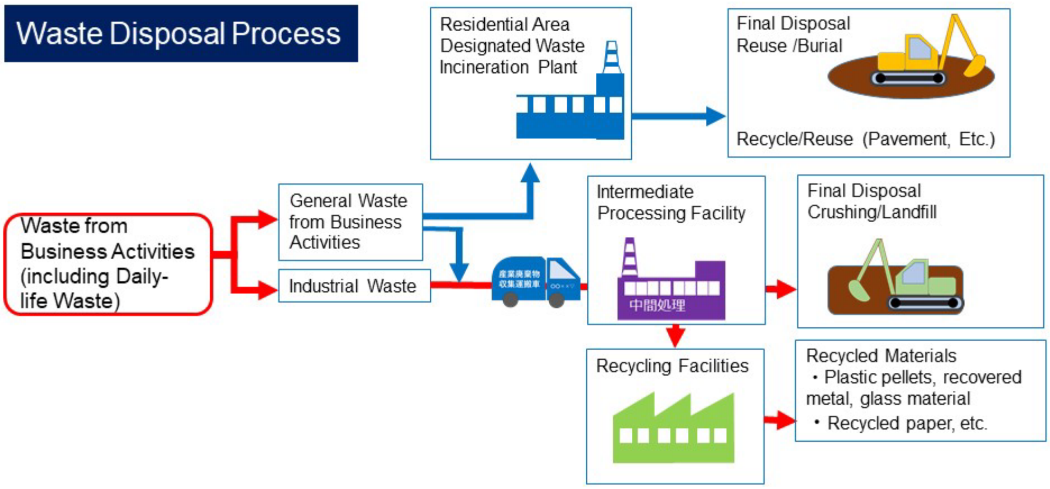
Installing LED lighting, high-efficiency air conditioners and renewable energy equipment did help to reduce our CO_2 emissions. However, electricity prices are expected to go up, and legally mandated CO_2 reduction requirements will become increasingly strict. In consideration of the situation, and to promote better energy conservation, we set up internal energy conservation inspections for each laboratory in buildings with high electricity usage per unit area to help improve laboratory operations. Requests are made after inspections, such as for appropriately managing laboratory room temperatures, cleaning HVAC filters, and optimizing use of experimental equipment. In addition, to increase awareness among the energy conservation promoters designated for each office/room/laboratory and promote energy conservation, we ask them to fill out energy-saving checklists.

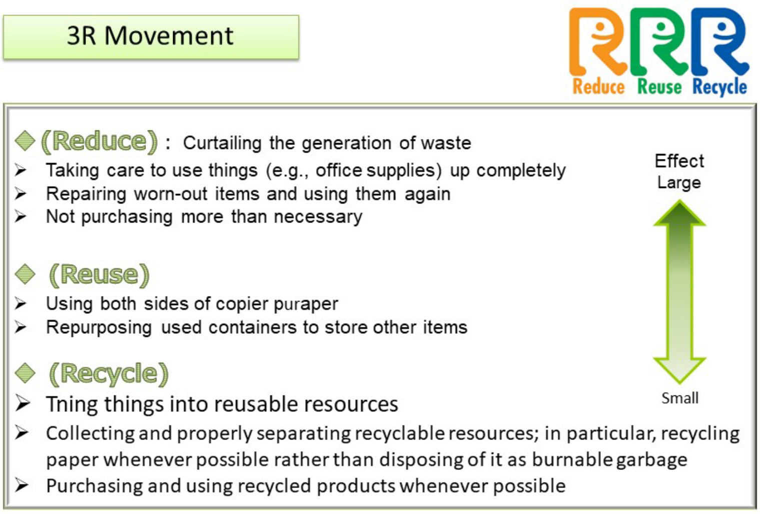


Conducting an energy conservation inspection

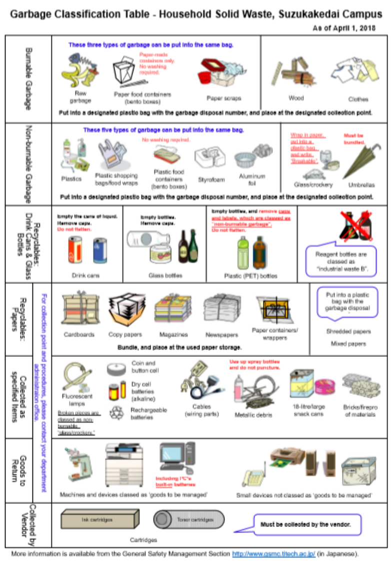
Initiatives to Reduce the Environmental Impact of General Waste

