Impact Objectives

- Develop a device which monitors CO_2 emissions from carbon capture and storage sites
- Construct a mathematical model of the surface CO_2 flux to be used for detecting the gas leakage in CO_2 storage sites

Demonstrating the efficacy of carbon storage sites

__Dr Salmawati Salmawati__ and __Professor Kyuro Sasaki__ are interested in understanding more about decarbonising the mining industry. They are collaborating on a project aiming to develop a device which monitors CO_2 emissions from carbon capture and storage sites

Dr Salmawati Salmawati

Professor Kyuro Sasaki

Can you begin by telling us a little about your research background?

KS: I have been a senior researcher at the Institute for Future Engineering (IFENG), and a Professor Emeritus at Kyushu University(KU) since April 2021. My research interests are mineral resources production, fluid mechanics and heat and mass transfer phenomena. I recently focused on studying CO_2 geological storage, CO_2 leakage monitoring system, CO_2 behaviors in reservoir conditions by PVT measurements and numerical simulations and engineering education.

SS: During my master's degree, I continued my research by making a numerical model of the water content in the embankment on a laboratory scale, because water is one of the causes of the acid mine drainage generation. From the results of this research, a method was produced that can be used to reduce the potential for formation of acid mine drainage.

Could you talk about your consulting work on the Climate Smart Mining Programme?

SS: I was engaged as a short-term consultant, responsible for the study of 'Carbon Emissions of the Mining Sector: A Scoping Study', which is one of the studies for the World Bank's Climate Smart Mining Initiatives Project. The study highlighted the greenhouse gases emission from mineral mining sector activity (starting from land clearing to the mineral processing). It was limited to the mineral mining that produces the material for renewable energy development, such as nickel, copper, tin, aluminum, etc., which referred to critical minerals.

What work are you currently involved at PT Tura Consulting Indonesia?

SS: In recent times, I have worked for a mining consultant company called PT Tura Consulting Indonesia. It is an integrated mining and energy consultant which aims to bring excellent services in geological, mining, processing and refining, economics and policy, including strategic financing, investment and management. I am responsible for all the mine environmental and social related projects, with the role of project manager. Besides these activities and responsibilities, I am also involved in the company's strategic development.

How are you developing the monitoring device through these studies?

KS: We do not use any special tools, yet we developed and modified the monitoring device. The monitoring device we have developed was used to measure the soil CO_2 flux. This measurement used the dynamic closed-chamber method – the principal of which is to place a chamber on the soil surface to trap the CO_2 emitted from the soil surface. The gas inside the chamber was pumped and circulated and was connected to an air pump and the gas analyser to measure the gas concentration.

SS: To validate and test our findings, the calibration was conducted in both the laboratory and in the field before the monitoring device was used for field measurement. The monitoring device needs to be developed more, especially to find a means of ensuring that the recorded data can be transferred online, to get the recorded data in real time.

What results have you been particularly pleased with?

SS: We were pleased with the process of developing the device and its measurement results. This is because it fits quite well with the general concepts we brought to the project from the outset. In addition, we have been able to construct a mathematical model of the surface CO_2 flux to be used for detecting the gas leakage in CO_2 storage sites. ●

A device to monitor greenhouse gas leakage

*A team of researchers and consultants based at **Kyushu University** is working on a highly collaborative project centred around monitoring the leakage from CO_2 storage sites. The findings could help reduce greenhouse gas emissions and enable countries around the world to meet their emission reduction targets*

Despite the mountain of evidence concerning climate change, countries around the world continue to heavily rely on the burning of fossil fuels to generate the energy society demands. This has caused rising greenhouse gas (GHG) emissions, which continue to increase global temperatures. On the other hand, in the coal mining sector, GHG gas emitted from large-scale spontaneous combustion of the coal seams is one of the major concerns.

As awareness and acknowledgment of these issues has grown, there have been a multitude of approaches and techniques that have been developed to mitigate GHG emissions and the resultant impacts. One particular technique that has gained attention in recent years is CO_2 geological storage. Simply put, this is a means by which CO_2 is stored in underground geological formations. This can be achieved in a variety of ways, but one of the most popular methods is to pressurise the CO_2 to such an extent that it becomes a liquid, which is then injected into porous rock formations.

This method has proved extremely popular, not least because of how effective it has shown to be. However, there is a need for researchers, scientists and industry to come together to find a means of monitoring the sites chosen for CO_2 storage - it is important that there is no leakage. This is because any leakage would render the process potentially redundant and it could also have adverse impacts on residents that are located near to any geological storage sites.

MEETING EMISSION REDUCTION TARGETS

It is with the need to monitor this leakage that a multi-disciplinary team has come together to form an exciting project. The team incorporates researchers based at Kyushu University in Japan that includes Professor Kyuro Sasaki, and Dr Salmawati Salmawati who is currently a Senior Mine Environmental Analyst from PT Tura Consulting Indonesia. Salmawati is well versed in the challenges associated with the climate effects of mining and has focused much of her work on Indonesia.

