ISERME 2024

International Symposium on

Earth Resources Management and Environment

ABSTRACTS

2nd September 2024

Sapporo, JAPAN

Jointly Organized by

Division of
Sustainable Resources Engineering
Hokkaido University

Department of
Earth Resources Engineering
University of Moratuwa

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Sri Lanka

2nd September 2024, Faculty of Engineering, Hokkaido University

Japan

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Message from the Symposium Chair

Professor Tsubasa Otake

Head/ Division of Sustainable Resources Engineering

Hokkaido University

We, the faculty members and staff of the Division of Sustainable Resources Engineering at Hokkaido University are honored to host the 8th International Symposium on Earth Resources Management and Environment (ISERME 2024), which is jointly organized by our division and the Department of Earth Resources Engineering at the University of Moratuwa, Sri Lanka. Since its inception in 2017, ISERME has been held annually, alternating between Hokkaido University and the University of Moratuwa, overcoming challenges like those posed by the COVID-19 pandemic. We have now established a hybrid format (both in-person and online) to ensure that many participants, including undergraduate and graduate students from both universities, can actively engage in the symposium.

The symposium covers a wide range of topics in earth resources engineering, including exploration geology, mineral processing and hydrometallurgy, rock mechanics, environmental and water management, and the application of machine learning to mining engineering. I firmly believe that this symposium offers an excellent opportunity for all participants to not only delve deeper into their research but also broaden their academic horizons and expand their global networks. In particular, I encourage students to interact with researchers with diverse expertise, as this may spark new ideas and solutions to the complex issues we face globally. I extend my gratitude to all the organizers for making this symposium possible and to the Faculty of Engineering at Hokkaido University for their financial support.

As the symposium chair, I wish all participants an enjoyable and productive experience at ISERME 2024.

2nd September 2024

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Keynote Address 1

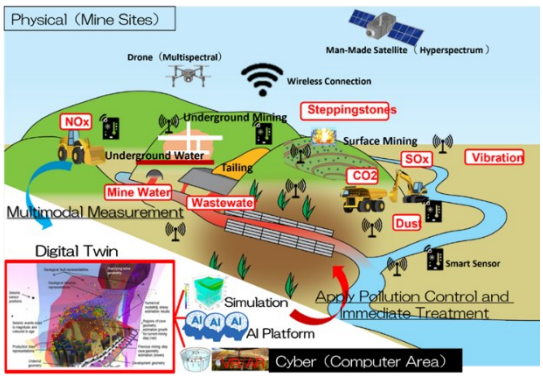
Professor Youhei Kawamura
Division of Sustainable Resources Engineering
Graduate School of Engineering
Hokkaido University, Japan

Environmentally Harmonious Mining System Utilizing Knowledge from Inactive and Abandoned Mine Management - SATREPS Project for Kazakhstan-

Youhei Kawamura, Takahiko Arima, Natsuo Okada

Division of Sustainable Resources Engineering, Graduate School of Engineering, Hokkaido University, Japan

The development of underground resources such as rare metals is essential to the realization of a decarbonized society. On the other hand, environmental destruction, such as carbon emissions and groundwater pollution from mining operations themselves, is a serious problem on a global scale. Kazakhstan is a resource-rich country with a wealth of underground resources, including rare metals, but its mining operations are causing environmental destruction. A sustainable mining development system that does not cause environmental destruction in Kazakhstan is indispensable for industrial development and improvement of the quality of life of the people. This research aims to contribute to the realization of a decarbonized society and measures against environmental destruction, which should become the norm for the global mining industry, through the construction and diffusion of a super-managed, environmentally conscious mine development system that utilizes smart mining technology and mine environment management technology in which Japan has an advantage.First, (1) environmental monitoring based on field surveys and various multimodal measurements will be conducted to establish a comprehensive environmental assessment method. Next, (2) Digital Twin will be implemented in the computer domain through digitization of information, including network development. By using a digital twin interface to “visualize” the environment and operations, search for environmental pollution hot spots, and utilize AI, an IoT platform will be built to identify pollution models, assess environmental risks, and propose countermeasures and mining methods. (3) Based on the findings, immediate measures to deal with pollution control are taken on site in a cycle. Finally, (4) the institutional design for the diffusion of the system. In collaboration with stakeholders, the project will communicate the "state" of the target mine to the world, publicize its usefulness and promising, industrialize the system, create jobs, and develop a system plan, including a funding scheme, for the mine.



Session 1

Numerical Analysis of Fluid Permeability in Compacted Sandstones

Otono Miura[1*], Ryunosuke Oishi[1], Shusaku Harada[1], Tsubasa Yagi[2]

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Keywords: *Permeability; Pore characteristics; Kozeny-Carman equation; Sandstone*

Fluid permeability in compacted sandstones were investigated numerically. The structural analysis of spherical particle bed which imitates compacted sand layer was conducted and pore region in the particle bed was extracted. The pore characteristics, such as effective porosity, tortuosity and specific surface area were quantified by various numerical methods. From these pore characteristics, fluid permeability was calculated using the Kozeny-Carman equation. The obtained permeability agreed quantitatively with those measured from actual sandstones (Fig.1). In order to clarify the role of respective pore characteristics on permeability, their dependencies on porosity were examined. The effective porosity and tortuosity obtained numerically were consistent with the experimental results and the physical models proposed in previous studies. However, although the specific surface area agrees with the experimental results, the physical model proposed in the previous study was inconsistent with the numerical results under small porosity conditions. We developed a new geometric model which describes specific surface area in compacted sandstones at small porosity. We also investigated why the original Kozeny-Carman equation is applicable to the permeability in compacted sandstones consisting of deformed particles. The numerical results indicated that the rapid increase of tortuosity and the rapid decrease of specific surface area were canceled out at small porosity and, consequently, the Kozeny-Carman equation keeps its original form even in compacted sandstones.

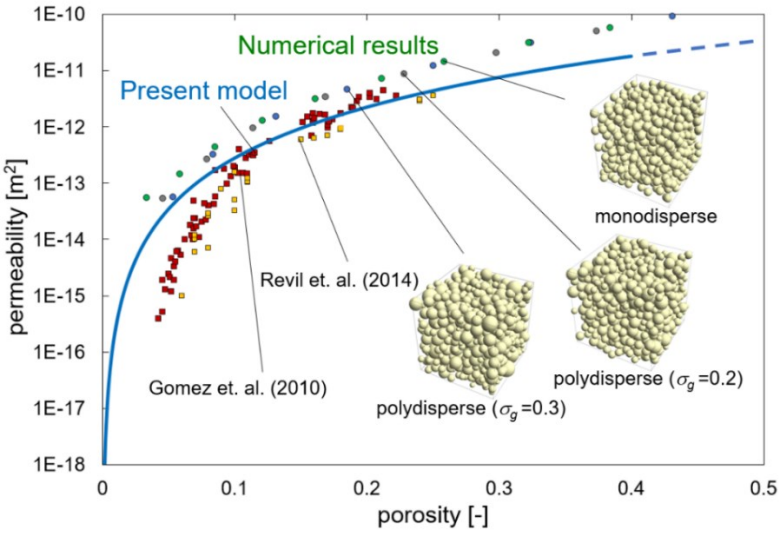

Fig.1 Experimental and numerical results and model of permeability of spherical particle bed.

Effect of Fracture Stiffness on Seismic Source Parameters of Induced Fault-Slip

Mingwei Gang[1*], Atsushi Sainoki[2], Lishuai Jiang[3], Hani Mitri[4], Jun-ichi Kodama[1]

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Keywords: *Fault-slip; Fracture stiffness; Seismic source parameters; Heterogeneous continuum model*

It is well recognized that inherent stress concentration within a fault damage zone may lead to induced fault-slip, resulting in severe damage to underground facilities. Previous research suggests that the intensity of fault-slip is influenced by not only the mechanical properties of the fault core but also the stiffness of the surrounding rock mass, implying that fracture stiffness could be an important factor that needs to be studied. Therefore, in this study, the effect of the fracture stiffness on seismic source parameters of induced fault-slip is investigated using a mine-wide scale heterogeneous continuum model. The model is constructed based on a discrete fracture network within a fault damage zone, utilizing the crack tensor theory and boundary traction method. The fault core is simulated as a discontinuous plane with interface elements at the center of the model, and fault-slip is induced by gradually reducing the effective normal stress on the fault plane. Seismic source parameters are computed and analyzed under various fracture stiffness conditions. Seismically radiated energy is defined as the work done by the stress perturbation across a closed surface at a distance from the earthquake source, while seismic moment is calculated using the moment tensor of a seismic source in an anisotropic medium. This study investigates increasing fracture stiffness while maintaining a normal-to-shear stiffness ratio of three. Dynamic analysis results reveal a notable impact of fracture stiffness on seismically radiated energy and seismic moment, both of which decrease significantly with increasing fracture stiffness. These findings imply the importance of considering fracture stiffness fore more accurate estimation of seismically radiated energy and seismic moment.

Mineralogical Classification and Concentration Estimation in Mining with App Using Hyper-Spectral Imaging and Machine Learning

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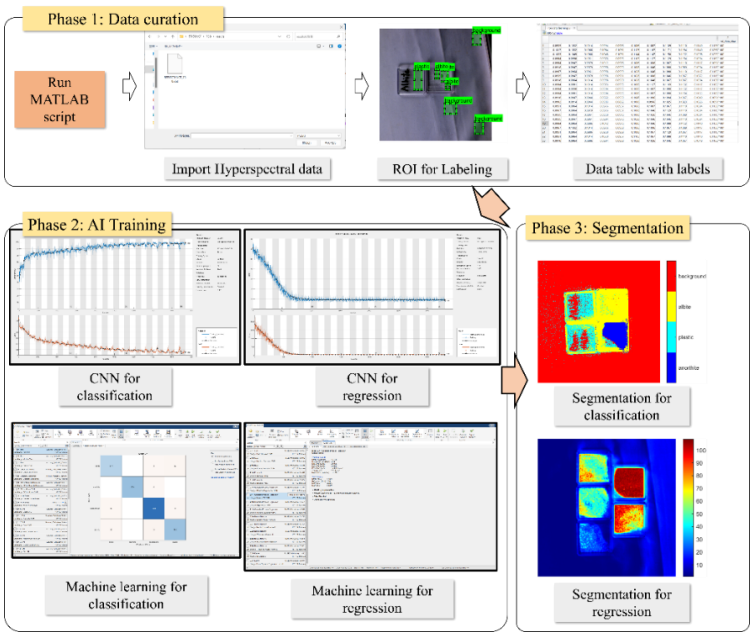
Keywords: *Hyperspectral Imaging; Spectroscopy; Mineral Processing*

This study presents an innovative method for identifying minerals by combining the capabilities of hyperspectral imaging with machine learning. Although hyperspectral images are challenging to process due to their extensive dimensions and substantial size, our solution effectively tackles this complexity by providing a user-friendly machine learning tool specifically tailored for hyperspectral data. This self-developed tool simplifies the process of constructing datasets and enhances machine learning processes for identifying mineral species and estimating their concentrations. Moreover, it includes integration of multispectral data processing with segmentation capabilities. The utilization of our MATLAB-based hyperspectral analysis tool has significantly transformed the process of analyzing hyperspectral data, streamlining previously complex operations. The interface is designed to be easy to use, allowing non-experts to effectively identify minerals without needing professional expertise. This is further enhanced by the integration of machine learning capabilities. In addition to hyperspectral analysis, the tool is capable of handling multi-spectral data, which suggests the possibility of conducting energy-efficient analysis. When paired with dimensionality reduction approaches, this efficiency is enhanced, resulting in a resource-efficient solution that minimizes the processing requirements. Our instrument is positioned as an innovative solution that greatly enhances geological surveys in mining regions, leading to useful outcomes for mineral-related research and industrial applications.



Session 2 – A

A Study of Groundwater Recovery Following Tunnel Construction in the Upper Highland Complex – A Case Study on the Ranwediyawa Tunnel

Dissanayake HM[1*], Perumal M[2] and Lees DJ[2]

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Keywords: *Aquifer; recovery; tunneling; water ingress; waterproof*

In Sri Lanka, understanding the hydrogeological conditions is vital when constructing tunnels, especially in areas like the Highland Complex, where groundwater supports local communities and agriculture. While some recent data sheds light on groundwater reduction during tunneling, little is known about the recovery process. The Ranwediyawa tunnel construction, part of the Mahaweli Water Security and Investment Program (MWSIP), offered a chance to monitor groundwater impact closely. We recorded a decrease during excavation, considering seasonal variations. Following tunnel completion and waterproof lining installation, we meticulously tracked groundwater recovery.This paper outlines essential planning, monitoring, and construction efforts for successful groundwater recovery. Insights gained can guide future similar tunnel projects in Sri Lankan hydrogeological settings. The Upper Highland Complex's hydrogeological conditions present unique challenges. As groundwater is vital for local communities and agriculture, the tunneling activities must be carefully managed to minimize disturbance. Our study aimed to understand the groundwater recovery process post-tunnel construction. During the Ranwediyawa tunnel excavation, we observed a noticeable groundwater level decrease due to water ingress into the excavation area. However, after post-construction with waterproof lining installation, promising signs of groundwater recovery emerged.Our findings stress the importance of comprehensive planning and monitoring during tunnel construction. Understanding hydrogeological conditions and implementing effective waterproofing measures are crucial to minimizing environmental impact and ensuring water supply and agriculture sustainability. The data and insights gained can inform future tunnel projects in similar hydrogeological settings, enhancing infrastructure project resilience and safeguarding groundwater resources for future generations.

