ISERME 2021

International Symposium on Earth Resources Management & Environment

10th December 2021

ABSTRACTS

Organized by
Department of Earth Resources Engineering
University of Moratuwa
Sri Lanka

ISERME 2021

International Symposium on

Earth Resources Management & Environment

10th December 2021, Colombo, Sri Lanka

Organised by

Department of Earth Resources Engineering

Faculty of Engineering

University of Moratuwa

Sri Lanka

Message from Dr. G.V.I. Samaradivakara - Symposium Chair

Welcome to the fifth International Symposium on Earth Resources Management and Environment [ISERME 2021], organised by the Department of Earth Resources Engineering, University of Moratuwa, Sri Lanka.

The research culture of the department revolutionary changed sixteen years back, and in year 2005 with the implementation of World Bank funded project for Improving Relevance and Quality of Undergraduate Education [IRQUE]. We are grateful to the "IRQUE" Project for encouraging and funding the department to organise the first annual research conference in year 2006, which eventually evolved up to an International Symposium in year 2017.

Since 2016, the department has been networking with the international Mining Engineers and Earth Scientists in organising this symposium, annually.

In the past year, we had scheduled to hold this symposium in Hokkaido, Japan, based on the collaboration that we have with Hokkaido University, Japan. However, as Hokkaido was affected by the spreading virus at that time, we had to change our plans. We look forward to having our symposium jointly with them and in Japan also, in the coming years, once the circumstances will back to normal.

On behalf of the Department of Earth Resources Engineering, I wish to extend my sincere thanks to Professor N.D. Gunawardena, Vice-Chancellor of the University of Moratuwa and Professor N.K. Wickramarachchi, Dean-Faculty of Engineering of the University of Moratuwa for granting their kind permissions to hold the inauguration of this year's symposium in the hybrid-mode at the University of Moratuwa.

I greatly appreciate Professor Ajith De Alwis, Dean-Faculty of Graduate Studies of the University of Moratuwa for providing Boardroom facilities of the Faculty, for hosting the inauguration of the symposium in hybrid-mode.

The external reviewers of the symposium are commended for their timely given insightful reviews. Thanks are also extended to all the authors for their excellent submissions made to this symposium.

I'm certain that this symposium will continue to network with more researchers in the fields of Mining and Earth Resources Engineering, in the coming years.

I wish you all, a productive and enjoyable Symposium!

Dr. G.V.I. Samaradivakara - Symposium Chair - ISERME 2021
Head - Department of Earth Resources Engineering, University of Moratuwa
02nd December 2020

Message from Dr. (Mrs.) A.B.N. Dassanayake - Symposium Secretary

On behalf of the Organizing Committee and as the coordinator of the symposium, I would like to warmly welcome your participation in the 5th International Symposium on Earth Resources Management and Environment organised by the Department of Earth Resources Engineering, University of Moratuwa, Sri Lanka. As with the most scientific forums, in ISERME 2021 we have to move to a virtual format due to the challenging times with the COVID-19 pandemic situation.

The event with the theme of "Earth Resources Management and Environment" brings together many academics, students, industry leaders, alumni, and well-wishers and is graced by Prof. P.K.S. Mahanama, Deputy Vice-Chancellor, University of Moratuwa as the Chief Guest, and Dr. Manoj Verman, a well-known Tunneling and Rock Engineering Expert and the President of International Commission on "Hard Rock Excavation" as the keynote speaker. This event creates an international forum for academics, researchers, industry leaders, professionals, and alumni to come together sharing the latest findings, and have constructive discussions across a broad range of disciplines related to Mining and Earth Resources Engineering. The event also seeks to network with a large number of organisations and individuals at national and international levels.

I wish to express our special recognition to our sponsors and supporting institutions for their financial support and dedication. I sincerely thank the organising committee and technical program committees for their contribution toward ISERME 2021 and all the academic and non-academic staff members of the Department of Earth Resources Engineering for effectively fulfilling the individual tasks undertaken to make the event a success.

We would like to express our deepest appreciation to the authors whose technical contributions are presented in these proceedings. We have been able to prepare this proceeding, because of their excellent contribution made and hard work.

Dr. (Mrs.) A.B.N. Dassanayake
Senior Lecturer – Symposium Secretary
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Keynote Address

Challenges of Tunnelling

Dr. Manoj Verman
Tunnelling & Rock Engineering Expert
President, International Commission on "Hard Rock Excavation"
President, Indian National Group of ISRM

These are exciting times for infrastructure growth. With the focus on development in several developing countries, we in the infrastructure sector are hoping for a great future, and tunnelling is one of the most promising areas.