Tokyo Tech is striving to reduce its environmental impact by cutting the amount of waste its business activities generate. One of the ways we do this is through 3R (reduce, reuse, recycle) activities, which include a transition to paperless operation, thoroughly separating waste, and recycling materials such as paper. To ensure compliance with the Tokyo Tech's waste separation and disposal rules, we post Japanese- and English-language versions of the garbage classification table on the Tokyo Tech website, near garbage bins, and elsewhere. The table was also disseminated through the Environmental Safety and Health Seminar and e-learning course at the start of the academic year. In addition, Tokyo Tech provides students with substantial information and instructions on general measures for reducing environmental impact as well as on the waste separation and reduction methods.





Excerpt from e-Learning Material



Waste Storage Area

Paper-Sorting Station

Promotion of Green Procurement

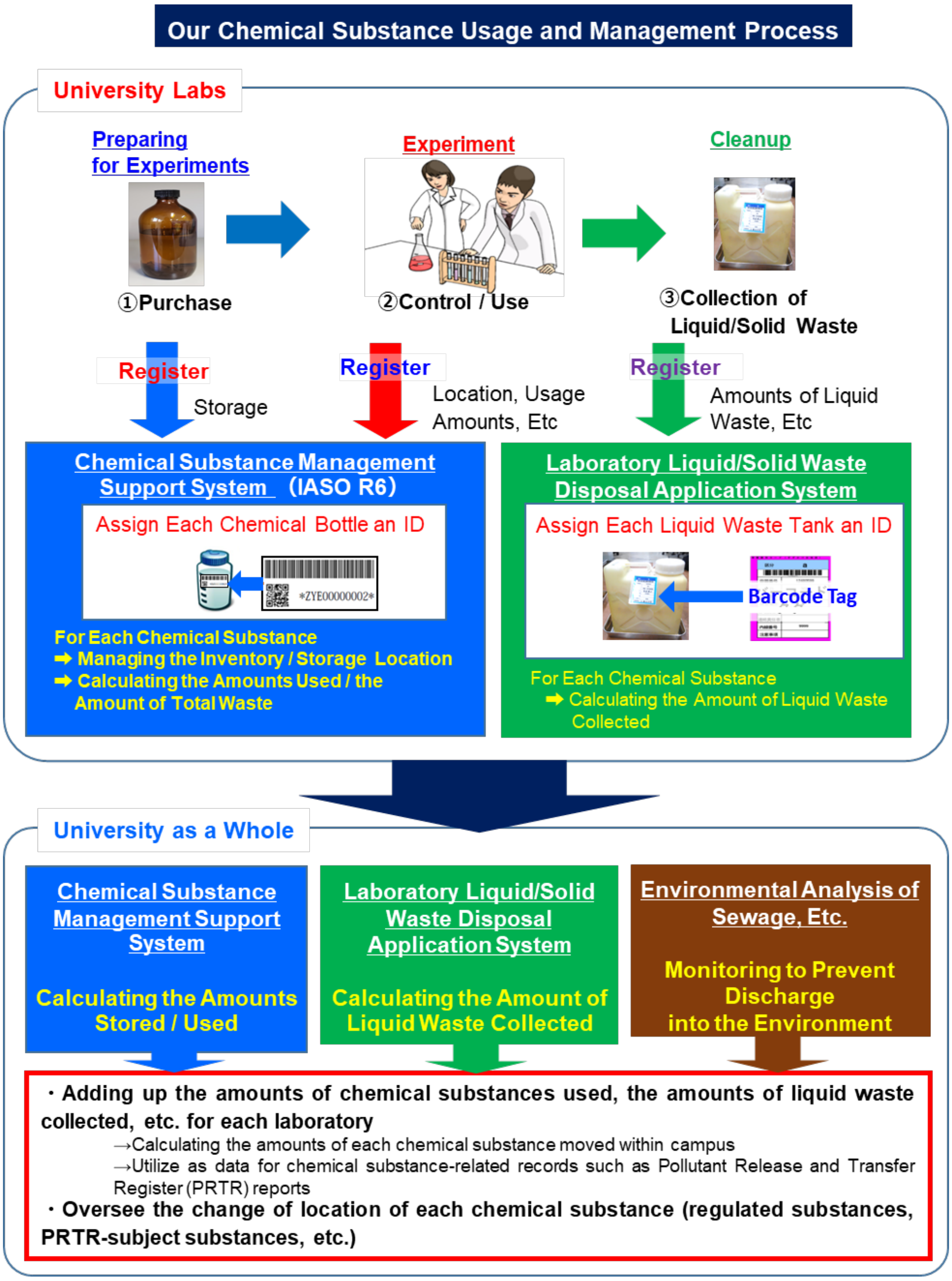
Tokyo Tech is also working to lessen the environmental impact of the goods and services it procures. We established a policy for promoting the procurement of eco-friendly goods and services in accordance with the Act on Promoting Green Procurement, and are focusing on the procurement of eco-friendly goods and services. The Act on Promoting Green Procurement specifies 276 designated procurement items in 21 categories. The most relevant to Tokyo Tech are paper products, stationery, furniture, etc. As for public works projects involving Tokyo Tech facilities, we choose the most appropriate goods and services on the basis of the objective and purpose of the project. Procurement is done accordingly, even when there are limits on the amount of regionally available goods and services that can be purchased.