Incident of Ground Collapse up to Daylight and Recovery Actions Taken in Shallow Ranwediyawa Tunnel in Sri Lanka.

Perumal M*, Wanigasekara WADID, Isuranga SNAMTK, Narangoda SRAIB

Program Management, Design & Supervision Consultants (PMDSC), for Mahaweli Water Security Investment Program (MWSIP), Dambulla, Sri Lanka

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Keywords: *weathering; recovery; collapse; pipe roofing; daylight*

The Ranwediyawa tunnel was constructed under the Mahaweli Water Security Program (MWSIP) to minimize the social impacts on the villages, where the irrigation canal runs through the village. The tunnel was slightly redirected from the original canal path which was planned to run through the village road having a deep excavation over a length of 620m with a mixed ground condition. The area has a high ground water table and seasonally slightly varies due to the area's weather pattern with varying topography which has a deep excavation from 12m to 18m for the construction of cut & cover conduit.Having a shorter period of design the Ranwediyawa tunnel was designed with a ground cover varying from 9m to 20m, including 5 support classes according to the RMR classification. Both tunnel portals start with completely to slightly weathered rock and move into moderately weathered to fresh rock. Both tunnel drives were driven by mechanical excavation with NATM concept with few small chimney collapses, however, a major collapse occurred once the upstream drive reached the rock-type boundary and it was developed to daylight.This paper describes the details of the initial excavation procedures, the major geological conditions and the recovery procedures which were taken to complete the tunnel excavation. Also, this paper covers special arrangements made by the Contractor in the shortage of resources available in the project as the incident occurred during the spreading of the COVID-19 period. The tunnel drive successfully passed this weak geological area with long pipe roofing support before the tunnel excavation after two months with a few days of site closure due to the identified worker getting COVID-19 in the tunnel team.

Polymer-Modified Microbial Induced Carbonate Precipitation for Stabilizing Unstable Slope Surfaces in Sri Lanka

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Keywords: *Polymer-Modified Microbial Induced Carbonate Precipitation; bio-cementation; slope stabilization; saturation method; percolation method; chitosan*

Cement grouting is a widely using technique in Sri Lanka to stabilize the unstable slope surfaces. Although cement grouting has been identified as an efficient mean of stabilization, it is not an ecofriendly practice. Polymer-modified microbial induced carbonate precipitation (PM-MICP) has been recently recognized as a promising pathway to produce bio-grout material that has the potential to be used for stabilizations in the place of cement. In MICP, calcium carbonate bio-cement is produced through enzymatic reactions. The efficiency of the process can be further improved by incorporating bio-polymer. In this research, the viability of the PM-MICP to stabilize the Sri Lankan unstable slope surfaces was evaluated. Representative soil samples were collected from unstable slope areas in Matale district of Sri Lanka. *Sporosarcina pasteurii* was the ureolytic bacteria, and chitosan was the natural biopolymer used for the experiments. Laboratory scaled specimens were prepared and treated using (i) saturation and (ii) percolation methods; for different concentrations of cementation solutions (i) 0.3 mol/L and (ii) 0.5 mol/L); (i) with 0.05% and (ii) without chitosan. Bacteria culture was injected twice during the fourteen days of treatment, while the cementation solution was injected daily. After the treatment, samples were removed from the mold and subjected to a comprehensive evaluation program. Laboratory-scale model slope was also prepared and treated after 28 days of treatment, and the surface strength was determined. The samples treated with 0.5 mol/L cementation solution and polymer, exhibited a strong solidification compared with the specimens treated without polymer in both saturation and percolation methods. However, bottom of samples showed a weak solidification due to the less penetration of the bacteria and cementation solution to the bottom of the sample. In without polymer case, a weak solidification was observed for the samples treated using percolation method compared with the saturation method. Higher cementation could be achieved for the samples with 0.5 mol/L cementation solution than the sample with 0.3 mol/L. Comparatively, the surface strength was higher for the slope treated with polymer, thus the PM-MICP can be recommended as a promising alternative approach to conventional cement grouting for stabilizing the unstable slope surfaces in Sri Lanka.

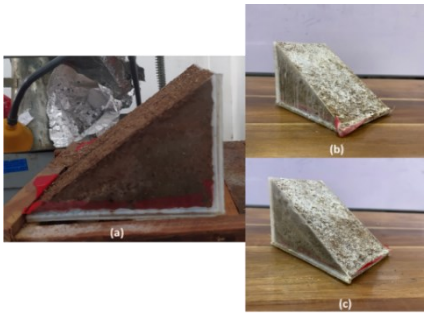

Figure 1. Laboratory scale slope model (a) before treatment (b) treated with MICP (c) treated with PM-MICP

Isolation and Characterization of Ureolytic Bacteria from Landslide-Prone Areas in Sri Lanka for the Stabilization of Unstable Slope Surface by Bio-Cementation

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Keywords: *Unstable slopes; bio-cementation; microbial induced carbonate precipitation (MICP); native ureolytic bacteria; urease activity*

Landslides are natural disaster, long-existing as one of the geotechnical threats in the central region of Sri Lanka. During the monsoon period of every year, number of human lives are lost due to the landslides. Therefore, early recognition of the potential areas and implementing landslide mitigative measure are essential to prevent the damages. Portland cement and chemical grouts are typically used to enable a protective cover over the slope surface. However, these approaches are recognized environmentally detrimental and expensive. The use of bio-grouting materials is a new proposal to stabilize the slope surface, disclosing the likelihood of eco-friendliness and sustainability. Among various bio-grouting techniques, microbial induced carbonate precipitation (MICP) has gained much attention recently. MICP is a process that triggers the precipitation of calcium carbonate using the metabolic aid of ureolytic bacteria. This paper presents the initial works carried out to isolate and characterize urease-producing bacteria that are competent for the application of MICP-based stabilization of Sri Lanka's unstable slopes. Few landslide-prone areas were identified in Matale district (of Sri Lanka) with the support of National Building and Research Organization. From each location, soil samples were obtained in sterile centrifuge tubes and transported to the laboratory. After a series dilution, soil samples were plated on trypticase soy broth agar medium and incubated at room temperature for two days. Grown-colonies were then carefully separated on new agar plates. Initial screening of potential bacteria was carried out using phenol red pH indicator. The growth and urease activity of identified bacteria were then measured over time. A set of test tube precipitation tests was also performed to verify the applicability of the bacteria. The results indicated that most of the identified bacteria exhibited adequate growth and urease activity during the second and third days of the culturing. The test tube test revealed that the natively-isolated bacteria were highly potential to produce $CaCO_3$, thus disclosed the potential for MICP application. Based on the preliminary results, laboratory-scale slope model tests and field-trails are to be performed in the subsequent phase of this work.

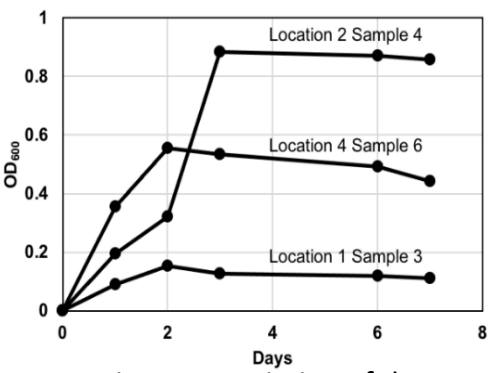

Figure 1. Variation of the growth of bacteria (OD_{600}) with time

Investigation of Suitable Methods to Protect Main Roads Adjacent to Water Bodies

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Keywords: *Bamboo; Bio-slope engineering; Gabion wall; Slope stability; Stream bank erosion*

Main roads adjacent to water bodies often face significant stability challenges due to erosion, due to heavy rainfall, increased water flow along riverbanks, sudden drawdown of water levels after flooding, sand mining and various other human activities within river catchments. These conditions can lead to failures in the river banks disrupting the functioning of the road. This paper presents four such problematic locations, identifies the root cause of the problem and present different rectification measures adopted. Common features and different aspects at the four locations are elaborated. The locations are; left side of the Kelani River bank along the low-level road (AB010) at the 26th-kilometer mile post, right side of the Halwathura Phalakotasa stream bank along the Ingiriya-Halwathura-Ekgaloya road (B068) at the 4th-kilometer mile post, right side of the Halkotiyawatta stream bank on Seelarathana Mawatha at the 1st-kilometer mile post, and right side of the Diyawanna Lake bank on Denzil Kobbekaduwa Mawatha at the 1st-kilometer mile post. While researchers worldwide have developed various techniques involving both hard and flexible solutions, including reinforcing techniques and integrating natural vegetation, Sri Lanka lacks innovative studies leading to cost-effective and environmentally friendly methods. In this study initially a comprehensive literature survey was conducted to identify novel approaches that can be applied in such circumstances. And different solutions were proposed for each site, considering cost, constructability and sustainability. The paper investigates the performance of three appropriate stabilization methods: Gabion wall with rock packing at the toe, vegetated live bamboo crib wall construction with Gabion at the toe, and vegetated flapped soil-bag with live stake retaining structure with Gabion at the toe. These methods were assessed for their effectiveness in stabilizing stream banks with varying heights and gradients under different hydrological condition giving, due consideration to the construction sequence.

A Preliminary Evaluation of River Sediment Load: A Case Study of Maha Oya River in the Western Coast of Sri Lanka

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Keywords: *Sediment budget; Littoral beach; Sediment trap; erosion; LCD*

Rivers have a significant role in the coastal sediment budget as the primary sources of natural sediment. Furthermore, it's critical to understand the actual contribution of river sediment load to the littoral beach. Due to the practicality of the measures, the information regarding river measurements is scarce making this difficult. This study focused on the Maha Oya River, which is situated on a severely eroding coastline on Sri Lanka's western coast between Negombo and Chilaw. In this instance, the river sediment load was captured by two streamer-type sediment traps along the upper 2 km streams of the Maha Oya River, but only one of them was recovered. The sediment trap was retrieved for the months of December 2021–February 2022 (recovery 1) and March 2022–October 2022 (recovery 2). During two recovery periods, we concurrently collected forty-four beach samples from the swash zone and berm crest on either side of the Maha Oya River. For recovery periods one and two, the retained sediment weights are 3.7 and 726 grams, respectively. Additionally, the statistical properties of a grain size distribution, skewness, kurtosis, median grain size (D50) and the littoral cutoff diameter (LCD) value were investigated. Average D50 value on the beach was found to be 394 µm of medium sand that was moderately sorted, symmetrical, and mesokurtic, compared to 655 µm of coarse sand that was poorly sorted, fine skewed, and mesokurtic in river sediment. The LCD value on the beach under study was 141 µm indicating that the river sediment below LCD may not have remained on the beach in any significant quantity. The literature states that river sand mining caused the sediment load via the Maha Oya River to decrease from 0.15 mcm/year in 1984 to 0.05 mcm/year in 2001. Our calculations show that in 2022, this number will be further decreased to 0.01 mcm/year. Thus, it is highlighted that there is a major shortage of river sand input into the coast, which may be the cause of the disastrous erosion occurring in the surrounding coastal cells.

Session 2 – B

Assessing the Influence of Microstructural Features on Deformation of Rocks under Triaxial Loading

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Keywords: *CT-images; Deformation; Porosity; Sandstone; Thin section images*

Assessing the influence of microstructural features on deformation of rocks under triaxial loading is vital in rock engineering applications, aiding safe and efficient operations through predicting the deformation of rocks. Triaxial testing offers the simulation of stress conditions within a rock to examine the deformation of rocks with confinements. This research focuses how microstructural features, such as cementing material and pore geometry, affect the deformation behavior of rocks subjected to triaxial loading. Two rock types were considered in this study; Kimachi sandstone (medium hard clastic rock) and Bibai sandstone (hard clastic rock). The progressive failure behaviour under Hydro Mechanical (HM) coupling effect was analysed by stress strain distribution and the fracture geometry was examined using CT images of the samples which were tested under different confinements. Thin sections were analysed to examine the changes in porosity and the effect on the cementing material with the confinement. The results of the proposed approach reveal a clear influence of the effective confinement on the failure of rocks and how it influences to the porosity and cementing material of rocks. It is found that the Bibai sandstone shows a brittle failure and a shearing deformation while Kimachi sandstone shows a brittle to ductile failure and shearing to compaction deformation with the confinement due to the less presence of cementing material within Bibai sandstone compared to Kimachi sandstone. Therefore, with the confinement, the porosity of Bibai sandstone increases while it decreases in Kimachi sandstone. The results highlight that the differences in the failure mechanism of a particular rock type for the same effective confinement which is a result of only a partial contribution of the pore pressure on the failure. These findings provide a valuable insight into the assessment of microstructural features on the deformation of rocks under triaxial loading, aiding in the development of safer and more efficient rock engineering operations.