Tunnelling has become a vast subject, encompassing a wide variety of topics within its realm. It is a surprise that, despite its vastness and its significant relevance to civil engineering, this subject is hardly taught at the graduate and post-graduate levels. The world is looking at a substantial shortage of engineers skilled at various aspects of tunnelling. This presentation is an attempt to create a spark in the minds of the youngsters to take up tunnelling as a career while, at the same time, to introduce the uninitiated into the exciting world of tunnelling - both in the difficult terrain of the mountains, and in the tricky conditions of an urban setting.

While keeping the above objectives in mind, the presentation will meander through a range of topics associated with tunnelling – from the basic philosophy to planning to design to construction and so on. Some interesting yet fiddly aspects of tunnelling will be particularly highlighted, and a few case histories will be included to drive the point home. Besides the technical aspects, some non-technical aspects of tunnelling would also be covered.

While it is simply not possible, in a short time, to dwell upon all the challenges that this exhilarating subject throws, an attempt will be made to give the participants a strong flavour of the exciting world of tunnelling.

Session I

Mining and Geomechanics

An Exploratory Factor Analysis on Issues and Constraints in Sri Lankan Aggregate Quarry Industry

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Mining activities are influenced by stakeholders such as regulators, operators, service providers, customers, residents, and other interest groups. The governing bodies seem to fail to adopt a stakeholder inclusive approach to gain the balance between the interest of the stakeholders and the organisational plans and revenues. Such issues are known at the surface level, but no solid quantitative approach has been used to scientifically prove their existence and associations. Thus, this study aims to find the issues with statistical evidence. Convenient sampling was used due to time restrictions and new work norms to pick a substantial number of respondents. A numerical assignment and logical ordering to qualitative data were done to perform the quantitative analysis. Factor analysis was used to find the principal components and the variables which mainly loaded the components showed significant interpretable correlations. The most significant factors associated with issues in quarry operations and management are found in terms of quality, reliability, and usage of monitoring, application of safety measures, quarry type based hazardous conditions, planning and maintaining quarry activities, combatting drilling issues via site planning, use of initiation technique by quarry type, the impact of environmental and social issues, handling public complaints and strategies to improve quarry operations.

Keywords: Correlations, Principal components

Numerical Analysis of Effects of Clay on a Cut Rock Slope Deformation at an Open-pit Limestone Mine, Japan

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Rock slope instability is one of the major challenges of rock engineering projects, including open-pit mining. In this regard, rock slope deformation due to excavation, change in temperature, and influence of rainfall and snowfall have been previously investigated to understand characteristics and causes of slope deformation observed at an open-pit limestone quarry in Japan. The results only revealed characteristics of the deformation as forward and downward displacement of the cut rock slope, but its causes were not clarified. To deduce the causes of the rock slope deformation, we employed the 2-dimensional finite element method (2-D FEM) to investigate the deterioration effect of clay found at the footwall of the rock slope in terms of reduction in Young's modulus of the clay based on experimental results. Firstly, change in distances was analysed from displacement data measured by the automated polar system (APS) over five years, which decreases gradually with time. Secondly, the simulation results were discussed and then compared with the measured displacement data, which shows similar tendencies at the middle and top of the rock slope revealing maximum displacement at the middle of the rock slope. Conclusively, deterioration of clay at the footwall of the rock slope is one of the possible causes of the deformation in the quarry.

Keywords: 2-D FEM, Deterioration effects, Rock slope deformation, Stability assessment, Young's modulus

A Role of Information Technology in Geotechnical and Mining Engineering for the Past, Present, and Future

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In this paper, the development of information technology is divided into three parts: 1975-2000 (past), 2000-2025 (present), and beyond 2025 (future). During the last century, mainframes were considered topmost in terms of processing power. However, with the evolution of personal computers and laptops, computational power has increased in an exponential manner, and at the same time cost of hardware has dropped substantially. Various tech giants are famous for their specific products, such as Microsoft for their MS Office, Oracle for databases, routers from CISCO, and SAP for ERP. In the mining industry, information technology has always been used as a supportive role in various functions such as exploration, drilling and blasting, production and quality monitoring, financial accounting, inventory management, and dispatch of the minerals. The computer science department or information technology department has become crucial to support all functions in geotechnical and mining engineering. Various exploratory and mine planning software such as Surpac and Data Mine are commonly used for exploration and short to long-term mine planning. With the increase in processing power, even the mobile phone has become a powerful and essential device for communication. With enhanced power of the camera and increased data storage, internet connectivity, several useful applications are developed on mobile phones. Various OEMs have their own software for monitoring mining equipment which has benefited mining companies. In the future, artificial intelligence and machine learning models shall be applied in a geotechnical mining operation to improve productivity, safety, and sustained mining operation.

