



# **6th UMaT Biennial International Mining and Mineral Conference**



## **Book of Abstracts**

**Theme**

**“Expanding the Frontiers  
of Mining Technology”**

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# **GEOMATIC AND GEOLOGICAL ENGINEERING**

## **Geospatial Assessment of Mine Sites in Plateau State, Nigeria**

A. Owolabi

### **Abstract**

The geospatial assessment of selected mine sites in Plateau State, Nigeria was carried out to assess the extent of environmental degradation and change in land use/cover (LULC) prompted by mineral exploitation. The terrain mapping was carried out using the Shuttle Radar Topographic Mission (SRTM) to determine the impact of mining activities on the landscape. The derived impact of mining on LULC between 1975 and 2014 was also determined. A time series analysis of Multi Spectra Scanner (MSS) satellite imagery of 1975, Thematic Manager (TM) of 1988, Enhanced Thematic Manager plus (ETM+) of 2001 and Operational Land Imager (OLI) of 2014 was carried out. Supervised classification of the aforementioned Landsat imageries into LULC was carried out using a hybrid manual and spectral based approach. The digital terrain map revealed that mining activity was concentrated around the central part of most of the mine locations. The edges of the study area had high land-terrain with steepness down their respective centres. The results show that out of the 1,523 sq.km landmass of the study area, the degraded area/land, built-up area, water bodies and exposed rock outcrop increased by 238.2 sq.km (15.68%), 71.4 sq.km (4.68%), 0.9 sq.km (0.06%) and 220.9 sq.km (14.5 %) respectively while arable farmland and forest reserve decreased by 430.8 sq.km (28.29%) and 100.6 sq.km (6.63%) respectively. Further research endeavour on the reclamation of the study area is recommended.

## **Identification of Permissible Landfill Sites at the District level: A Case Study in Tarkwa-Nsuaem Municipality of Ghana**

E. A. A. Kwesi, K. N. Asamoah, A. K. Mends and L. C. Hlorvor

### **Abstract**

Municipal solid waste (MSW) management continues to present formidable challenges for urban areas in Ghana and other developing countries. One such challenge is the acquisition or provision of sites for landfill development as suitable alternatives to help solve the environmental pollution and health hazards that emanate from open dumping at inappropriate locations. This paper presents the steps and results of a GIS-based site selection method that explicitly accounts for groundwater vulnerability in addition to meeting existing regulatory requirements and policy guidelines by EPA and Municipal Authorities. A case study approach is adopted with the Tarkwa Nsuaem Municipality as the study area. Equipment used include a desktop computer, ArcGIS and Microsoft Office Software, Google earth, GPS receiver and field cameras. With the waste management needs of the study area and the regulatory requirement as bases, the necessary data sets were gathered and organised into a spatial database suitable for site selection analysis. The factors considered include proximity to rivers, roads, railways, settlements, land-cover, slope, hydrogeology and groundwater. The ArcGIS, was vital for the preparation of the spatial database, processing models and the generation of criterion and output maps and other analytical steps and results. The analysis tools and methods used include buffering, overlays, raster-vector conversion, boolean algebra and "model-builder". Ground water vulnerability map was included as one of the main criteria to preclude areas of high

groundwater contamination risk from the candidate sites. The methods and final results which indicate both the prohibited and permissible sites are available to support improved waste disposal efforts in the study area. The paper recommends the method for use by waste management departments in TNMA and other similar areas and that groundwater vulnerability analysis should be included in the site selection process as demonstrated in this paper.

### **Supporting Waste Management and Sanitation at the District Level through Surveying and Mapping: Case Study in the Prestea-Huni Valley Municipality of Ghana**