Identification of the Optimum Replacement Ratio of Quarry Dust as a Substitute for Sand and Cement in Cement Plastering

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Keywords: *Quarry Dust; River Sand; Cement Plastering; Compressive Strength; Durability*

River sand and cement are important construction materials, but their scarcity creates significant challenges for the construction industry. Quarry dust is being explored as a possible alternative, as crushed rock is a common aggregate source in Sri Lanka. Therefore, this study focuses on determining the possibility of using quarry dust as a partial replacement for cement and river sand in plastering mortar. Selected Manampitiya river sand and quarry dust from four quarries were subjected to sieve analysis (ASTM C136). Four quarry dust samples obtained from two different crusher types (cone crusher and vertical shaft impact crusher) were sieved to separate 0.1-2.36 mm particles and <0.1 mm particles to replace with sand and cement, respectively. Plastering mortar's cement-sand ratio was selected as 1:5 and developed in 12 mix proportions, varying the replacement of sand with quarry dust (0.1-2.36 mm particles) at 0%, 33%, 50% and 100%, as well as varying the replacement of cement with quarry dust (<0.1 mm particles) at 0%, 5% and 10%. The flow table test (ASTM C1437) was performed for each mix proportions to obtain the water-cement ratio of plastering mortar which gives acceptable workability (105-115 mm). Four 50 mm cubic specimens from each mix proportion were prepared according to the obtained water-cement ratio. Cubic compression test (ASTM C109M) and water absorption test (ASTM C140) were performed for the cubic specimens after completion of 28 days of curing period. Results indicate that sand and quarry dust samples analysed are poorly graded. An increase in quarry dust in the plastering mortar reduced the workability but it reached acceptable range with water-cement ratio of 1.1-1.2. All tested specimens indicate compressive strength >3MPa, which was the minimum strength required for plastering. Compressive strength results indicate that the cement replacement can be further increased with 100% sand replacement. The durability of plaster slightly reduces with an increase in quarry dust proportion, indicating a maximum of 2.4% increment of water absorption for 100% sand replaced 10% cement replaced specimen than the specimen made from 100% sand. Furthermore, 100% sand replacement can achieve a cost reduction of 23%. Hence it is recommended to replace sand 100% with quarry dust 0.1-2.36 mm particles for cement plastering.

Evaluation of Satellite-Derived Gravity Field Models in Offshore and Coastal Regions of Sri Lanka

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Keywords: *Observed Marine Gravity; Mean Sea Surface Height; Satellite Altimetry; Gravity Field Model; Coastal and offshore regions of Sri Lanka*

To understand many geophysical phenomena, including ocean circulation, tectonic plate movement, and the Earth's interior, it is important to study the Earth's gravity field. During the past three decades, satellites have measured the Earth's static gravity. As a result, high-resolution global gravity field models have been available. This paper aims to examine the appropriateness of the satellite derived gravity field models for the offshore and coastal regions of Sri Lanka.While these eight gravity field models with ID 155-EIGEN-6S4 V2, 168-Tongji-Grace 02K, 171-GO-CONS-GCF2-TIM-R6, 174-ITSG-GRACE 2018S, 178-Tongji-GMMG2021S, 148-EIGN-6C4, 152-GECO, 167-SGG-UGM-1, and 177-SGG-UGM2 were used for the study. The mean difference value, standard deviation value, and Root Mean Square values modeled by each of the model between the observed gravity data and the BGI observed gravity data. The results indicated that 171-GO-CONS-GCF2-TIM-R6 and 177-SGG-UGM2 is the more suited model for the coastal and offshore region of Sri Lanka. The study used the SARAL-Altika satellite Altimetry data to investigate the relationship between Mean see surface height and observed gravity. No significant relationship between Mean sea surface height and marine gravity is indicated by. In addition, the influence of gravity model type on each of the LEO satellite orbit predictions was also studied. The findings of the research demonstrate that the optimal type of gravity model applied for LEO satellite orbit prediction depends on a short-term or long-term predictions. The models JGM3, EGM2008, and GL04C are more appropriate for short-term predictions, while the models JGM3, EGM96, and EIGEN2 are the best for long-term predictions. The gravity order and permanent tides also have to be taken into account for the orbital prediction.In conclusion, this research provides valuable insights into the suitability of various satellite-derived gravity field models for Sri Lanka's coastal and offshore regions. The findings also emphasize the need to consider the impact of gravity models on LEO satellite orbit prediction, particularly for new applications such as LEO navigation, which require real-time precise orbits.

Comparative Analysis of Mechanical and Mineralogical Properties of Rocks from Maddhapara Granite Mine,Bangladesh

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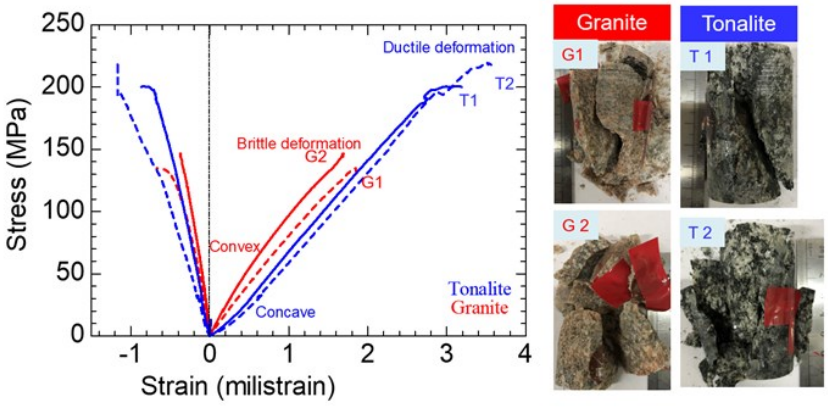
Keywords: *Maddhapara Granite Mine; rock characterization; mineralogical analysis; mechanical properties; UCS testing*

This study presents a comprehensive analysis of the mechanical and mineralogical properties of rocks collected from Maddhapara Granite Mine (MGM) in the northern region of Bangladesh. The research focuses on the characterization of two main categories of rocks, distinguished by their color and mineral composition, namely the dominant black rock and the flashy colored rock. Microscopic studies were conducted to categorize the rocks, leading to the identification of minerals such as quartz, feldspar, amphibole, and biotite within the rock samples. The black rock was classified as Tonalite, with specific mineral compositions, while the flashy colored rock was identified as granite, exhibiting distinct mineral proportions. The research further delves into the physical properties of the rocks, including density, effective porosity, P-wave velocity, S-wave velocity, and Uniaxial Compressive Strength (UCS). Notably, UCS tests were performed to characterize stress parameters such as crack closure stress, crack initiation stress, crack damage stress, and peak stress for both rock types. The results revealed significant differences in stress levels and mechanical responses between the two rock types, with tonalite exhibiting higher stress levels and distinct mechanical behaviors such as plastic deformation and shear deformation, compared to the granite. These variations are attributed to the dominating minerals present in each rock type, particularly amphibole and quartz for tonalite, and feldspar and quartz for granite. The findings of this study have implications for the stability of drifts and stopes in mining operations, as the mechanical responses of the rocks, influenced by their mineralogical composition, may impact their suitability for various engineering applications. This research contributes to the understanding of rock properties in the context of mining engineering, providing valuable insights for the assessment and utilization of rocks from MGM and similar geological formations.



Assessment of Biodiesel Production Potential and Capacity Analysis Utilizing Animal Fat Waste

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Keywords: *Animal Fat; Biodiesel; Bioethanol; FFA; Wastewater*

New Anthony's Farm, a major chicken producer in Sri Lanka, generates significant wastewater during production. This study aims to find a solution for the sludge produced in their treatment plant. Animal fats, a common waste in various industries, require expensive treatment due to environmental regulations. They mainly consist of triglycerides (90-95%), which are further made up of fatty acids like saturated (SFAs), monounsaturated (MUFAs), and polyunsaturated (PUFAs). Animal fat waste offers valuable opportunities for industrial use, but its improper disposal poses significant environmental threats. Sustainable management and utilization of this waste are crucial to protect the environment and extract valuable resources. First, an FFA (Free Fatty Acids) test was done for the top and bottom animal waste fat samples taken from the fat separation Dissolved Air Floating unit in the wastewater treatment plant in 'Anthony's Farm. The NaOH base with the Phenolphthalein indicator titration method was used for this FFA identification. After that, acid treatment was performed to reduce the FFA value of these samples, 60^{0}C hot water washing was done to purify the animal waste fat sample, and biodiesel was produced by transesterification. Direct transesterification was not obtained for the bottom sample, so the resulting liquid layer was centrifuged at 3000 rpm for 15 minutes and trans-esterified. After that, both samples were used to produce bioethanol. There, the top sample was directly used for bioethanol production without pretreatment, and bioethanol was produced using the glycerol layer of the bottom sample. The acid treatment was done with an H_2SO_4 Acid-to-fat ratio of 12:1, Temperature around 64°C, and pH - around 7, and it was reduced the FFA value of the top sample from 20.72% to 12.60%, and the initial FFA value of the bottom sample, which was 3.36%, was reduced to 2.80%. Considering this FFA value, the bottom sample seems to have more potential for biodiesel production. Also, the flash point of the biodiesel produced in this way was measured using the Flashpoint analyser, and it was found to be 55.5 ^{0}C.

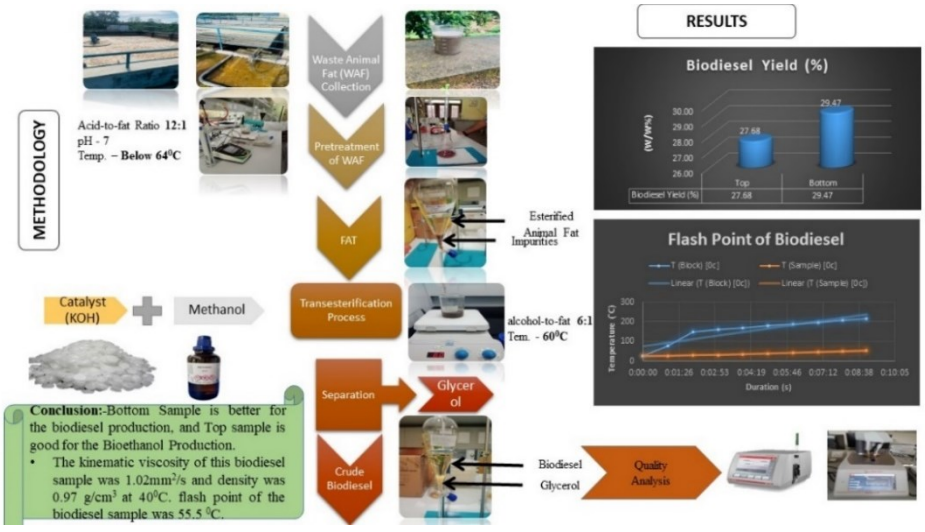

Figure 1. Graphical Abstract

Distillery Spent Wash as an Alternative Fuel In Boilers and Potash Recovery from that Ash Remaining In Boilers

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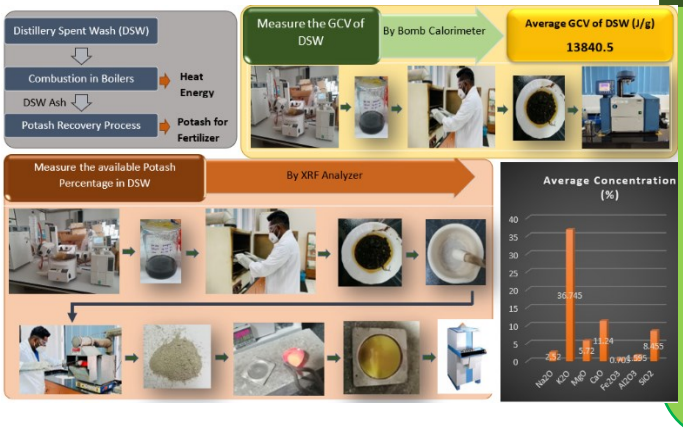
Keywords: *Alternative fuel; Byproduct recovery; Calorific value; Distillery effluent; spent wash*

Waste management stands as a critical global environmental challenge, with a growing emphasis on waste avoidance and the generation of revenue through byproduct recovery. Pollution prevention strategies aim to minimize waste generation, while waste minimization efforts focus on reducing waste volume or toxicity, often through water recycling, process modification, and byproduct recovery. In this context, the utilization of distillery effluent in agriculture presents an opportunity to save on fertilizer costs, enhance agricultural output, and mitigate pollution. However, molasses-based distilleries, along with their primary product, alcohol, generate significant volumes of wastewater known as spent wash. Improper disposal of spent wash into water bodies or land leads to a host of environmental issues. Consequently, recent efforts have shifted towards waste minimization and revenue generation through byproduct recovery. This study focusses a approach to address the challenge of distillery spent wash management by drying the spent wash and utilizing the resulting dried solids as an alternative fuel for boilers. The distillery spent wash contains approximately 14.6% solid content, and the dried solids have a gross calorific value of 13840 J/g. Furthermore, the dried solids possess an ash content of 2.26%, with the ash containing a notable 36.7% potassium oxide content. By transforming distillery spent wash into a valuable resource for boiler fuel, this research not only addresses waste management concerns but also offers a sustainable solution for revenue generation. The utilization of dried solids as an alternative fuel for boilers contributes to reducing environmental pollution associated with improper spent wash disposal while offering a viable source of renewable energy. This study underscores the potential of waste-to-energy initiatives in fostering sustainable waste management practices and enhancing economic viability in the distillery sector.