Keywords: Artificial intelligence, Drilling and blasting, Information technology, Machine learning, Mine planning software

Applicability of Tunnel Muck as an Alternative for Fine Aggregates in Cement Concrete

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One of the recent applications of Tunnel boring Machines (TBM) in Sri Lanka is Uma Oya Multipurpose Development Project (UOMDP). During rainy periods, the washed tunnel muck particles sediment in low agricultural lands forming infertile soil. It mainly affects the agricultural sector in the respective area of the country. Therefore, it appears that there is a need to study the reuse of the tunnel muck as an alternative for sand which is a very expensive construction material these days, or any other field as a useful material in an effective manner. The objective of this study is to determine the applicability of tunnel muck as an alternative for sand in concrete as fine aggregate. The material properties of tunnel muck were analysed. Water absorption and workability were higher in the concrete mixed with tunnel muck because the tunnel muck particles are finer than normal sand particles. It was observed that there was a slight decrease in the compressive strength of the concrete casted with tunnel muck. However, the compressive strength could be increased with higher cement content in the concrete. Furthermore, the mix designs with adjusted values were proposed for the concrete mixed with tunnel muck as fine aggregates.

Keywords: Mix designs, River sand, Tunnel boring machine

Correlations between Durability, Mineralogy and Strength Properties of Limestone

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Durability is used to depict the obstruction of rock to weathering and the pace of events of such changes. Wetting and drying cycles cause evaluation of physical changes and slaking behaviour of rocks, and that can be appraised by the slake durability test. Correlations between durability, mineralogy, and other physical-mechanical properties are different with the rock. Physical and mechanical characteristics of High-grade limestone samples and Low-grade limestone samples from the Aruwakkalu mine were determined according to ASTM standard methods. X-ray diffractometer (XRD) analysis and scanning electron microscope (SEM) analysis were used to determine the mineralogical contents of the studied samples. Regression analyses were performed between the slake durability index and the physical-mechanical properties of limestones to identify the best wetting and drying cycle to assess the relationships. Differences between the physical, mechanical properties, and mineralogical contents of High-grade limestone and Low-grade limestone were also identified from the laboratory test results. Finally, this study will help to understand any rock engineering problem relating to durability, mineralogy, and other physical-mechanical properties of areas with limestone.

Keywords: Limestone, Regression analysis, SEM analysis, Slake durability, XRD analysis

Critical Evaluation of Industrial Mineral Mining Methods in Sri Lanka

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Sri Lanka is rich in industrial minerals, including graphite, apatite, ilmenite, rutile, quartz, feldspar, kaolin, apatite, garnet sand, mica, calcite, and dolomite. Even though lots of mining methods are used to extract such minerals, only limited studies have been carried out in Sri Lanka to evaluate mining methods by means of main mining principles, such as safety, economy, and efficiency. This study focuses on the Bogala graphite mine, a narrow vein medium depth underground mine, and Aruwakkalu limestone open pit mine. To evaluate the overhand cut and fill mining method in Bogala mine, Equivalent Linear Overbreak or Slough (ELOS), which is a useful measurement for quantifying the unplanned dilution in narrow vein mining, is used. The favourability of the underground mining method is evaluated for a particular mine site using Key Deposit Indicators (KDIs), and it provides the best suited underground mine based on characteristics of the ore body. The fracture system presence in the Bogala mine requires a good support system to ensure the safety of underground workers. The efficiency of the loading and hauling equipment in the Aruwakkalu mine site is evaluated by Match Factor (MF).

Keywords: ELOS, KDI, Limestone, Match factor, Narrow vein, RMR

Session II

Mining Industry and Mine Safety

Mine Safety Issues in Quarry Industry: Case Studies of Recent Fatal Accidents in Sri Lanka

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Sri Lankan metal quarries supply almost all grades of aggregates throughout the country for the construction industry. But the future of these metal quarries may look bleak owing to the rise in the number of mine accidents being reported. The Geological Survey and Mines Bureau (GSMB) is the main regulatory body that regulates the mineral industry, issues licenses to almost all quarries in Sri Lanka. When considering the industrial mining licenses, there are four types of mining licenses, i.e., type-A, type-B, type-C, and type-D, issued by the GSMB. Of the four types of categories, the multi borehole blasting method can be adopted for type-A and type-B category mining licenses, while the single borehole blasting method is adopted for the type C and type D categories. Of the two types of initiation methods majority of cases with regard to accidents being reported from the single borehole blasting method. But they were not properly documented earlier. However, with the dawn of the Mining Safety Unit, these cases were documented. Of the cases being documented, five cases, i.e., fatalities, occurred due to fly rock, falling to a lower level, collapsing rock overhang on to the people who work underneath it, burning of explosives, and unintentional blasting due to lightning were described in this paper for risk assessment. When these cases are analysed, it is observed that among the contributory factors, excessive face height and human negligence are the most predominant factors for these incidents. At the end, it is mentioned that how this method is unsafe and proposed a multi-hole blasting method under the guidance of a suitable person.