E. A. A. Kwesi, C. Assencher, L. C. M. Kwofie and A. K. Mends

#### **Abstract**

Waste disposal and sanitation problems continue to present formidable challenges to waste managers, health officials, environmentalists and town planners in developing countries. This is especially true in the urban cities of Ghana, including the mining centers, where the collection of the large volumes of waste being generated, allocation and clearing of waste containers and the management of indiscriminate waste disposal at unsafe locations are still major problems to be solved. Only about 16% of the refuse generated daily are being collected by the municipal authorities, leaving a backlog of about 84% to pile up in the communities. The large volume of uncollected waste are being dumped sporadically at ecologically and hygienically unsafe, and inaccessible locations with adverse consequences on the environment, human health and socio-economic development. Even in the few areas where waste collection take place, the waste containers often stay overfilled for weeks without being emptied due to funding, inaccessibility and other problems. Furthermore, the inadequate waste collection and sanitation services are rendered to few privileged locations, leaving large areas, particularly those inhabited by the poor and the slums out. For effective analysis of these problems and the subsequent planning of intervention efforts to improve the situation, there is the need for spatial information on the locations and distributions of existing waste dumps and waste collection services as well as the related access routes and the existing sanitation conditions in the communities and where to allocate new sites or improve existing situations. One available avenue for handling these problems is the application of surveying and mapping, including the use of sanitation maps. This paper discusses aspects of the results of a survey and mapping project that was carried out to provide such supports for the Prestea-Hunivalley Municipality and how they may be applied for effective planning and improved management of the waste and sanitation problems in the area.

### **Preliminary Flood Vulnerability and Risk Mapping of Koforidua and its Environs using Integrated Multi-Parametric AHP and GIS**

A. Asante-Annor, E. Ansah and K. Acherefi

#### **Abstract**

Koforidua and its environs experiences flooding due to anthropogenic and natural causes. There is the need for better understanding of the spatial extent and demarcation of flood prone areas for effective management of flood risk in the municipality. This study aims at providing flood vulnerability and risk map of Koforidua and its environs for planning purposes. The Analytical Hierarchy Process (AHP) integrated into GIS has proven to be an

effective and cost-effective method. This paper integrated Remote Sensing Data, Geographic information System (GIS) and Analytical Hierarchy Process (AHP). This technique enabled the hydrological mapping of the study area. The study utilised six flooding causative factors that are relevant to the study area and their respective percentages; rainfall intensity (35 %), drainage density (9 %), elevation (9 %), slope (11 %), soil media (24 %), and land use (12 %). About 20% of the area is highly vulnerable to flooding, concentrated in North-western part of Koforidua and Asokore township. Other areas of Koforidua, Koforidua Ada, and Okorase are found in moderate flood risk zones of about 60% of the area. Low flood risk areas constitute about 20% of the study areas and includes towns such as Nyerede and Okorase. A consistency index (CI – 0.023) and the consistency ratio (CR – 0.018) obtained ascertain and confirms high accuracy for the flood vulnerability and risk assessment.

### **Mapping of Ground Water Vulnerability for Landfill Site Selection Assessment - Case Study in the Prestea-Huni Valley Municipality of Ghana**

E. A. A. Kwesi and K. N. Asamoah

#### **Abstract**

The potential of groundwater pollution is an important concern in the siting of municipal solid waste disposal facilities. This factor is however often ignored or not adequately catered for in the location of most landfilling (including open dumping) facilities in Ghana and other developing countries where the practice is common and constitutes the main method of waste disposal. This paper discusses and demonstrates the need for accounting for groundwater protection in more improved or comprehensive ways by using pollution potential vulnerability modelling and mapping in the selection of landfill sites. The Prestea-Huni-Valley Municipal Area (PHMA) of Ghana is selected as a case study area. Map overlaying, index-based DRASTIC modelling and other geospatial analysis were employed in a GIS to assess the intrinsic vulnerability and risk for groundwater contamination in the study area. Groundwater vulnerability map has been developed by incorporating the major geological and hydrogeological factors that control the movement and contamination of groundwater, using an overlay and indexed-based DRASTIC method with GIS. These factors were rated, weighted and overlaid to create a vulnerability map showing areas prone to groundwater contamination. The computed DRASTIC Index (DI) was categorized into five vulnerability classes; namely "Very Low", "Low", "Moderate" "High" and "Very High". Based on the vulnerability assessment results, landfill sites situated in the high and very high zones would have high potential of contaminating groundwater, whiles landfill sites situated in the medium- to- very low would have low to moderate potential of contaminating groundwater. It is recommended that this approach be integrated into landfill site selection analysis to help reduce the risk of groundwater pollution in the disposal of municipal waste.

### **Assessing the Impact of Illegal Mining in the Apamprama Forest Reserve of Ghana using Unmanned Aerial Vehicle (UAV)**

S. Mantey and E. K. Otoo

#### **Abstract**

Over the years, forest reserves have been encroached by illegal mining activities carried out by the local community members in together with foreigners with consequences on

the environment. The Government of Ghana (GoG) developed and subsequently implemented several developmental policy frameworks as part of the formalisation of illegal mining activities to reduce its impact on the environment. Therefore, assessing the impact of illegal mining activities on the Apamprama Forest Reserve is important in understanding the nature and cause of the impacts. In this study, UAV was used to acquire orthophotos in 2019 and Google Earth scenes of 2013 were used to estimate the impacts of illegal mining activities in the Apamprama Forest Reserve over a six year-period. An estimated total area of 645,426 ha of land has been mined and the forest cover decreased from 3 629,238 ha to 3 477,333 ha between 2013 and 2019. The study confirms that, UAV technology is vital for assessing the impact of illegal mining activities in our forest reserves. This study recommends that, the Forestry Commission (FC) should increase surveillance activities in and around the Apamprama forest to prevent illegal mining activities.