Conclusion

The cv value obtained by dried Distillery Spent Wash is 13840.5 J/g and the potassium oxide obtained by Distillery Spent Wash Ash is 36.745%

The daily removal of 1,030,000 liters of raw spent wash from all sugar factories in Sri Lanka can be effectively utilized by burning it in boilers. This process yields approximately 23,000 kilograms of ash, from which around 8,300 kilograms of K2O can be produced per day.

Enhancing Concrete Sustainability through Carbonated Recycled Cement Powder: A Review

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Keywords: *Concrete recycling; supplementary cementitious materials; Carbonated recycled cement powder; circular economy*

Concrete is a vital construction material, but the rapid urbanization has led to a significant accumulation of demolished concrete, especially in developing countries. Despite efforts, only a small fraction of this concrete is recycled, leading to environmental challenges. However, countries like Japan have successfully recycled a large portion of their demolished concrete, primarily for use in road subbase and as Recycled concrete aggregate (RCA) which is typically yields lower quality compared to natural aggregate (NA). Additionally, during RCA production, a significant amount of cement powder is generated, which has the potential to be used as a supplementary cementitious material (SCM). Recent research has explored various valorisation methods for recycled cement powder (RCP), with carbonation emerging as the most sustainable option. Carbonated RCP not only stores CO_2 but also improves concrete properties such as compressive strength and durability. Considering the environmental impact of traditional cement manufacturing, the utilization of SCMs, such as carbonated recycled cement powder (cRCP), has emerged as a promising strategy. This approach promotes sustainable recycling practices and contributes to ecological conservation efforts, aligning with the circular economy philosophy. This review highlights recent findings on the accelerated carbonation treatment of RCP, exploring its benefits and applications as a sustainable building material.

Keynote Address 2

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Geospatial Technology for Better Decision-Making and Planning

In an era marked by rapid urbanization, climate change, and complex socio-economic challenges, the demand for precise, data-driven decision-making has never been more critical. Geospatial technology, encompassing Geographic Information Systems (GIS), remote sensing, and spatial analytics, has become a pivotal tool in transforming our understanding, interpretation, and interaction with the world. This keynote addresses the revolutionary impact of geospatial technology on decision-making and planning across various sectors. Future urban planning stands to benefit immensely from geospatial technology through optimized land use, smart infrastructure development, and enhanced environmental management. In disaster management, advancements in geospatial technology will improve our ability to predict, prepare for, and respond to natural hazards with greater accuracy. The agriculture sector will witness significant improvements in precision farming, resource management, and crop monitoring. Integration with cutting-edge technologies such as artificial intelligence (AI), machine learning (ML), and the Internet of Things (IoT) will further enhance the capabilities of geospatial technology, enabling real-time data analysis and predictive modeling. This convergence will empower organizations to achieve higher accuracy, efficiency, and transparency in their decision-making processes. Despite challenges related to data quality, accessibility, and privacy concerns, the ongoing innovation and increasing adoption of geospatial technology hold the promise of revolutionizing decision-making and planning processes. This keynote will inspire participants to harness these technologies, fostering a more informed, resilient, and sustainable future planning and decision-making.

Session 3 – A

Comparative Analysis of Vertical Metal Zonation in Ginigalpelassa and Indikolapellassa Serpentinite Complex

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Keywords: *Serpentine; Metal Zonation; Weathering; Mineralogy; Sri Lanka*

Serpentinite deposits have been identified in every continent, and mostly occur near convergent margins. As far as the global distribution of serpentinite deposits is concerned, Serpentinites and their associated soils encompass roughly 1% of the Earth's total surface. Serpentinite deposits in Ginigalpelassa and Indikolapelassa, Sri Lanka, are known to exhibit lateral variations in soil metal concentrations and are primarily attributed to weathering processes as well as no studies regarding the metal Zonation inside the deposits. However, understanding the vertical metal zonation within these deposits is crucial for critical metals like Nickel efficient exploration and extraction efforts. In this study, soil and weathered rock samples were collected from several locations in both deposits where the vertical zonation was visible to analyze metal concentrations and understand the weathering process. Utilizing Inductively Coupled Plasma Mass Spectrometry (ICPMS), X-ray Diffraction (XRD), and leaching techniques, the chemical composition of each layer, mineralogy, and the extractable forms of Ni, Co, Cr, and Cu were determined to identify the distribution of each metal. Our findings revealed rich metal concentrations in the soil or highly weathered rock compared to the rock samples. The Ginigalpelassa deposit demonstrates more concentration compared to the Indikolapelassa deposit. It was observed that metal concentrations in the topsoil were lower compared to deeper horizons (A, B and C), maybe because the plant absorbs Ni, Co, and Cu, excluding Cr. According to the literature, in moderately acidic conditions, Cr remains immobile, whereas Ni and Co exhibit scarce mobility, as rainwater leaches metal ions from the O and A horizons, accumulation occurs in the B horizon, resulting in significantly higher metal concentrations, particularly for Ni. Based on these findings, we recommend Acid leaching as the preferred mining method for extracting Ni from low-grade Ni deposits. This research contributes to a deeper understanding of vertical metal zonation in serpentinite deposits, facilitating more efficient and sustainable exploration and extraction practices in similar geological settings.

Assessing the Applicability of Geophysical Methods for Exploring Vein Type Mica Deposits - A Case Study in Matale District, Sri Lanka

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Keywords: *Vein deposits; Mica; Ground Penetrating Radar; Very Low Frequency Electromagnetic; Resistivity; Sri Lanka*

Due to the subsurface nature of the deposits and the often structurally complex geological conditions, vein type mica is highly challenging to explore. This paper aims to study the applicability of Ground Penetrating Radar (GPR), Very Low Frequency Electromagnetic (VLF-EM), and Resistivity geophysical methods in exploring vein type mica deposits, utilizing the Atipola mine area located in the District of Matale, Sri Lanka. The minefield has been known for the extraction of phlogopite mica. The deposits are mostly of vein type or hydrothermal origin. Vein type deposits are formed as fracture filling structures in the subsurface. These structures often result in poor geological mapping which creates significant issues for the mine planners and resource estimators as the extraction is performed without full knowledge of the vein structure and origination. This leads to resource wastefulness and an inefficient operation. To address this problem, we conducted GPR, VLF-EM, and Resistivity surveys on the vein deposit sub-surface structure at the Atipola mine area. Preliminary, field observations in the field lead us to generate the field survey data collection and coverage design to explore the most suitable and relevant area. Promising result has shown the potential suitability of geophysical methods on vein type mica deposit exploration. This study will also help to explore and advance the discovery of the vein type mineral deposit exploration in regions like Matale district, where the mica mining has become one of the critical economic activities in this region. Integration of GPR and Resistivity could enable non-destructive and appropriate explanation of the sub-surface structure, which could lead to the right decision on a proper mineralogy deposit characterization and contribute to informed mining practices.

Characterization of Heavy Mineral Sand in Sri Lankan Beach Stretches: A Comparative Study at Nilaveli and Batticaloa Beach Stretches

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Keywords: *Heavy minerals; Bromoform Separation; Petrographic microscopic grain counting; Particle size distribution; Sri Lanka*

The northeastern coast of Sri Lanka boasts globally significant heavy mineral prospects. Pulmoddai deposit contains approximately 70% to 85% heavy minerals, while Verugal deposit holds 45% to 50%. However, there are untapped areas like Batticaloa and Nilaveli with great exploration potential. A comparative study was conducted on their beach stretches to characterize heavy minerals and analyze correlations between sand grain size distribution and heavy minerals. Composite samples were collected along these stretches, then Bromoform separation was carried out to determine the heavy mineral content. Petrographic microscopic grain counting was then conducted to determine the volumetric percentage of each heavy mineral type. Particle size distribution of heavy minerals and beach sand was analyzed using laser particle size analyzer, and the accuracy was cross-checked with sieve analysis. The results indicate a higher mineral content in the Batticaloa beach stretch compared to Nilaveli, despite Nilaveli's proximity to the Mahaweli River. Batticaloa has the potential for nearly 20 km of economical beach stretch with the highest heavy mineral content at 14.5%, whereas it is 6.42% for Nilaveli. The average total heavy mineral content of the potential area is 8.9%, with average ilmenite content at 53.14%, rutile at 2.06%, garnet at 6.44%, zircon at 31.94%, and monazite at 4%. It indicates the high content of economically valuable monazite.

Exploration and Characterization of Potential Iron Ore Occurrence in the Pelpitigoda Area

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Keywords: *Iron Ore Occurrence; Exploration; Characterization; Mineralogy; Geochemistry*

The exploration and characterization of potential iron ore occurrences in the Pelpitigoda area constitute a significant endeavour aimed at identifying new sources of iron occurrence. This research project is designed with the objectives to explore the potential iron occurrences, characterize the mineralogy and geochemistry of the area, and investigate value addition for industrial applications. The methodology comprises three phases. In the initial phase, geological settings are studied to understand the rock formations and structures surrounding the area. This is followed by a magnetic susceptibility survey to identify variations and anomalies, along with systematic sample collection across the deposit. Phase two involves laboratory analysis, including sample preparation, colorimetry, X-ray Diffraction (XRD), Atomic Absorption Spectroscopy (AAS), and Inductively Coupled Plasma Mass Spectrometry (ICP-MS). Phase 3 will entail roasting samples to extract iron oxide through reduction roasting and magnetic separation by converting the minerals to magnetite for value addition for an industrial application from laterites. Notably, colorimetry results from phase two indicate iron content ranging between 40-60 percent and in the samples, with goethite identified as the predominant mineral, alongside magnetite and hematite with the XRD analysis results. The significance of this research lies in its potential to introduce a new iron occurrence possibility. Additionally, successful outcomes could provide a sustainable method to extract iron from laterites, thus contributing to the development of efficient industrial processes. Future work entails completing the last phase of roasting the samples to extract iron oxide, followed by comprehensive laboratory testing of the prepared samples. In conclusion, this research endeavour holds promise for unlocking new avenues in the exploration and utilization of iron resources, thereby addressing the demand for sustainable raw materials in various industrial sectors.

Extraction Potential of Nickel from Native Hyperaccumulator Plants from Ginigalpelessa Serpentinite Deposit

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Keywords: *Leaching efficiency; incineration; Ni hyperaccumulators; phytomining; serpentine soil*

Serpentine soils are low-grade Ni resources that have been utilized widely to extract Ni to meet its burgeoning demand in the renewable energy sector. However, the economic impracticability of Ni recovery by conventional mining techniques has been directed towards Ni phytomining, in which native hyperaccumulators grown in serpentine soils are used for commercial Ni recovery. In this context, the Ginigalpelessa serpentinite deposit in Sri Lanka harbors a wide variety of plants that can accumulate high Ni concentrations from the soil. Despite the promising Ni potential (0.4-1.7%) in the Ginigalpelessa serpentinite deposit, the lack of detailed studies on the hyperaccumulation ability of native plant species and proper extraction methods retards the commercial application of Ni phytomining in this deposit. Therefore, the present study carried out ex-situ phytomining trials using two native hyperaccumulator species namely, *Crotalaria verrucosa* and *Apluda mutica*. The harvested biomasses were then incinerated to produce Ni-rich bio-ores, which were analyzed for Ni concentration using Inductively Coupled Plasma Mass Spectrometer (ICP-MS). The bio-ore of *C. verrucosa* contained 7,279 ± 106 mg/kg of Ni whereas the bio-ore of *A. mutica* showed 3,867 ± 39 mg/kg of Ni. The bio-ore of *A. mutica* was used for the leaching experiments due to its highest abundance in the deposit. The leaching assays were carried out with *A. mutica* bio-ore under different pulp densities (100 g/L and 200 g/L) and H_2SO_4 concentrations (1 mol/L and 5 mol/L). The bio-ores used in leaching experiments were produced from an open flame and muffle furnace (at 550 ^oC). The highest leaching efficiency was observed as 59% in open burnt samples (leachate Ni concentration = 649 mg/kg and total Ni concentration = 1,098 mg/kg) under 100 g/L pulp density and 5 mol/L H_2SO_4 concentration. The overall low leaching efficiency of bio-ore can be attributed to the formation of an aluminum silicate matrix ($Al_2O_3.2SiO_2$) during leaching experiments which inhibits the Ni leaching. Therefore, the present study requires further investigations to optimize the leaching efficiency to implement a sustainable Ni extraction method for the local serpentinite bodies.