Keywords: Aggregate quarries, Mine accidents, Mine safety

A Study of Underground and Surface Mining Methods in Sri Lanka and its Suitability Assessment

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The demand for minerals is rapidly increasing with industrialisation, urbanisation, and population growth. Sri Lanka has the potential to penetrate the world market with its endowed rich base of minerals despite its small land area. However, selecting a suitable mining method and its optimum utilisation have significant roles in the growth of the local mineral mining industry. The lack of systematic approaches in mining methods is suboptimal for the economic growth of Sri Lanka, which demands immediate investigation and reassessment of contemporary mining practices. Thus, this study aims to critique the major mining practices and evaluate their suitability through characteristics and numerical analysis. This investigation was performed for underground mining methods: cut and fill stoping and open stoping; surface mining methods: open pit, and mechanised open cast placer mining with reference to Bogala graphite mine, Kahatagaha graphite mine, Aruwakkalu limestone mine, and Pulmoddai minerals sand deposit, respectively. A detailed study complying with the principles of the grounded theory was conducted through a multimethod approach, comprising semi-structured interviews, participant and non-participant observations, followed by a thematic and content analysis along with the deductive approach. Moreover, the suitability of these methods was evaluated employing the University of British Columbia method through a numerical approach. This study reveals that the existing mining methods are appropriate for all four mines, and mining practices are modernised and traditional, complying with site-specific requirements.

Keywords: Cut and fill stoping, Mining methods, Open-pit, Open stoping, Placer mining

Development of Mathematical Model to Decide the Optimal Graphite Product Mix to Enhance the Profit

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Sri Lanka is the only country in the world known to extract and produce commercially viable quantities of natural crystalline vein graphite. Currently, Bogala graphite mines and Kahatagaha graphite mine are famous underground mines and the largest natural graphite producers, which supply natural vein graphite in the form of various product categories to the international graphite market. Out of that two major mines, Bogala graphite mines extracts approximately 350 metric tons of natural graphite per month. When it comes to extracted graphite from underground (run of mine), the raw graphite consists of various carbon contents in the form of lumps, chips, and powder. Such graphite is subjected to hand sorting or mechanical separation before it is used for further processing to produce various product categories as requested by local or international customers. During the graphite processing stage, it is a real dilemma to decide that with available graphite in raw form in which carbon content varying from 80% to 99%, to produce saleable product to which customer orders with a view to getting maximum profit out of various pricing for various saleable graphite products that Bogala graphite mine produces. So, it is worth finding out which product mix gives the highest monthly revenue utilising its limited monthly underground mine production and limited machine capacities. The problem addressed here is to determine the product mix (combination of sales package) to be adopted by the company for selling her graphite products at which the optimal profit level would be attained.

Keywords: Carbon, Crystalline vein graphite, Processing, Run of mine, Underground

Evaluation of Ventilation Network through Hybrid Analytical-Numerical Approach in Underground Working Block

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The mine environment is complex and highly dynamic due to the developments over time and surrounding climatic changes, which urge the necessity for a frequent and comprehensive assessment of its ventilation network. Heedlessness to supply adequate quantity and quality of air will catalyse short and long-term ailments to the workers. Therefore, this study emerges as the new research frontier in incorporating software-assisted numerical simulation with analytical computations to evaluate the adequacy of the ventilation requirements in a Sri Lankan mine. This investigation assesses the existing ventilation parameters at the Bogala underground graphite mine for the propriety of the working environment. The uttermost bottom block between 240 and 275 fathoms (FM) levels was examined as it contains a higher number of workplaces and significant air recirculation. The parameters were obtained through the in-field ventilation survey. Measured air quantity, psychometry, and air quality values were analysed and fed to the computer-simulated model. Moreover, the re-entry time for a development drive at 275 FM level was estimated using the throwback method. Adequacy assessment unveils that all the parameters besides air quality are inadequate at most stations for optimal mine conditions to attain maximum efficiency. Furthermore, the re-entry time after the development blast at the selected drive is meager and necessitates re-calculation for each blast. Moreover, it is apparent that stale air mixing and air recirculation are extant at 240 FM and 275 FM levels, respectively. Thus, mine ventilation at Bogala needs to be optimised, admitting workers' health, safety and comfort, and productivity of the mine.