We also strives to procure goods and services that have a minimal environmental impact whenever possible. Furthermore, if no products are available that are compliant with the Act on Promoting Green Procurement, we select goods by considering factors such as price or quality as well as factors such as the reusability rate and appropriate disposal of the goods in question.

Initiatives to Reduce the Environmental Footprint of Chemical Substances

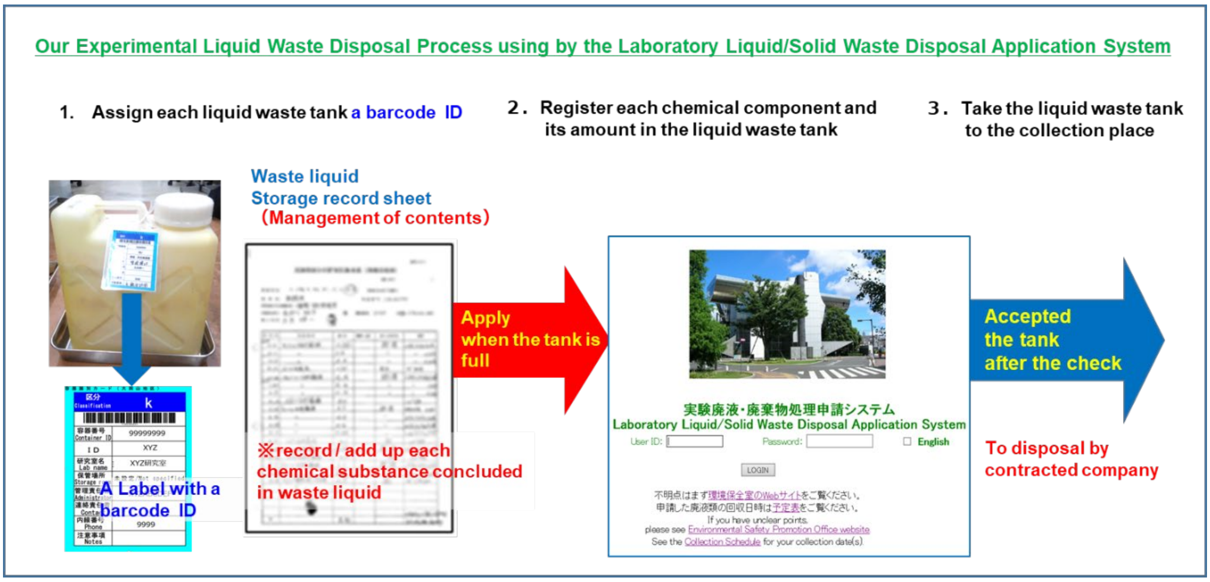
To ensure that we manage chemical substances properly, we have introduced IASO R6 (also known as the Tokyo Tech Chemical Substance Management Support System), which allows us to determine the inventory and use of chemical substances at the university in real time. We also have two ways to reduce the environmental footprint of the chemical substances we use. The first is a 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.