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Comparison of Critical Metal Potential in Beach and Offshore Sediments of Pulmoddai, Sri Lanka

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Keywords: *Critical metals (CMs); Dynamic deposit; Pulmoddai coastal stretch; Rare earth elements(REEs); Sediments*

The global transition towards renewable energy resources for power generation has increased the demand for critical metals (CMs), including rare earth elements (REEs). This rapid growth of demand coupled with geological scarcity and geo-political concerns has posed great challenges in securing the supply chain of CMs. Therefore, prospecting new CM sources worldwide is of timely importance. In this context, the Pulmoddai coastal stretch in Sri Lanka has been recognized as a dynamic deposit with established potential for REEs and other critical metal resources, currently undergoing beach face mining operations. The focus of this study is to compare the critical metal potential in the beach and offshore sediments in Pulmoddai, Sri Lanka, crucial for determining the origin and delineating the extent of this deposit. Twelve onshore and nineteen offshore samples were collected and analyzed for CMs (V, Cr, Co, Ni, Cu, Zn, Ga, As, Rb, Sr, and Cs) and REEs. Based on the results, light REE content (LREE), heavy REE content (HREE), and total REE content (TREE) were computed for both onshore and offshore locations. For onshore sites, LREE, HREE, and TREE ranged respectively from 43.27 to 244.09 ppm, 19.62 to 92.29 ppm, and 62.92 to 336.39 ppm. Conversely, offshore locations exhibited higher concentrations with the corresponding values ranging from 116.12 to 363.62 ppm, 8.57 to 120.93 ppm, and 167.93 to 484.55 ppm. Sr, Ni, and Cr were determined as the most abundant CMs for both onshore and offshore locations. Sr, Ni, and Cr concentrations ranged from 227.17 to 674.58 ppm, 116.17 to 675.88 ppm, and 43.55 to 112.87 ppm respectively for the onshore locations. The corresponding ranges for offshore sites were determined as 370.86-754.30 ppm, 235.43-721.44 ppm, and 32.51-172.62 ppm. The higher CM content in offshore regions suggests an offshore origin to this dynamic deposit, which is enriched by the offshore sediments transported onshore and deposited on a long-term basis. Therefore, regulatory authorities overseeing the mining operations of Pulmoddai deposit should accurately delineate its extent, integrating both onshore and offshore regions as a unified system, rather than solely focusing on prospecting the longshore areas.

Review on Biochar for Enhancing Biogas Production from Anaerobic Digestion of Food Waste

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Keywords: *Biochar; Anaerobic Digestion; Food waste; Biogas; Enhancement*

Food waste is the major waste fraction in municipal solid waste and is indeed a significant issue in society, with substantial economic, environmental, and social impacts. Various technologies exist to manage food waste, including animal feeding, anaerobic digestion, composting, incineration, and landfilling. Among these technologies, anaerobic digestion is the most recognized, efficient, and sustainable method. It can produce biogas and nutrient-rich fertilizer simultaneously. Because of the high organic load of food waste and the presence of mass nutrients, it is a suitable substrate for the anaerobic digestion process. However, the anaerobic digestion process faces challenges such as process instability, slow rate of biogas generation, and sudden failure of biogas generation due to susceptibility to inhibitors. All these challenges have affected its efficiency. Biochar has been identified as a promising alternative to address most of the drawbacks in the anaerobic digestion process and enhance methane production. Biochar is a carbon-rich material produced through thermochemical conversion processes. Because of its specific properties, such as its high specific surface area, porous structure, adsorption capacity, buffering capacity, and a higher number of functional groups, it has the potential to enhance biogas production in anaerobic digestion processes. Biochar exhibits pH buffering properties, enhances the enrichment of functional microbes, alleviates the effects of inhibitors, and accelerates the process of direct interspecies electron transfer (DIET). This paper reviews the effectiveness of biochar as an additive in the anaerobic digestion process of food waste. It further examines the properties of biochar, the factors influencing these properties, and the mechanisms through which biochar enhances the AD process.

Session 3 – B

Analysis of Subsurface Strata of Colombo and Gampaha Districts of Sri Lanka, Based on Geotechnical Investigation Data

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Keywords: *geotechnical investigation; subsurface strata; boreholes; modelling*

The subsurface exploration for geotechnical engineering applications in Sri Lanka is mainly based on borehole investigations. There are several leading geotechnical engineering companies in the country who have already done more than a couple of thousands of subsurface investigations for small- and large-scale civil engineering projects. Even though project wise subsurface information is available, integration of available subsurface data in proximity, and development of subsurface three-dimensional (3D) models can hardly be seen in the country. This has been a significant disadvantage in costing and planning of large-scale new investigation projects. Due to lack of information, most of the projects start even being not knowing the tentative bedrock level of the area. Hence, in investigation cost estimations, pricing for most of the items is recorded as "rate-only". Accordingly, the total cost could be immensely higher than the available budget with the client. However, if 3D modeling of subsurface strata can be done area wise, based on already available borehole data, such uncertainties could be minimized. In this research, more than thousand subsurface investigation reports were reviewed; data were recorded and analyzed targeting to interpret the subsurface of the western province of Sri Lanka. However, scattered data had to be excluded in data analysis, and eventually the study was confined to Colombo and Gampaha districts, in which more than sufficient data could be found. By using interpolation methods, geological surfaces were interpreted in between borehole locations by matching similar subsurface features. In addition, artificial neural networks were used to forecast borehole data in exceptional cases for a few locations. This helped to improve the spatial coverage and accuracy of the 3D model developed by means of "Surfer" software. The 3D model developed for the study area well demonstrates the subsurface strata, and facilitates taking of cross sections in any direction within minutes. Hence, the findings of this research will enhance the outcome of general geotechnical investigation practice in Sri Lanka. This will also be immensely beneficial in planning and budgeting of future large-scale geotechnical investigation projects, more accurately than in the past, with great time savings as well.

Machine Learning Based Spatio-Temporal Analysis for Abandoned Quarry Management

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Keywords: *Adaptive management; Land cover; Satellite imageries; Support vector machine*

The need for monitoring abandoned quarries for land cover changes is underscored by the significant environmental and ecological impacts these sites can have if left unmanaged. On-site monitoring of abandoned quarries is often neglected due to accessibility and safety challenges. This emphasizes the need for a systematic monitoring approach that can be executed with minimal on-site involvements. To address these challenges, this study aims to develop an automated classification approach for mapping the land cover in the neighbourhood of abandoned quarries. The study employs a comprehensive methodology with key stages: data preparation, feature extraction and selection, hyperparameter optimization, and identification of the algorithm that exhibits superior accuracy. The analysis assesses the efficacy of machine learning models - decision tree (DT), random forest (RF), and support vector machine (SVM) - in analyzing Landsat 8 and Sentinel 2 satellite images at a specific site in Anuradhapura, Sri Lanka.The outcome of the study reveals that the SVM model produced the highest accuracy of 91.30% (kappa index of 0.898) when applied to the Sentinel 2 image. This superior performance is attributed to the higher spatial resolution of Sentinel 2 compared to Landsat 8. The SVM's superior performance in the classification can be credited to its efficient handling of high-dimensional data, its robustness against overfitting through the use of regularization, and its flexibility in dealing with complex separations through kernel functions. In addition, textural features and spectral indices were incorporated to augment the model training procedure. The results indicated that augmenting the number of features can help alleviate the misclassifications that occur when depending exclusively on spectral data. Utilizing the developed machine learning model, a temporal analysis was performed spanning from 2016 to 2024 providing a comprehensive overview of the changes in land cover over this period.This analysis underscores the model's potential for monitoring land cover changes in abandoned quarries. By enabling continuous monitoring with minimal human intervention, the model can help mitigate the environmental impacts of these sites. Furthermore, the insights gained from this analysis can inform the development of effective management and rehabilitation strategies for abandoned quarries.

Experimental Synthesis of Zeolites from Pre-processed Coal Fly Ash using Microwave Irradiation Method

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Keywords: *Washing cycles; Microwave irradiation; Qualitative Phase Analysis; Zeolites*

Coal power plants contribute by an excess of 40% for the generation of electricity worldwide. Coal fly ash, being a dominating byproduct of coal power generation, is unique due to its physicochemical properties such as thermal stability, chemical inertness, compressive strength, and adsorption. However, reducing the inherent impurities of coal fly ash, which is heterogenous in nature, has proven to enhance its ability to be valorised into different second-generation products of high value, such as zeolites. Zeolites are well renowned for their excellent adsorption ability due to high surface area and porosity, being an excellent solution for greywater treatment. Preprocessing has been a successful method in eliminating impurities of CFA, and performing washing cycles is the preprocessing method used in this study. Also, microwave irradiation method has proven to be a useful and rapid method in synthesising zeolites. This study analyses the effect of pre-processed coal fly ash obtained through optimised utilisation of wash cycles, compared to raw coal fly ash, and the feasible conditions of zeolite synthesis from coal fly ash which has undergone the wash cycle preprocessing technique, considering NaOH concentration and microwave irradiation power as key parameters. X- Ray Diffraction and Scanning Electron Microscopy coupled with Element Dispersive Spectroscopy were utilised to verify the enhanced nature of CFA after preprocessing, and formation of zeolites. The results of XRD infer that Mullite ($Al_{4+2x}Si_{2-2x}O_{10-x}$) is the major crystal match for CFA obtained from the site, and pre-processed CFA yields a better qualitative phase analysis with Mullite than raw CFA, with the former having a peak coverage of Mullite that is approximately three-fold than the latter. Also, according to the experimental results, zeolite L and zeolite Na-Y-CO_2 were produced from the microwave irradiation process, having an optimal NaOH concentration of 2.5M and irradiation power of 600W. These findings have been corroborated using XRD and SEM with EDS analyses, and we recommend further extension of the frontier to check the viability of zeolite formation with other critical parameters such as Al/Si ratio, pH and its adsorption of heavy metal ions that are present in greywater, rendering them purified.

Use of Integrated Geophysical Technology for Exploring Gem Gravel Beds in Rathnapura District, Sri Lanka

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Keywords: *Secondary deposits; Gems; Sri Lanka; Ground Penetrating Radar; Resistivity*

Exploration of gem gravel beds, particularly in renowned regions like Ratnapura, is essential for uncovering valuable gemstone deposits. Traditional exploration methods often prove inefficient and costly, necessitating the adoption of advanced geophysical technologies. This study investigates the efficacy of integrating Ground Penetrating Radar (GPR) and Resistivity Methods in exploring gem gravel beds in the Ratnapura area of Sri Lanka. The study aims to assess the effectiveness of these geophysical techniques in identifying and characterizing gem-bearing gravel layers beneath the Earth's surface. GPR offers high-resolution imaging capabilities, allowing for the detection of subsurface anomalies associated with gem deposits. On the other hand, Resistivity Methods provide insights into the electrical properties of the subsurface, aiding in the delineation of geological structures and potential gem-bearing formations. Through data acquisition, processing, and interpretation, the study aims to delineate potential gem-bearing formations and geological structures within the Ratnapura area. Integration of geophysical data with geological information and known gem occurrences will facilitate the identification of prospective areas for further exploration and mining activities. The findings of this study are expected to contribute to the advancement of gemstone exploration techniques in Ratnapura and similar regions. By leveraging integrated geophysical technology, the efficiency and accuracy of gem gravel bed exploration can be enhanced, leading to sustainable resource management and economic development in the gemstone industry.

Enhancing Stockpile Inventory Management through UAV-Based Volume Estimation: A Case Study of Salt Stockpiles in Hambantota Mahalewaya

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Keywords: *Differential Global Position System; Total Station; Ground Control Points*

Accurate volume estimation of stockpiles is crucial in industries such as Mining, Construction, salt, and Agriculture to optimize resource utilization. This study evaluates the effectiveness of Unmanned Aerial Vehicles (UAVs) compared to Differential Global Positioning System (DGPS) and Total Station (TS) methods for volume estimation of outdoor salt stockpiles in Hambantota Mahalewaya, Southern province of Sri Lanka. The inventory identified two stockpiles, stockpile 1 and stockpile 2, with volumes of 1832.25 m3 and 819 m3, respectively. An optimal elevation of 55m was utilized for UAV surveys, and the results were compared with DGPS and TS measurements. UAV surveying factors affecting errors, including image resolution, Ground Control Points (GCPs), and image processing software, were assessed for both stockpiles. Survey time and cost for each method were also analyzed. Pix4dMapper and Agisoft Metashape software processed UAV images, while Civil3D software processed DGPS and TS data. Results indicated that increasing UAV survey elevation reduced volume error percentages for both stockpiles, with and without GCPs. For Stockpile 1, UAV volume estimation showed a 0.88% difference from the actual volume, compared to 4.81% for DGPS and 3.35% for TS. Conversely, for Stockpile 2, UAV estimation differed by 0.95%, while DGPS and TS showed differences of 0.56% and 0.10%, respectively. UAV surveys proved efficient in terms of survey time and labor intensity. Despite technological advancements, challenges remain, particularly in addressing topographical variations for accurate volume estimation. To improve UAV-based estimation, addressing bottom elevation discrepancies by establishing fixed benchmarks on flat terrains was suggested. Nonetheless, UAV-based approaches offer fast and relatively reliable results, indicating their potential for widespread adoption.