Keywords: Adequacy assessment, Mine safety, Mine ventilation, Re-entry time, Throwback method, Ventsim

Determination of Depleted Rock Volume in Open Cast Mines Using Photogrammetric Techniques for the Purpose of Royalty Calculation

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In Sri Lanka, Geological Survey and Mines Bureau (GSMB) imposed royalty levy for aggregate production volume using an equation (indirect method) which utilises the quantity of explosives for the calculation. Since the equation resulted in higher deviations and the previous studies emphasise the advantages of photogrammetric 3-dimensional (3D) modelling (direct method) when determining production volume of bench blast, the present study focus on investigating its applicability to irregular faced dynamic quarry with uneven overburden. Pre and post 3D Digital Surface Models (DSMs) of the quarry were generated using the structure from motion (SFM) algorithm with Real-Time Kinematic (RTK) positioning system and Pix4D mapper software. Golden Software Surfer 16 was used to determine depleted rock volume as the difference between pre and post 3D DSMs. Results indicate a 5.50% deviation of the proposed method from true depleted rock volume determined by truck measurements due to uncleaned quarry face during the pre-Drone survey and unaccounted soil overburden removal. Presence of overburden while generating DSMs can be overcome by pile volume estimation of overburden and decreasing it from depleted rock volume when calculating production volume. GSMB equation calculated production deviate -32% from true production due to the unaccounted explosive amounts which contributed to the production and confirm the suitability of the proposed direct method (5.5% deviation) for determining the depleted rock volume in open-cast mines.

Keywords: Digital surface model, Drones, Pix4D, Real-Time Kinematic positioning

Session III

Environmental Engineering

Decision Tree Regression Approach for Detecting Spatiotemporal Changes of Vegetation Cover in Surface Water Bodies

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Surface water bodies in urban areas, such as Bolgoda lake, show complex vegetation dynamics, typically noticeable by the fluctuating vegetation cover throughout the year. Primary factors governing these fluctuations include wastewater discharge, anthropogenic activities (e.g., surface mining), invasive plant growth, and climate change. It is exceptionally challenging to physically measure and monitor these dynamics over the spatial extent of these waterbodies consistently over many years. Recent studies have explored the potentials of employing satellite imagery to quantitatively detect spatiotemporal changes of surface water vegetation cover. Such attempts have utilised vegetation detection indices, such as the normalised vegetation index (NDVI), to classify the vegetation cover with significant statistical accuracy. However, these conventional geospatial analyses require substantial computational power. They are limited to small timescales and spatial extents. This study employs the computational power of the google earth engine to address this limitation. Moreover, it integrates a machine learning classification approach, namely decision tree regression, to monitor the vegetation cover change over coarser and finer temporal resolutions using Landsat 8 hyperspectral imagery. Initially, NDVI classification was performed on 390 Landsat 8 images acquired throughout 2013-2021. Five locations, which represent different vegetation cover characteristics on the lake, were selected to generate the time series of the NDVI classified values. The results show that the vegetation cover varies at two temporal frequencies. The annual variation of the water, vegetation, and non-vegetation classes are undetectable. However, vegetation dynamics fluctuate rapidly at a finer temporal resolution (i.e., on monthly cycles). The statistically significant results claimed in this study will be further explored to support policymakers in optimising environmental resource management strategies and prioritising eco-preservation that can enhance the health and productivity of urban surface water bodies.

Keywords: Google Earth Engine, Decision Tree Regression, Invasive plants, Surface water bodies

Assessment of the Effect of Aruwakkalu Waste Dump on Surrounding Water Resources

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In developing countries like Sri Lanka, waste management is a vital necessity. Solid waste dumps play a major role in handling waste in most countries. These solid waste dumps can cause severe environmental pollution via leachate generation and transport of toxic material along with both surface and underground water flows. The Aruwakkalu waste dump, which is the subject of the study, is a sanitary landfill situated in Puttalam district, Sri Lanka. The landfill is planned to receive and store municipal solid waste (MSW) from Colombo metropolitan area. Locations for these waste dumps must be selected strategically to minimise the risk of contamination of the surrounding environment. A distributed hydrological model was used to determine the effect of rainfall, evapotranspiration, and surface runoff on the site. It identified the direction of the water flow through the waste dump. The analyses have illustrated that the area receives lesser rainfall and a higher rate of evapotranspiration. The hydrological analysis illustrates the water flow direction from the waste dump to the outside is towards the West and away from the nearby settlement areas. The results were used to assess the effect of the waste dumpsite on the surrounding water resources.

Keywords: Evapotranspiration, Flow direction, Hydrology, Landfill, Rainfall

Characterisation of Coal Fly Ash for Potential Wastewater Treatment Opportunities

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Lakvijaya coal power plant, which is in Norochcholai, Puttalam District, Sri Lanka, is the largest coal power plant in Sri Lanka. It annually produces about 150,000 tonnes of fly ash (FA) as waste, and the management of it is a pressing concern. Various studies have been conducted to valorise FA in a useful manner without simply dumping it into the nearby lands. To this end, we propose the utilisation of FA in wastewater treatments to adsorb heavy metal ions in wastewater to promote environmental sustainability. The direct application of FA for that purpose may be questionable due to the contaminants present in the FA; however, it is reported commercially. Therefore, we attempt to initiate a pre-processed preparation route to ensure the leachate contains fewer contaminants compared to the use of raw FA. Washing is a commonly used preliminary pre-processing step, though it is not studied extensively in the literature with reference to the FA. Herein, we aimed to study the effects of the number of washing cycles and temperature on the characteristics of the FA. With the results, we could conclude that washing is an effective means of pre-processing to alleviate the contaminants of FA, *en route* for wastewater treatment.