### **Determination of Drill-Cuttings Size Distribution and Rock Properties for Mechanical Breakage Performance Analysis**

B. Adebayo and V. A. Babatuyi

#### **Abstract**

Size distribution of blast-hole drill cuttings and rock properties were investigated to estimate mechanical breakage performance. Drill-cuttings were obtained from the blast-holes drilled and size distributions of the cuttings were determined. In addition, top-hole-hammer drill with button bit of 38 mm diameter was employed at two quarries for rock drilling. Rock samples from two operating quarries in Edo state, Nigeria were tested for Uniaxial Compressive Strength and Rebound Hardness using 1100 kN compression machine and Schmidt hammer respectively. The number of blast holes drilled, depth and duration were obtained; these data were used to evaluate average penetrate rate of drilling. Mineral composition was determined by method of modal analysis. The result of size distribution analyses of the blast-hole cuttings of the weight retained on 1700  $\mu\text{m}$ , 212  $\mu\text{m}$  and 75  $\mu\text{m}$  sieve sizes varied from 36 - 96 g, 36 - 65 g and 73 - 98 g respectively for Fanalou Quarry. The size distribution of the blast-hole cuttings of the weight retained on 1700  $\mu\text{m}$ , 212  $\mu\text{m}$  and 75  $\mu\text{m}$  sieve sizes varied from 16 - 80 g, 36 - 65 g and 70 - 96 g respectively for Golden Girl Quarry. Uniaxial Compressive Strength of selected rocks from Fanalou Quarry and Golden Girl Quarry were 44.39 MPa and 46.95 MPa, while the rebound hardness values were 34.7 and 39.7 respectively. The percentage of quartz, calcite and clay were 10%, 56%, 20% and 13%, 59%, 15% for Fanalou and Golden Girls respectively. The average penetration rates varied from 10.02 - 15.47 m/min and 10.36 - 15.77 m/min for both quarries at drilling length of 3,810 m and 3,429 m respectively. The breakage performance of the drill is likely to be better when drilling on rocks at Fanalou quarry and bit stalling that occurred at the two locations may be due to clay content of 15 % to 20% present in the rocks.

## **Product Marking and Conformity Assessment of Portland Cements on the Ghanaian Market**

J. S. Y. Kuma, M. Affam and E. N. Asare

### **Abstract**

Cement bound concrete materials and complementary fittings are requisite ingredients for all civil engineering works. In all these, Portland cement, a basic binding ingredient for the concrete work is the dominant binder. In Ghana there are various brands of cement on the market. Five major brand products currently in circulation include the *Ghana Cement* (GHACEM), *Western Diamond Cement* (DIAMOND), *CIMAF Cement*, *Dangote Cement* and *Supacem Cement*. Increased infrastructural development has placed high demand on cement consumption. Consequently, new products keep emerging in the market. Indeed, a standard measure to provide product marking and evaluations of conformity to standard *Class* thresholds are required for the desired specification, properties and the performance quality of the cement products. This research therefore sets to ascertain the strength quality of the five cement brands on the Ghanaian job market by checking their conformity to *C-30* and *C-40* standard compressive tests, using their 76.9-R and 42.5-R flagship brands. To achieve this, concrete cubes were moulded with fixed mix ratio of  $1:1\frac{1}{2}:3$  and  $1:1:2$  for *C-30* and *C-40* respectively. To achieve the desired strength conformity, the slump as well as the coarse and fine aggregate constituents were standardised. The results indicated that the cement brands despite parading same strength thresholds in the market, do not exhibit same strength build-up. There are significant variations in growth of compressive strength over time. It was observed also that conformance threshold within 28 days was not attained for a number of the brands. Indeed, not until 56 days or more some of the brands could not achieve their desired compressive strength thresholds.