Assessment of Seasonal and Spatial Water Quality Changes in Kelani River

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Keywords: *water quality; land use types; regression analysis; Kelani River Basin; GIS*

The deteriorating water quality of the Kelani River over time has negatively affected environmentalhealth and sustainability. This study aims to determine the relationship between land use types and its impact on the water quality within the Kelani River basin. The analysis utilized a dataset comprising 23 parameters related to water quality, spanning 17 sampling locations along both the primary river and its tributaries from 2003 to 2023. IBM SPSS Statistics (Version 26), was utilized for data analysis, focusing on 7 water quality parameters (pH, dissolved oxygen (DO), chemical oxygen demand (COD), biological oxygen demand (BOD), nitrate, phosphate, and turbidity) that were influenced by land use. From this analysis, 6 sampling locations were selected to represent various segments of the stream, including Aguruwella and Nakkawita for the upstream segment, Pugoda Ela and Wak Oya for the middle stream, and Rakgahawatte Ela and Maha Ela for the downstream segment. This study utilized a combination of GIS and statistical methods over 4 years with a 6-year time interval (2004, 2010, 2016,and 2022). The land use maps were generated by categorizing area into 4 land use types as agricultural area, vegetation area, built-up area, and others, using maximum likelihood supervised classification. Accuracy assessment using the kappa coefficient revealed that overall accuracy was greater than 85 %,for all six sub-catchments across all four years. From the analysis, it shows that the water quality parameters are significantly varied spatially and temporally. From upstream to downstream and over time,water quality has declined. Regression analysis shows the relationship between land use types and 7 water quality parameters. pH, DO, COD, BOD, and nitrate show a correlation with built-up lands, pH, DO, COD, nitrate and turbidity with vegetation areas, and phosphate with agricultural areas. Moreover,this study highlighted, built-up lands and agricultural lands negatively influenced the water quality, while vegetation areas positively influenced. By identifying the correlation between land use types and water quality, this study helps to preserve and enhance the water quality of the Kelani River basin by implementing proper land use management strategies.

A Predictive Model Derived from Sattellite Data and Selected Water Quality Parameters for Invasive Plant Dynamics in North Bolgoda Lake

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Keywords: *Landsat-8; Surface water temperature; Dissolved Oxygen; Chemical Oxygen Demand; Auto-correlation techniques*

The proliferation of aquatic weeds and algae in water bodies, such as Water Hyacinth coverage in North Bolgoda Lake, underscores potential pollution concerns associated with prolonged plant growth on surface water, changing nutrient levels and subsequently the water quality. This study aims to develop a regression model employing remote sensing techniques to identify and map the spatial distribution of invasive plants, primarily Water Hyacinth, in North Bolgoda Lake. Integration of surface temperatures derived from the Thermal Infrared (TIR) band of Landsat-8 satellite data facilitated by the field measurements of selected parameters are the main components of this research. Utilizing TIR band 10 data, converted into Lake Surface Water Temperature (SWT) imagery, alongside the surface water temperature measurements from pre-identified locations and computed Dissolved Oxygen (DO) and Chemical Oxygen Demand (COD) values for the same locations includes the main data used for the study. Lake SWT and DO, COD gathered from 30 locations during February and March 2024, revealed a linear inverse correlation between Lake SWT, COD, and DO. A composite map was generated for the selected locality of the North Bolgoda Lake with all the above information including provisions for precision enhancements by continuing insertion of field data. Despite the involvement of limited parameters this dynamic map could serve as a preliminary model for recognizing the behaviour of invasive plants and their impact on the selected elements of the waterbody. Further, this could be extended to determine the lake bottom dynamics, behavioural characteristics of the water column and the potential for encountering contaminations. It is recommended to develop this map by including further parameters and replicate the same methodology to cover the North Bolgoda Lake extent to assist authorities to make informed decisions. This study merges the satellite-derived data with ground-truth measurements to validate and refine the predictive models, ensuring their accuracy and reliability in forecasting. Utilizing spatial autocorrelation techniques this predictive framework could be further improved.

Session 4 – A

Forecasting the Impact of Land Utilization on Flood Vulnerability through Machine Learning and Remote Sensing in Athuraliya and Akuressa Divisional Secretariat of Sri Lanka

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Keywords: *Flood Vulnerability; Land Utilization; Remote Sensing; Machine Learning.*

The Akuressa and Athuraliya Divisional Secretariats in Sri Lanka are recurrently affected by devastating floods, posing significant threats to human lives, infrastructure, and economic development. These floods stem from various factors such as land usage patterns, rapid urbanization, and environmental degradation. This study endeavors to establish a nexus between flood vulnerability and land usage, crucial for formulating effective disaster management and mitigation strategies. Consequently, it contributes valuable insights into predicting flood vulnerability based on land usage patterns, aiding policymakers, urban planners, and disaster management authorities in informed decision-making. Notably, this research is pioneering as it applies state-of-the-art techniques to assess flood risks in the area, addressing a notable gap in existing knowledge and practice. By scrutinizing land utilization and its impact on flood vulnerability, identifying key environmental variables, and employing machine learning models like XGBoost, Random Forest, and CatBoost, this study achieves a high predictive accuracy (0.91 for XGBoost), showcasing the efficacy of machine learning in flood susceptibility prediction. The results inform a feature importance analysis, culminating in the creation of a future risk map using ArcGIS software. This underscores the superiority of prediction-based planning over post-event recovery measures in fostering resilient communities in flood-prone regions. Moreover, the study underscores the potential of Machine Learning (ML) and Remote Sensing (RS) in enhancing flood forecasting and mitigation techniques.

Feasibility Study of Iron Extraction from Laterite

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Keywords: *Laterite; Pelletization; Minerology; Economic viability; Slag*

This study investigates the feasibility of extracting iron from laterite, a low iron-bearing rock, with a focus on the economic viability of the process. The aim to develop a feasible method to extract Iron from Lateritic rock. The laterite samples were collected from Panirendawa, Pelpitigoda and Padukka. Mineralogy of the laterite was investigated by means of X -ray Diffraction (XRD) analysis, whereas chemical composition of the sample was determined by using Energy Dispersive X-ray analysis (EDX). The pelletization process was used to enhance iron recovery. Economic viability is evaluated through a detailed cash flow analysis that considers operating costs, revenue from iron extraction, and potential market factors. Iron extraction was done using the laboratory type cupola. The main results indicate that laterite contains significant iron content within the range of 30-40% and aluminium 25-27%. The cash flow indicates it is not a potential source for extraction iron only, however using a zero wastage multi-disciplinary process, slag can be used to produce bricks because of high aluminium silicate content of the slag. In conclusion, this study establishes the feasibility of iron extraction from laterite, showcasing it's not an economical process however using a zero wastage multi-disciplinary process it is economically viable.

Disaster and Attitudinal Vulnerability: A Systematic Conceptual Review

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Keywords: *Attitudinal vulnerability; attitude; disaster; PRISMA Method*

Natural hazards represent a destructive force that poses a significant risk to human life, property, and the economy, among other aspects. The impact of natural hazards on the economy and human populations is profound. Various attitudes, beliefs, and behaviors are linked to different demographic groups, some of which may be more susceptible to these hazards than others. In developing nations, catastrophic natural events like tsunamis can deliver a sudden blow to their development trajectory, leading to a costly and challenging recovery process. A key contemporary challenge in disaster preparedness involves the effective application of soft measures, focusing on assessing local awareness, knowledge, perception, and attitudes towards disasters. The primary research inquiry in this investigation pertains to understanding the existing knowledge surrounding attitudinal vulnerability to disasters. The aims of this study include conducting an extensive review of current knowledge on attitudinal vulnerability in disasters and identifying potential avenues for future research.PRISMA framework and guidelines have been followed to conduct this systematic conceptual review. Total of 128 articles were initially identified from the Scopus database using the key words “Disaster”, “Vulnerability” and “attitude”. Review protocol has been developed according to the PRISMA guidelines. Analysis method used in this study was keyword co-occurrence utilizing the VOSviewer software (Version 1.6.20). The principal discoveries of this theoretical manuscript encompass the delineation of forthcoming avenues for research and areas of research deficiency, such as knowledge lacunae, empirical deficiencies, contextual deficiencies, and methodological deficiencies. A comprehensive framework is imperative to grasp the extent of the matter, encompassing both the technical and social repercussions. Subsequent research endeavours should concentrate on the amalgamation of Blockchain and the internet of things to facilitate real-time data utilization in the realm of disaster readiness. Initiatives aimed at enhancing disaster preparedness should specifically target younger demographics for enhancement purposes. In conclusion, the influence of past experiences on current and future preparedness needs to be explored enhancing public attitudes and knowledge of climate change and disaster risk.

An Alternative Underground Hoisting System for Kahatagaha Underground Graphite Mine, Sri Lanka - A Case Study

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Keywords: *cost-effective; design; productivity; wire ropes; winzes*

Hoisting systems used in underground mines are essential for the transportation of equipment, personnel, mined ore and thus for the productivity of an underground mine. It consists of various components in which there are shear wheels, winches, wire ropes, lift cages, carriage boxes and electric motors etc. The safety and reliability of the hoist depends on its design, therefore proper and accurate design of a hoist is essential. A properly designed hoisting system also supports to increase underground productivity as well. Kahatagaha underground graphite mine is the deepest underground graphite mine in Sri Lanka, where the deepest level is 2080 feet below from the surface. The main lift operates up-to 1130 feet level from the surface and there are 5 inclined winzes equipped with pneumatic winches & hanging wooden boxes with the support of wire ropes for hoisting or lowering men & material as hoisting method from 1130 feet level to 2080 feet step by step between main underground levels.This hoisting method is very primitive and it has many bottlenecks when going to increase underground production, productivity & safety. This paper aims to provide a solution for current hoisting system & it`s issues mentioned above and presents the benefits of proposed hoisting system for Kahatagaha underground graphite mine. In fact, a cost-effective & safe hoisting system is a great support for any underground mine so that the proposed design would be a good alternative against the primitive system still in operation.

The Impact of Physiochemical Conditions on Hydrogen Stability and Storage in Depleted Carbonate Hydrocarbon Reservoirs

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Keywords: *Underground hydrogen storage; Hydrogen loss; Carbonate reservoir; Geochemistry; PHREEQC; MATLAB*

Hydrogen fuel derived from renewable energy and low-CO_2 fossil sources has an immense decarbonization role in electricity generation, energy storage, transportation, and heavy industry. However, its lightweight nature necessitates a large storage capacity to enable its instrumental utilization. Underground hydrogen storage (UHS), particularly within readily accessible depleted hydrocarbon reservoirs (DHR), emerges as a promising solution, offering substantial, cost-effective, and secure storage capabilities. Yet, the risk of hydrogen loss due to both biotic and abiotic phenomena poses a challenge to the safety and integrity of these storage sites. In this study, we investigated the effects of mineralogy, salinity, pressure, and temperature on the interactions of hydrogen/brine/mineral and the rate of hydrogen loss within carbonate DHRs. Utilizing three distinct brine and limestone rock samples, we conducted static batch simulations across temperatures of 50-130°C and pressures ranging from 15 MPa to 30 MPa over a year-long storage cycle period, using PHREEQC and MATLAB. The results show that the dissolution of H_2 and formation of CH_4 and H_2S increased with the increase in reservoir temperature and pressure at a rate of 1:2, respectively. In the various brine and mineral compositions studied, the lowest risk of H_2 loss rate (<20%) was shown to be 115-130℃ (at 17MPa); meanwhile pressure above 18 MPa (at 50℃) indicated the highest risk of loss (>50%)—with even much loss percentage >85% above 19 MPa. Moreover, the mineral sample with the highest reactive mineral composition (25 wt%), had 80% H_2 loss within the initial 50 days of the storage period across all pressure and temperature conditions, indicating a potential one-month risk of 50% loss within such mineralogy. However, in rock samples with over 90 wt% calcite and a 2 wt% reactive composition, H_2 molality increased 4-fold on average across the storage period, salinity, temperature, and pressure condition, highlighting the dominant influence of mineralogy, particularly the reactive component, over temperature and pressure considerations in carbonate mineral systems. The findings, in summary, indicate that high temperature (~120℃), low pressure (~17 MPa), and reactive rock mineral (<2 wt%) may be appropriate physiochemical conditions to limit H_2 loss risk below 20% during its storage in carbonate DHR.