Keywords: Preliminary separation, Washing cycles, Particle size distribution

Remote Sensing and GIS Approach to Assess Landform Changes in Kaduwela Divisional Secretariat Area and its Impacts to the Environment

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Land use/land cover (LULC) change plays one of the major key roles in environmental impacts, and it is common to all nations. Monitoring this LULC change together with quantifications of environmental changes is an important concept in the Sustainable Development process. Therefore, remote sensing and geographic information system technique (RS & GIS) was used to exploit the variation of the LULC pattern, and satellite images of five years between 1997 and 2019 were used in this research. LULC changes in the Kaduwela Divisional Secretariat area were analysed using the Maximum likelihood supervised classification method and found that there was a significant decrease in vegetation cover due to rapid urbanisation. To assess landform changes and their impacts on the environment, normalised difference vegetation index (NDVI), normalised difference built-up index (NDBI), and land surface temperature (LST) were used. Further, relationships in-between them were used to analyse the correlations between NDVI and LST, NDBI and LST, and NDVI and NDBI, and it was noticed that negative, positive, and negative correlations respectively among them. It indicates that healthy vegetation can decrease the land surface temperature, whereas built-up will enhance land surface temperature. More than 70% of overall accuracy for LULC classification was able to achieve in this study.

Keywords: LST, LULC, NDBI, NDVI, Supervised classification

Water Hyacinth (*Eichornia crassipes*) as a Phytoremediation Agent for Heavy Metal Removal in Acid Mine Drainages Generated from the Urban Mining of e-Wastes: A Bibliometric Review

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Generation of Acid Mine Drainage (AMD) is a problem that is associated with the urban mining of e-waste. Raised acidic conditions resulting from AMD discharge into the surrounding environments and cause toxic heavy metals (HMs) to dissolve, transport, and accumulate in the aquatic environments. Since the elevating concentrations of heavy metals due to AMD discharge exceed the threshold limits, beyond which the health of the living organisms is compromised, remediation of AMD has proven to be taken into consideration. Out of many strategies, passive treatment techniques can be mentioned as the newest approach to remediation AMD. Remediation methods for AMD can be divided into two categories, and they are active systems and passive systems. When comparing these two methods, active systems accrue more financial costs than passive treatments. More than 50 studies have focused on constructed wetland systems under passive technologies since it is self-sustaining once established, and they are cheaper than active treatment systems. The use of several aquatic plants such as water hyacinth, water lettuce, and water cabbage for the remediation process is of significance in constructed wetland systems. This study reviews the experimental findings on HM removal under several conditions using water hyacinth plants in different studies that have been done previously.

Keywords: Acid mine drainage, Heavy metal, Phytoremediation, Urban mining

Assessment of Rehabilitation Options for Environmental Impacts of Abandoned Mines

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The quarries which are abandoned ceasing operations without a proper closure plan cause negative impacts on the environment and also risk for the health and safety of society and the economy. This research focused on the environmental aspects that are affected by abandoned quarries and a sustainable methodology to design future land use. The objective of this research is to introduce a quarry rehabilitation method that is effective and has a positive impact on the environment, and applicable for abandoned quarries in Sri Lanka. In this respect, the district of Colombo has been chosen due to its importance in social and economic aspects. The research was conducted by identifying abandoned quarries through remote sensing and geographic information system technique (RS & GIS) analysis of satellite images of the concerned area. Prioritised two quarries among identified quarries for further analysis and suggested possible rehabilitation options. According to the land use analysis around the two quarries, the better rehabilitation option is to transform the lands into a vegetation area.

Keywords: Colombo district, Land use, Quarry rehabilitation, RS & GIS, Sri Lanka

Session IV

Mineral Exploration, Subsurface Exploration, and Mineral Processing

Hydrometallurgical Approach to Investigate the Recovery Potential of Gold Available in Waste PCBs

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Gold is one of the highly demanded precious metals which have applications in jewellery, investment, electronic and medical industries due to its unique chemical and physical characteristics. Although the demand for gold is continuously increasing, gold producers have failed to meet the existing demand for gold through gold mining. Therefore, seeking out secondary sources of gold is vital. Since gold is one of the major metals used in the electronic industry, e-waste has enormous potential as a secondary source of gold. This study outlines the recovery potential of gold and several other valuable metals quantitatively in Printed Circuit Board (PCB) components of end-of-life computers, namely, microprocessors and Integrated Circuits (ICs), plated connectors in network cards, and plated metallic pins. The research workflow consists of a sample pre-processing and an acid leaching (digestion) process followed by a sample analysis process using an Inductively Coupled Plasma - Mass Spectrometer (ICP-MS). According to the results, the recovery potential of gold is significant in every e-waste component tested under this study.