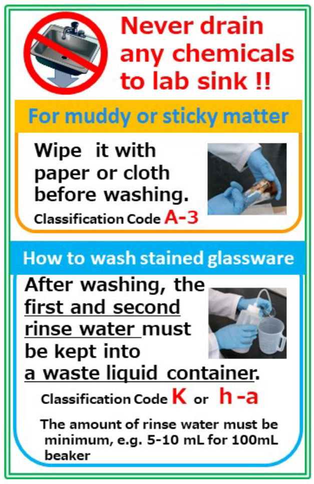
● Our Laboratory Liquid/Solid Waste Disposal Process (from pickup requested by a laboratory to disposal by a contracted company)



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.

Management of Laboratory Liquid Waste (Lab Sinks)

Because our lab sinks are considered washing facilities as specified in the water Pollution Prevention Act, we have implemented a management system to prevent chemical substances from being flushed into lab sinks. Specifically, water from the first and second rinses is collected as waste liquid and disposed of by a contracted company (see the figure at right).



At the Ookayama Campus, rinse water from the third rinse and beyond is poured down lab sinks into the sewer system, where it merges with domestic wastewater and flows off the campus grounds.

On the Suzukakedai Campus, this waste water is purified at a treatment facility and reused as gray water in toilets and elsewhere before flowing off campus grounds as domestic wastewater. Unused gray water is discharged into public waters (a river that flows into Tokyo Bay). In accordance with Yokohama City ordinances, we installed automatic total nitrogen/phosphorus and chemical oxygen demand measuring devices to measure those substances in the gray water in real time before discharge.

Monitoring through Analysis of Wastewater (Domestic Wastewater and Laboratory Wastewater), Laboratory Waste Liquid, Etc.

Tokyo Tech monitors the emission of harmful substances into the sewage system and elsewhere in a number of ways, including environmental analyses of wastewater and analyses of waste liquids.

Because our analysis equipment would become outdated, we began outsourcing analysis to external organizations starting in AY2019. Our wastewater management policy has not changed, however. If any signs are detected indicating possible environmental impact, we swiftly issue alerts to prevent harmful substances from being discharged into the environment.

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 education/talent development activities and research 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 2019, 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 : 66,004,000 kWh

City Gas : 612,000 m^3

Fuel Oil : 0.97 kl

Gasoline : 0.2 kl

Material

Chemical Substances

(2,335 types) : 75.3 t

Pollutant release and transfer register (PRTR) related Substances

32.3 t

Paper : 53.6 t

Water : 212,500 m^3

Recycling

Paper: 307 t

Other Recycled Materials 404 t

Graywater Reuse 52,000 m^3

OUTPUT

Atmospheric Emissions

Greenhouse Gas Emissions

32,223 t CO_2

Purchased Electricity : 30,706 t CO_2

Fossil Fuels : 1,371 t CO_2

Water and Sewage : 146 t CO_2

Waste

General Waste : 159.5 t

Industrial Waste : 547.8 t

Water Discharged

Total Sewage Discharged

210,500 m^3

Pollutant Emissions

BOD : 14.5 t Nitrogen : 9.8 t

Phosphorus : 0.8 t

FY2019 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)	0.04011 (kl/m^2)	0.03883 (kl/m^2)	-3.2%	Achieved (*4)
Tokyo Ordinance (*2)	149,110 (t/five years)	106,946 (t/five years)	-28.3%	Achieved
Yokohama Ordinance (*3)	82.69 (t/1000 m^2)	82.09 (t/1000 m^2)	-0.7%	Achieved (*5)

*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 five years compared to the standard emission level for five 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 -1.9% for the past five years met the nonbinding target set in the Energy Conservation Act.

*5 Yokohama City ordinances obligate us to make a 3% reduction in the three years between FY2019 and FY2021.

Use the QR codes below to see the full version and digest of the Tokyo Institute of Technology Environmental Report 2020 (both in Japanese).

Environmental Report 2020(Japanese)

Digest Version(Japanese)

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