Indonesia is one of the most mineral resource-rich countries in the world and has an important and strategic position within the global critical minerals commodities market. Nevertheless, the government of Indonesia is acutely aware of the need to consider the environmental impacts of mining. 'Indonesia is cognisant of the fact that currently, on both the regulator and business fronts, data on GHG emissions caused by each business activity along the mining and minerals value chain needs to be improved,' outlines Salmawati. 'The lack of a robust database creates a major challenge in designing climate-resilient policies for sustainable natural resources management and implementing climate change-responsive action plans,' she says. On a more granular level, a baseline data on emissions is essential for maximising the efficacy of Indonesia's critical mineral ▶

The monitoring device is being tested in the field

mining sector at the same time as supporting the growth of clean technologies that minimise the sector's carbon footprint. The scoping study that the team is engaged with includes diagnostics of existing data on GHG emissions in the mining sector and represents the first critical step towards the design of Indonesia's own Climate Smart Mining Roadmap in the future.

THE SURFACE FLUX

The main focus of the current study that the team is engaged with is to develop a device that is capable of automatically and continuously monitoring the surface flux in order to detect any leakage in the carbon capture storage (CCS) sites. However, it is not quite as simple as building the device and considering the project complete - before any leakage can be detected, it is essential that the baseline natural soil CO_2 flux can be analysed.

Soil naturally emits CO_2, so that needs to be considered before the device can be used. To achieve this, the researchers measure the natural gas flux and the surrounding characteristics, particularly those relating to the soil, such as temperature, moisture and carbon content. 'Measuring this baseline data for a year will provide the data necessary to make an accurate detection of the leakage,' highlights Sasaki.

CHANGING CONDITIONS

Establishing a relational expression between different environmental conditions is a complicated process. As mentioned above, surface CO_2 flux is affected by the soil condition, such as its temperature and moisture; the flux increases exponentially with soil temperature, although there are instances when even this point is complicated. 'Increasing surface CO_2 flux due to soil temperature was observed only in the condition when soil temperature was less than 30±1°C. The surface CO_2 flux decreased as the temperature increased in the condition where the soil temperature was higher than 30°C,' explains Kyuro. 'On the other hand, soil moisture has two important roles in the process of CO_2 flux - not only does it influence the activity of the microorganism and root plants respirations to produce CO_2, it also affects the CO_2 gas diffusivity in the soil layer moving upward to the surface,' he states.

The team found that the response of the soil moisture to soil CO_2 flux was different in summer and winter, and some changes were detected depending on rainfall events which can be significant in certain parts of Asia - the team detected a change in the hourly mean surface CO_2 flux and soil temperature. 'However, based on our observations, the reduction response of surface CO_2 flux occurred in a short period of time - the results of which showed that there was a reduction in the flux up to 95 per cent of the time,' confirms Sasaki.

> *If the device can be scaled up in the future, then it can help industries reduce GHG emissions which will benefit every person on Earth*

HOPES FOR THE FUTURE

Ultimately, the team has shown the efficacy of the device they have developed but the success of the overall project will make a significant contribution for the mining sector of Indonesia and other countries to achieve their respective climate ambitions, especially when coupled with other climate-smart actions and initiatives. The team is planning to collaborate in the future with the Institut Teknologi Bandung and Universitas Gadjah Mada, both of which are renowned as some of the best institutions in Indonesia, and there are hopes that the device they have developed can be modified so that it can be used for monitoring gas leakage in underground mines. The next step is to develop the device in Indonesia and use it on a pilot scale. 'If the device can be scaled up in the future, then it can help industries reduce GHG emissions which will benefit every person on Earth,' observes Sasaki.

Project Insights

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BIO

Dr Salmawati Salmawati received her PhD degree from the Earth Resources Engineering Department at Kyushu University, Japan in 2019. Since July 2019, she has been engaged at PT Tura Consulting Indonesia as a Senior Mine Environmental Analyst. She had worked on a contract with the World Bank Group for an assignment with Infra Energy Extractive Industry. Salmawati was working on the Climate Smart Mining Program as a first step program to Decarbonizing Indonesia's Mining Industry: Roadmap of a Low-Carbon Mineral Value Chain for RE Development.

Professor Kyuro Sasaki taught at the Mining College, Akita University for 20 years, and the Department of Earth Resources Engineering, Faculty of Engineering KU for 16 years. He is now based at Kyushu University. Sasaki has published several papers on SAGD, methane hydrate production method and enhanced coal bed methane recovery, CO_2 geological storage, spontaneous combustion of coal and mine ventilation, etc. His research interests are mineral resources production, fluid mechanics and heat and mass transfer phenomena.