Keywords: Acid leaching, E-waste, Gold, Metals, Printed circuit boards, Urban mining

Exploration for Potential Sources of Rare Earth Elements in Sri Lanka

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The global demand for rare earth elements (REEs) has been skyrocketing lately due to their excessive usage in numerous high-technologies. Therefore, the current study explores the REE potential in different geological formations of Sri Lanka. Accordingly, REE geochemistry and mineralogy of granites at Massenna (n=10), Arangala (n=6), and Thonigala (n=16); Eppawala phosphate deposit (EPD) (n=20); Ratthota pegmatite (n=6); southwest beach placers (n=18); and Walave alluvial placers (n=20) were analysed by the Inductively-Coupled-Plasma Mass-Spectrometer (ICP-MS) and X-ray Diffractometer (XRD), respectively. Based on the results, only EPD (2676.0-6486.3 mg/kg), Arangala (1634.9-4031.6 mg/kg), and Massenna (65.3-2153.4 mg/kg) showed high total REE (TREE) contents, and they contained REE minerals, such as apatite, monazite, rinkite, mosandrite, and eudialyte. Currently, carbonatites and ion-adsorption clays are the dominant REE sources in the world, and commercial REE extractions are only focused on the minerals: bastnaesite, monazite, and xenotime. In this context, the EPD is the most potential REE source in Sri Lanka (0.46% REO), especially for light rare earth elements considering not only its high TREE content but also the carbonatitic origin and the mineralisation of apatite and monazite. However, the EPD should be further explored for mineralogy, composition, and impurities to assess its viability as a future REE source in Sri Lanka.

Keywords: Eppawala phosphate deposit, Geochemistry, Rare earth exploration, Rare earth mineralogy

Investigation of Rare Earth Elements Potential in Iron Ore Deposits in Sri Lanka

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Sri Lankan geological terrain is mainly comprised of three different types of Iron ore deposits, which are not in the scale for economic extraction. When we consider the iron deposits on a global scale, most of them are associated with high concentrations of rare earth elements (REE). This research is focused on investigating the potential for REEs of the Sri Lankan iron ore deposits. Three major iron ore deposits of different genesis were selected for sampling, and collected samples were subjected to inductively coupled plasma mass spectrometry (ICP-MS) analysis. Analysis revealed a high potential for REE in Panirendawa and Buttala deposits, while Dela deposits showed the least potential. Although high concentrations were shown in a few samples collected from magnetite deposits, it also contains high variation within a few (10–100) meter distances. This variation was due to different degrees of weathering and transportation of iron ore materials. The highest REE potential was associated with the heavily weathered and transported material rather than the fresh iron ore. If the explored potential for REEs are consistent with the associated geological profile of these iron ore bodies, they could present mineable REE source for Sri Lanka

Keywords: Chondrite normalisation, Hydrated iron ore, ICP-MS analysis, Magnetite

Value Addition of Sri Lankan Dark Spinels through a Heat Treatment Technique

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Ruby, Sapphire, and Emerald are the gem varieties that come under the precious gem category. Therefore, they have a high economic value in the global gem market. Semi-precious gem types are already gaining significant commercial importance in the worldwide gem trade. Gem quality Spinels has a high demand as a semi-precious gem variety. Sri Lanka is very famous for gem-quality Spinels, but apart from that, a high quantity of low gem-quality dark Spinels are found in Sri Lankan gem fields. Currently, the Sri Lankan gem industry is facing the challenge of enhancing the clarity and transparency of dark spinel using heat treatment techniques. Therefore, this study focused on whether the Sri Lankan dark Spinels can be lightened through heat treatment and to develop a heat treatment technique for clarity enhancement of dark Spinels. Spinel samples were analysed to find the content of d block transitional elements which are responsible for the formation of colours in crystals. X-ray fluorescence spectroscopy was used to provide information about the chemical composition and trace element content of Spinel samples. The samples were heat-treated in oxidising and reducing conditions at a temperature ranging from 600° C to 1800° C for 1 hour to 6 hours using the Lakmini gas furnace to find the critical temperature at which Spinels change their current state of transparency. Chemical analysis has proved the dark Spinels primarily consist of high Fe and Zn content. Some rare elements, such as Pt, are also found apart from 3d transitional elements. The critical temperature at which Spinels enhance their clarity was around 1050° C. Prominent clarity enhancement was observed in samples that contained a high percentage of 3d transitional elements such as Mn, Cr, and Cu. The results of this research proved that dark spinel could be value-added by heat treatment.