Solidification of Organic Waste Oil in Geopolymer using Graphene Oxide as the Emulsion Stabiliser

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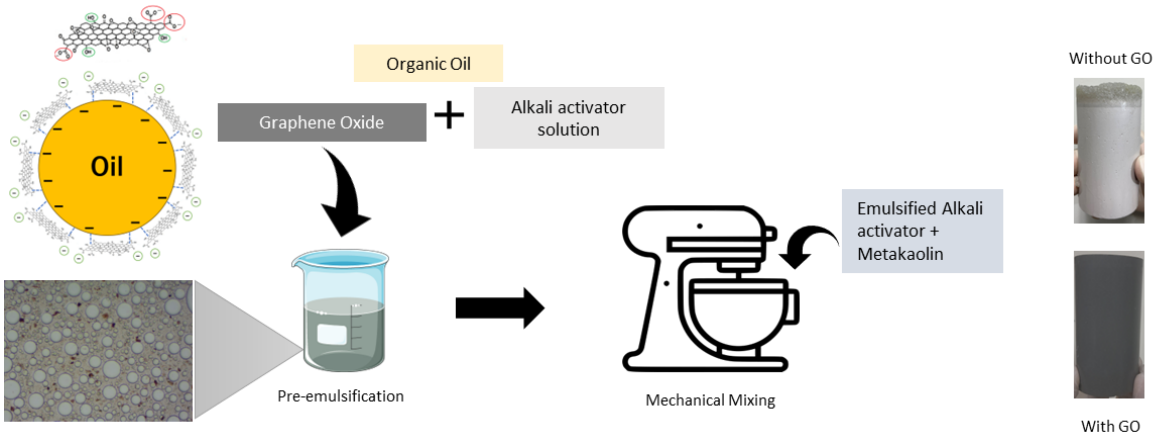
Keywords: *waste oil; solidification; geopolymer; metakaolin; graphene oxide*

The recycling and recovery of waste oil from various sources is a critical process, ultimately leading to its disposal in a diminished or non-hazardous state compared to its original form. Solidification is one of the promising methods of disposal of hazardous organic and inorganic wastes. Due to the hindrance of hydration of Ordinary Portland Cement (OPC) by organic compounds present in the oil, metakaolin-based geopolymer was selected as a suitable solidifying agent. Incorporating organic oil into the geopolymer via pre-emulsification, with Graphene Oxide (GO) nanosheets serving as Pickering particles for emulsion stability, ensures successful stabilization. The stability conferred by GO-stabilized Pickering emulsion of alkali activator-oil emulsion facilitates the effective incorporation and solidification of waste oil in metakaolin-based geopolymer. Furthermore, the addition of GO enhances the strength properties of the resultant geopolymer, albeit with a diminishing effect on strength and flowability with increasing oil content. This research underscores the significance of emulsion stability in pre-emulsified alkali activator-oil emulsion and demonstrates excellent leaching results, indicating the effective removal of organic components from solidified samples. Post-solidification experiments confirm the success of organic oil solidification through pre-emulsification utilising GO as an emulsion stabilizer.

Graphical Abstract



Recovery of Valuable Metals from Acid Mine Drainage using Aluminum-Iron (Al-Fe) Bimetallic Particles

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Keywords: *acid mine drainage; waste recycling; geochemical waste remediation*

Acid mine drainage (AMD) is a mining industry waste that has been identified as a global critical pollutant. Due to its high acidity and high metal content, it poses detrimental effects to the environment and ecosystems. Current approaches to the study of AMD control perceive it as an environmental concern due to its nature; with current mitigation and remediation methods focusing on either controlling its acidity or sequestering the metals present in the waste effluent. The high metallic nature of AMD, however, may be viewed not only as an environmental concern but also as a potential secondary source for valuable metals. This study investigated the viability of utilizing locally sourced recycled Al-scrap to synthesize magnetic Al-Fe bimetallic materials to recover copper (Cu) and zinc (Zn) from synthetic AMD. The effects of varying bimetal dosages (5, 10, and 20 g/L) and contact times (5–120 mins.) were investigated (see Figure 1). The results revealed that Al/Fe bimetallic materials can positively recover Cu and Zn and that both bimetal dosage and contact time were significant factors in metal recovery. For Cu, a maximum recovery of 100% is observed after 10 min using 10 g/L bimetal dosage. A maximum recovery of 98% for Zn was obtained after 120 mins at 20 g/L bimetal dosage. XPS and SEM-EDX results revealed the presence of zero-valent Cu and Zn on the bimetal surface after the recovery process. This suggests that the main mechanism for the metal recovery is electrochemical reduction from three occurrences: (1) direct reduction by Al, (2) direct reduction by Fe, and (3) reduction from the galvanic interaction in the Al/Fe bimetal system. Furthermore, a significant increase in pH from 2.12 to 5.72 was recorded after the process. This suggests that the application of Al-Fe bimetallic materials does not only have potential in metal recovery but also in simultaneously neutralizing the AMD. Hence, the recovery of valuable metals from AMD using scrap-based Al-Fe bimetallic materials shows promise as a metallurgical extraction method which additionally offers a practical approach for possible remediation and sustainable management of waste streams, specifically mining effluents such as AMD.

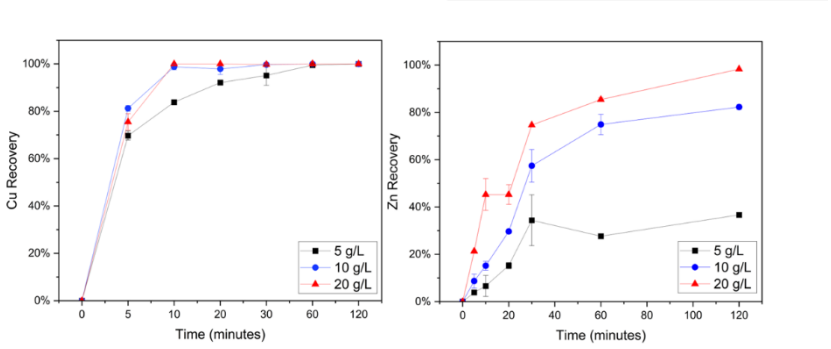

Fig. 1. Metal Recovery of Cu (left) and Zn (right) from AMD.

A Statistical Analysis of Urban Location Data Obtained from Smartphones for Disaster Response

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Keywords: *One-way ANOVA; Gaussian Distribution; Correlation techniques; geo-tagged information; GPS*

Technological advancements in device hardware and application software platforms have enabled smart phones to be used for multiple purposes as an all-in-one hand-held device. Its readily availability among majority of individuals, ease of use as a compact unit with access to remote storage and capacity to communicate makes it a perfect tool for emergency response specially with reference to disaster management provided having sufficient reception. Nevertheless, its embedded location services facility which communicates with the GNSS not only facilitates navigation, location sharing etc. but also capable of producing geo-tagged information, which could be vital under emergency conditions. Hence, this study statistically evaluates the reliability of location data recorded from a combination of smartphones and hand-held GPS units under selected urban environmental conditions. Commonly available four devices and a combination of applications were performed at five locations over a period of two months as the data collection for this exercise. The results reveal, regardless of the device and software combinations the location readings approximately follow the Gaussian distribution. However, a varying functionality has been observed in certain locations despite the consistency in environmental factors. Also, the mobile phones demonstrated a reasonable consistency among them in most of the horizontal positioning coordinate display events, despite the differences extracted from statistical analysis. Except in one location the smartphones indicated a significant difference in linear location data when compared with those obtained by handheld GPS. Analysis of Variance (ANOVA) was conducted to test the differences at 5% significance level. There is a growing emphasis on capturing records of geo-tagged spatio-temporal data not only to enhance the smartphone user experience but also for the disaster response considering the capability of smartphone to determine positions. Through this research, valuable insights into the performance of smartphones as tools for spatial data collection are sought to be provided, and best practices for location-based applications are aimed to be informed.

Session 4 – B

The Impact of Gas Impurities on CO_2 Storage in Depleted Oil Field with Carbonate Reservoirs

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***Keywords**: CCS; carbonate reservoir; gas impurities; PHREEQC; simulation*

The carbon dioxide capture and storage (CCS) is considered as a promising technology for carbon dioxide emission reduction. High-purity CO_2 mixture gas is separated from the flue gas and pumped into underground for a long-term storage. The impurities of gas can affect the trapping mechanisms. Various research studies about how impurity changes permeability were carried out. However, the effect of impurities in long-term trapping mechanisms is still unclear. This research studies the effects of H_2S, SO_2, and NO_2 in CCS for a long-term period of 2000 years using a PHREEQC geochemical simulator. The simulation presents formation water and rock samples from the previous research and the mixture gas groups to emphasis the effect of each impurity. The simulation contains two parts: the equilibrium block and the kinetics block. The former is to simulate the reversible reaction between the pure phases and the aqueous phase, which is defined by the equilibrium constant and dependent on the temperature. The latter is to simulate how phases react by time defined by kinetics rate, which is defined by the Arrhenius equation and depends on the pH, temperature, surface area and other reaction condition constants. Firstly, the gas and formation water are input into the equilibrium block to get CO_2 enriched solution and remaining gas components. Then, the remaining gas and solution and mineralogy are put into the kinetics block. Results indicate a shift from mineral trapping to solubility trapping in the presence of impurities, with a significant decrease in pH affecting CO_2 storage ratios. Furthermore, the changes in each mineralogy and the effects of each impurity are discussed.

Seasonal Dynamics of Nickel Attenuation in Acid Mine Seepage: Implications for Remediation Strategies at BCL Copper-Nickel Mine Tailings, Botswana

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Keywords: *Acid mine drainage; Tailings seepage; Nickel attenuation; Seasonal dynamic; Remediation strategies*

Mining activities in Botswana have posed significant environmental challenges, notably acid mine drainage (AMD) resulting from sulfide ore processing at the BCL copper-nickel mine tailings. This generates AMD seepage characterized by low pH and high concentrations of dissolved toxic metals such as Fe, Ni, Cu, Pb, Zn, and Mn. The elevated concentration of heavy metals, particularly nickel, in the surrounding environment, groundwater, and nearby river underscores the challenge of remediating nickel contamination from tailings seepage. Thus, understanding nickel's behavior from acidic mine seepage is crucial for developing sustainable recovery and remediation strategies. The study aims to investigate the mechanisms controlling the natural attenuation processes of nickel from tailings seepage during rainy and dry seasons, informing geochemical passive treatment strategies. Objectives include determining the chemistry and behavior of toxic elements (Ni) from tailings seepage to the nearby river system in different seasons, understanding the release and mobility of toxic metals from the tailings, and elucidating the seasonal dynamics of nickel's natural attenuation from the tailings. Field surveys were conducted during both rainy and dry seasons, collecting tailings sediment, precipitate samples around the tailings, and sediment samples. Water samples were collected from the underground mine, tailings, and nearby river system. Heavy metal concentrations (Fe > Ni > Cu > Mn > Co > Pb > Ag > Cr) in the tailings seepage were notably high in both seasons, with higher values during the dry season. However, heavy metal concentrations exceeded the World Health Organization (WHO) and Botswana (BOBS) effluent standards in both seasons. In the dry season, heavy metal concentrations decreased post-treatment, except for nickel concentrations from the holding dam to the river, surpassing BOBS standards. Conversely, in the wet season, toxic metal concentrations, including nickel, fell below BOBS standards. Detailed analyses of tailing seepage, wastewater, river water, tailings sediments, precipitates, and river sediment furthered understanding of nickel's natural attenuation mechanism.

An Investigation into the Pretreatment Methods for the Extraction of Platinum (Pt) from Platinum Oxide Ores

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Keywords: *PGM (Platinum Group Metals); Oxidised PGM ores; Mineral Processing; Hydrometallurgy; Recovery*

Platinum (Pt) is known to be one of the rarest metals in the world.It's unique physical and catalytic properties make it largely valued across a number of various demand segments and technologies. The four main segments of Pt demand are automotive (30-40%), industrial (27-36)%, jewellery (23-30%) and investment ~10%. There has been a global Pt demand with automotive demand being on the highest rising to 16% in 2023 and predicted to grow in 2024. To meet the current rising demands, there has to be an increase in the production of platinum however, there has been a fast depletion of platinum group metals (PGMs) bearing sulphide ores which has activated interest in exploring the likelihood of the recovery of PGMs from near-surface oxidized PGM ores. In Zimbabwe and South Africa, there is an estimated resource of over 500MT of PGM oxides that is either unmined, mined, stockpiled or discarded as overburdened waste. The recovery of these PGMs has shown to be difficult to process by conventional means as an alternative source to sustain the production of PGMs. Several attempts to process the oxidized ores via conventional hydrometallurgical methods by concentrator plants in Zimbabwe and South Africa have been made, but these also yielded poor recoveries. The attempts saw some PGM values that fall within the floatable size range not being floated and successively reporting to the tailings. The poor recoveries are believed to be a result of the complex mineralogy of oxidized PGM ores as a result of the modification of the original pristine sulphide ores by weathering and oxidation. The product formed as a result of oxidation is hydrophilic iron (III) oxyhydroxide (FeOOH), which coats the base metal particle surfaces and renders them less responsive to sulphide flotation collectors. Attempts to process oxidized PGM ore have been made worldwide using different methods. This scrutinises the different hydrometallurgical methods previously used to process the oxidized PGM ores and their recoveries, the challenges encountered and the research gaps to be considered for future research. Recommendations for future research will also be given based on current research techniques in the mineral processing field.