Keywords: Clarity enhancement, Dark Spinels, Heat treatment, Semi-precious gems, Value addition

Investigation of Rare Earth Element Potential in Granitic Rocks of Sri Lanka Special Reference to Thonigala Granite

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Rare earth elements include lanthanide series elements plus Sc and Y. These 17 elements are characterised by the European Union (EU) as critical raw materials with significant supply risk due to their broad of emerging technological applications. Due to this ever-increasing demand for rare earth element (REE) related products, new REE-bearing mineral deposits need to be identified and evaluated for the purpose of filling the supply scarcity in the world. Therefore, this research is focused on investigating REE potential in granitic rocks of Sri Lanka, with special reference to Thonigala granitic intrusions. Thonigala granite is enriched with REEs, relatively with high light REE (LREE) concentration. In the rock samples, the average total rare earth element (TREE), LREE, and heavy REE (HREE) concentrations were 328, 285, and 43.1 mg/kg, respectively. The corresponding sediment values were 619, 472, 147 mg/kg, respectively. The presence of REEs in both insitu rock and sediment samples indicated that significant weathering and erosion occurred in the area. Therefore, this research provides insights into REE potential in granitic rocks of Sri Lanka, focusing on Thonigala granite. More geochemical analysis followed by mineralogical and compositional analysis needs to be carried out for future benefit.

Keywords: Granite, ICP-MS analysis, Rare earth elements, Sri Lanka, Thonigala

Extraction of Rare Earths from Monazite in Pulmoddai Deposit

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Rear earth elements (REEs) have considerable demand in the world and higher market value due to various applications, emerging economies, and continuous depletion of rare earth (RE) metals. Monazite is a perfect source for REEs (61%) and consists of RE and Thorium Phosphate. The Phosphate component was removed by alkaline leaching using NaOH (80 W/V%) at 1800° C for 4 hours at 500 rpm. Thorium was removed by acid leaching using (60 W/V%) HCl at 90° C for 1hour at 500 rpm and 15% pulp density. The solvent extraction method was carried out to separate and purify RE-Oxides from other impurities. 50% Tributyl phosphate (TBP) in kerosene was used as an organic phase with available facilities, and an experiment was done for phase ratio 1 and phase ratio 2, for 3, 6, and 12 minutes of contact time. Inductively coupled plasma mass spectrometry (ICP-MS) analysis was done for elemental analysis. Most abundant REEs in Monazite were Cerium (39%), Lanthanum (20%), Neodymium (12%) and Praseodymium (4%). The main objective of this research was to identify an industrial-level efficient method for separating and purifying RE from Monazite. Economically viable industrial level extraction of REEs was obtained when the phase ratio equals one and 3 minutes contact time.

Keywords: Acid leaching, Alkaline leaching, Dephosphorization, Solvent extraction, Rear earth

Characterisation of Sediment Deposition of Bolgoda Lake using Acoustic and Sampling Methods

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Bolgoda Lake is one of the main water resources in the western province, which has two major basins explained as Bolgoda south and north lakes. Lake sedimentation is a serious dilemma for water scarcity, productivity, and flooding effect. So, identification of sediment characteristics is most critical. The attempt of this study is to identify the sedimentation pattern, sediment type, and mineral composition of the sediment from the data collected from core sampling, grab sampling, and the bathymetric data obtained from spot depth eco sounder that combines with Magellan 510. Hence, grain size distribution (GSD), scanning electron microscope (SEM), and bathymetric surveys were utilised to recognise sediment type, heavy metal composition, and sedimentation pattern, respectively. These analyses revealed that bottom sediment has poorly sorted, very fine skewed, physical characteristics have statistical distribution and discover the sediment type as sandy silt. Also, bathymetric analysis upholds the sedimentation pattern that accumulates sediment from the left bank to the right bank of the Bolgoda lake via the water column and to identify the sediment distribution along the lake bottom.

Keywords: Bathymetry, Grain size distribution, Kurtosis, Sedimentation, Skewness

Investigation of Bolgoda Lake to Establish a Ferry Service for University of Moratuwa

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Colombo is one of the major cities which has a high population density with a smaller number of transportation facilities over many years. Even though it has a good canal system, waterway transportation is not implemented for no reason. With the idea of establishing a ferry service from the University of Moratuwa to Panadura along the Bolgoda lake, our research was carried out to determine the main parameters relevant to the aim of the project. Prioritise factors considered are Bolgoda lake bathymetry, identification of restricted areas, highly sensitive areas, material type to be dredged, and possible locations for terminals. Initially, the research area was narrowed down from the boatyard of the University of Moratuwa to the Vijayarama temple. There are several ways to determine the bathymetry of a water body, and echo-sounding techniques were used in our research. Bathymetry of the region was determined with cut volume to be dredged to make the ferry path safe using "Hondex PS 7" echo sounder and Surfer software. "ArcGIS" software was utilised to generate maps, and "Slope W" software was used in analysing dredge slope and its stability. The research was carried out during the dry season, and the water level was indicated as 4.2 m on the gauge at the bridge.

Keywords: Bathymetry, Bolgoda lake, Echo sounding, Ferry

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