Fundamental Study of the Influences of Discontinuities on Rock Slope Displacement Due to Excavation

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Keywords: *Mining; Numerical Simulation; Rock Slope; Discontinuities; Displacement Monitoring*

In open-pit mining, the stress at the foot of the rock slope increases as excavation deepens, heightening the risk of collapse. Monitoring displacement is crucial for predicting such collapses, with increases serving as early warning signs. At the Higashikagoshi limestone quarry in Minamifurano, Japan, where a previous collapse occurred, ongoing monitoring of rock slope deformation reveals forward movement. Despite this, the exact mechanisms behind the deformation are still not fully understood, necessitating further research to enhance mining safety.In this study, we investigated the impact of discontinuities' presence and dip angles on the slope deformation by numerical simulations since discontinuities including faults are found in the rock slope of the Higashi-Shikagoe quarry. As shown in Figure 1, we developed four distinct three-dimensional numerical models: a 'Continuum Model' with no discontinuities, three models incorporating a single, zero-thickness discontinuity with different angles— a 'Vertical Model' with vertically dipping discontinuity, an 'Inward Model' with inward-facing dipped discontinuity, and an 'Outward Model' with outward-facing dipped discontinuity. We simulated the displacement of the rock slope resulting from excavation within these models to assess and compare the impact of each discontinuity on slope deformation.Our results showed that in the Continuum Model, upward (+z) and backward (+x) displacements increased at the slope as excavation progressed. However, in the vertical and Outward models, the increase in upward displacement at the slope above the discontinuity stopped, and forward (-x) displacement increased after the excavation level passed down the discontinuity. In the inward model, downward (-z) and forward displacements above the discontinuity increased after the excavation level passed down the discontinuity. These results indicate, that the rock slope above the discontinuity is likely to show forward deformation, which is similar to the field measurement in the Higashi-Shikagoe quarry suggesting that discontinuities play a crucial role in the actual field of the Higashishikagoe mine. Thus, we could qualitatively clarify the impact of the presence and dip angles of discontinuity on the deformation of the rock slope.

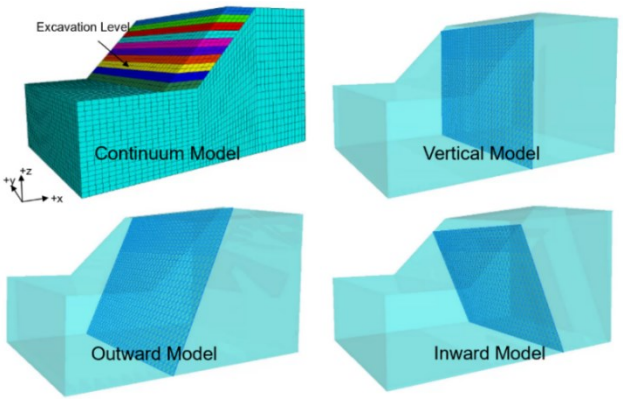

Fig.1: Three-Dimensional Mine Model

Silica and Polyphenol-Based Adsorbents of Heavy Metals Fabricated by Enzymes

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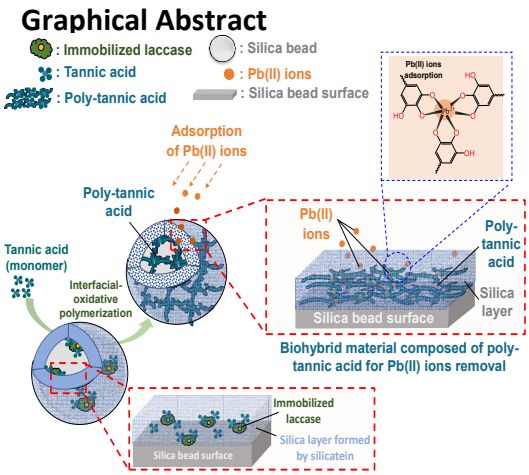
Keywords: *Bioremediation; Laccase-mediated polymerization; Poly-tannic acid; Silica-polymerizing enzyme; Surface immobilization*

Lead (Pb) contamination in water sources poses severe health risks to both humans and ecosystems. Conventional methods for Pb removal often rely on chemical treatments or expensive filtration systems, which can be economically burdensome and environmentally hazardous. In response to this pressing issue, this study presents a novel approach leveraging biologically inspired fabrication techniques by using enzymes for the development of an efficient and eco-friendly silica-based biosorbent incorporating poly-tannic acid for efficient Pb (II) ion removal from aqueous solutions. The process involves the biological immobilization of laccase enzyme on the bead's surface via a protective silica layer formed by the functional silica-polymerizing enzyme, silicatein. Silica beads were chosen as the support material for enzyme immobilization due to their favourable chemical and physical properties and natural compatibility with the silicatein enzyme. This innovative method prevents the immobilized enzyme from leaching and enhances laccase immobilization on the beads, ensuring the enzyme thermostability, and maintains its activity even under harsh conditions such as at an acidic-alkaline pH. Furthermore, poly-tannic acid was formed on the bead surface through oxidative polymerization mediated by immobilized laccase. Successful coverage of poly-tannic acid polymerized by laccase on the beads was confirmed by using SEM-EDS and FTIR spectra. The silicatein-treated biosorbent exhibited high laccase loading capacity and retained about 48% of its initial activity when tested under alkaline conditions. Additionally, it showed a remarkable enhancement compared to the biosorbent treated without silicatein in activity across varying temperatures which indicated favourable thermostability properties. The silicatein-treated biosorbent revealed its effectiveness in removing Pb(II) ions from aqueous solutions with a maximum adsorption capacity of 52.4 mg/g, a threefold increase compared to that of the biosorbent without silicatein. This silica-based biohybrid material presents advantages over conventional methods, including higher adsorption capacity and enhanced stability, offering a promising environmentally friendly solution for heavy metal bioremediation in water sources.

Graphical Abstract



Experimental and Numerical Analysis of Dynamic Fracture Processes in Rock and Rock-like Materials Using NRC Vapor Pressure Agent

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Keywords: *Nonex rock cracker(NRC); Vapor pressure crushing agent; Polymethyl methacrylate (PMMA); Granite; Fracture process of rock; 3-D combined finite-discrete element method (FDEM)*

In the field of rock blasting, controlling rock fracturing, vibration, and noise is crucial for safety, environmental considerations, and economic efficiency. Recently, a vapor pressure crushing agent, the Nonex Rock Cracker (NRC), has been applied in urban areas, effectively controlling these aspects while maintaining rock fragmentation efficiency. This study explores the fracture characteristics of rocks and rock-like materials subjected to NRC, which generates vapor pressure by instantaneously vaporizing a crystallized water mixture through the thermite reaction. Lab-scale tests on a Polymethyl methacrylate (PMMA) block, a transparent artificial brittle material, have been first performed by employing high-speed cameras and dynamic pressure gauges to capture vapor pressure generation and measure pressure-time history. These tests demonstrate that main crack propagation in PMMA is driven by gas pressure infiltrating pre-existing cracks rather than dynamic loading along the borehole surface. The PMMA block fracturing into two halves, displays a simpler pattern compared to typical blasting fractures. Subsequent fracturing tests conducted on granite rock blocks using NRC also demonstrate that the blocks split into two halves, each exhibiting a smooth fracture surface similar to those observed in the PMMA block tests. Finally, to clarify the mechanism of rock fracturing by the vapor pressure of the NRC, a three-dimensional (3-D) numerical simulation tool specializing in the fracture process of rock based on a 3-D combined finite-discrete element method (FDEM) is utilized. The equivalent rock fracture test by the vapor pressure of NRC has been modeled using the numerical simulation tool. The vapor pressure applied to the rock specimen is also modeled based on the overpressure-time curve measured from the PMMA test because the overpressure-time curve cannot be obtained in the rock fracture test. The numerical simulation result presents a fracture pattern similar to the experimental results. It is concluded that developing numerical tools may further apply to design rock fracturing of rock mass or rock structure when a rock-crushing agent similar to the NRC is applied.

Prediction of Overbreak Phenomenon in Tunnel Blasting Using ORF Index

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Excessive excavation areas known as overbreak are recognized during tunnel excavation using the drill & blast method. Overbreak causes an increase in project costs and a decrease in work efficiency. It is one of the factors that hinder the smooth development of tunnels. The occurrence of overbreak is a significant problem in tunnelling site activity all around the world. Reducing this phenomenon and establishing optimal blasting designs are urgent tasks. In recent years, automation of excavation work and simplification of measuring various parameters have advanced. It has led to expectations for cost-cutting blasting systems that can adapt to various sites. While the factors influencing overbreak are still unclear, the geological conditions of the tunnelling site are believed to be influential. Therefore, a system is needed to predict overbreak occurrence and clarify the impact of geological parameters on overbreak. The Overbreak Resistance Factor (ORF) is an index proposed for predicting and evaluating the occurrence of overbreak. In this study, a new dataset of geological parameters and overbreak occurrence data was collected to create a chart using the ORF index. This chart was developed by predicting overbreak occurrences and evaluating the influence of each parameter. In addition to the geological evaluation data used in Japanese mountain tunnels, the angle of fractures relative to the contour was evaluated from images of the tunnel face. This data is used in input data. A 3DCG model of each face was created using Structure from Motion (SfM), a type of 3D photogrammetric model, which is based on images taken in the tunnel. Using this model, the amount of overbreak is measured by calculating the distance between point clouds and the collected data. A predictive model for overbreak was developed using Artificial Neural Network (ANN) based on the collected geological and overbreak data. The model achieved an R-value of 0.75 or higher. The relationship between overbreak and each parameter became clear through the sensitivity analysis, enabling the creation of the ORF chart. This chart allows visualization of the amount and trends of overbreak occurrence at each tunnel face, potentially aiding in the optimization of blasting design.

Development of a Numerical Simulation Method for Complex Fracture Process of Rocks Based on 3-D ECZM-FDEM using GPGPU Parallel Computation

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In the realm of rock engineering, which includes surface/underground mine development, and construction of surface/underground rock structure, numerical simulation is regarded as a highly crucial approach for designing operational sites and processes as well as evaluating safety and feasibility. The combined finite-discrete element method (FDEM) has attracted significant attention for reasonably simulating very complex fracture processes of rocks based on the cohesive zone model (CZM) by utilizing initially zero-thickness cohesive elements (CEs). The FDEM based on the intrinsic CZM (ICZM), which inserts the CEs at the onset of the simulation, has been the mainstream of previous studies applying FDEM due to its simpler implementation. Although the FDEM is generally known as a computationally expensive numerical method for both two-dimensional (2D) and three-dimensional (3D) problems, the acceleration of the ICZM-based FDEM can be achieved with relative ease through parallel computation using General-Purpose Graphics Processing Units (GPGPUs). However, the accuracy of continuous deformation when rock is intact is significantly compromised in the ICZM. The FDEM based on the extrinsic CZM (ECZM), which activates CEs only when and where the local stress reaches the given activation criteria, is expected to overcome this issue. However, although the implementation of 2-D ECZM-based FDEM with the GPGPU parallel computation has been reported, its 3-D GPGPU-based implementation has not been achieved. This paper proposes a novel master-slave algorithm to achieve the implementation of the GPGPU-parallelized 3-D ECZM-based FDEM. This paper briefly introduces the developed algorithm of the proposed GPGPU-parallelized 3-D ECZM-based FDEM, and the verification and validation of the developed code are presented through rock mechanics problems under quasi-static and dynamic loading scenarios. Furthermore, the precision of continuous deformation could be enhanced when our results are compared to those of the parallelized ICZM-based FDEM, and computational performance also shows improvement in certain instances. The proposed approach could be an important basis for the further developments of the ECZM-based 3-D FDEM for simulating rock fracturing in the various rock engineering problems.

Enhancing CO_2 Mineralisation in Steel Slag with Amines for Developing a Waste to Construction Material

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Global warming has become an urgent issue due to the increasing atmospheric emission of CO2. In Japan, the steel industry emits a large amount of CO_2 and produces steel slag as an alkaline waste product. Using this steel slag to absorb CO_2 in flue gas is an effective approach for CO_2 emissions and recycling. This study introduces a novel technology utilizing amines to facilitate CO_2 sequestration in blast furnace slag. This innovative approach demonstrates significant potential and flexibility compared to conventional CO_2 capture technologies. In this study, changes in the carbonation efficiency of slag with three types of amines (N-Methyldiethanolamine(MDEA), 2-(Methylamino)ethanol(MAE), 2-Amino-2-methyl-1-propanol(AMP)) were investigated. In addition, this study examined the effect of Portland cement on the carbonation efficiency. In wet carbonation, the CO_2 fixation process entails the introduction of 1 mol/L of amine, water, slag, and cement, followed by a 24-hour leaching process and subsequent 24-hour carbonation. The results showed that adding AMP and cement exhibited the most significant increase in carbonation efficiency, resulting in the formation of 11.07% of the solid weight as $CaCO_3$, as confirmed by thermogravimetric analysis (TGA). Changes in calcium ion concentration and pH were also investigated in this study. The results showed that a small amount of Ca^{2+} dissolution and an increase in pH occurred in the early stages of the reaction and that the majority of Ca^{2+} dissolution occurred simultaneously with carbonation. In dry carbonation, slag cement paste, made by mixing amine, slag, and cement, was carbonated for 28 days after a 28-day curing period to determine changes in its properties. W/S ratio is 10, slag/cement ratio is 19, amine concentration is 1 mol/L, and CO_2 concentration is 0%, 0.04%, 5%, and 15%. Strength tests showed an increase in strength in the slag cement paste with the addition of MDEA.