## **Feasibility Study on the Suitability of Granite Outcrops for a Proposed Quarrying Operation at Kpoyipma Community, Kaduna, North-Western Nigeria**

L. K. Salati and J. T. Adeyemo

### **Abstract**

This study carried out a feasibility study to determine the suitability of granite outcrops located at Kpoyipma community in Kagarko Local Government Area of Kaduna State, Nigeria, for a proposed quarrying operation. In the study, geometric survey of the community was carried out to determine the lateral extents of the granite outcrops. Samples of granite collected from outcrops A and B were prepared and tested in the laboratory for the determination of their physical, mechanical and chemical properties that are required for determining the suitability of the granite rock for construction and engineering purposes. The results of the study showed that the values of all the parameters determined from the two outcrops (East and West) considered are within the specified ranges of the globally accepted standards. The results from the uniaxial compressive test with an average strength of 156.29 MPa indicated that the outcrops are very competent for aggregate production and can be used for any engineering purposes. The results of the point load test showed a tensile strength of 6.04 Mpa indicating that the outcrops are suitable and moderately brittle for massive quarrying operation. Petrographic/thin section results also indicated that outcrop A is a coarse grained granitic rock, while outcrop B is hornblende-biotite granite. The rocks are found to be hard granitic rock, suitable for use in monuments and ornaments when cut and polished as dimension stones and construction works. It was

estimated that the granite reserve of 150,102,190 tonnes is large enough for the establishment of a quarry in the area. Hence, the proposed quarrying operation in the area is considered feasible and suitable.

## **Streamlining Geotechnical Slope Reconciliation for Open Pits: A Slope Optimization and Recommendation Approach at Brockman 2 Operations in the Pilbara Region, Australia**

G. Owusu-Bempah

### **Abstract**

Geotechnical slope reconciliation is driven indirectly by legislative framework of most advanced jurisdictions to meet regulatory requirements, firstly on personnel safety and secondly mining production. This has also become organisational culture for some mining industries to promote and improve its own internal safety practices as well as ensuring economic recovery of out of design resources that could have been missed during design process to limited data and conservative slope design parameters. Over the years, many iron ore mine in the Pilbara region of Western Australia have acquired enough primary geotechnical data through numerous site investigations to characterise the geology, rock mass, geological structures as well as groundwater conditions. Geological information such as rock mass shear strength parameters of the Brockman Iron Formation (BIF) stratigraphy in Pilbara are known in different operations of generally having similar geologic origin. Generally, the geology of the BIF possesses common mechanical properties that could be used for ground characterisation and slope designs elsewhere within the Hamersley Province. However, capital expenditure for drilling for new data is increasing for new projects with similar geotechnical and geologic resembles to those mined over 50-year period. Mining companies today are reviewing the traditional ways of acquiring data for new projects by utilising bench progression mapping data for slope optimisation and geotechnical risk management to minimise capital cost through systems such as geotechnical slope reconciliation. Acquired bench face mapping combined with historic drilling data could be utilised for new projects without compromising on quality but has great potential for saving cost. This paper discusses the framework for geotechnical reconciliation for open pit practitioners adopted at Brockman 2 operations owned by Rio Tinto in Western Australia. The paper focuses on three areas and methodology used for two open pits in Brockman 2 operations namely the BS2 and Pit 7 pits. A successful reconciliation process for achieving additional ore recovery in Pit 7 and managing geotechnical risks associated with mining beyond planned depth in BS2 pits are discussed.

## **Economic Evaluation of the Kottraverchy Pit Deposit of Gold Fields Ghana Limited, Tarkwa Mine**

K. N. Asamoah, S. Al-Hassan and E. B. Fiadonu

### **Abstract**

Kottraverchy pit is one of the pits of Gold Fields Ghana Limited, Tarkwa Mine. The auriferous orebody at the pit consists of a succession of stacked tabular palaeoplacer units consisting of quartz pebble conglomerates. Operations at the pit has been halted since 2016, due to technical reasons. The mine intends to revisit the pit. For mining to resume at the Kottraverchy pit, the economic viability of the deposit must be determined per current economic and technical factors. The objective of this research work is to determine the economic viability



of the Kottraverchy pit deposit. A final pit design has been developed for the exploitation of the deposit using Geovia Whittle and Surpac software, under the given geotechnical and economic factors. The total tonnage from the final pit design was 4 669 685 t. A Life of Mine (LoM) schedule carried out in Alastri Tactical Scheduler predicted a mine life of 4 years. With a gold price of US\$ 1 200/oz. and minimum rate of return (MRR) of 9.8%, the project's net present value (NPV) is US\$ 8.31 M and the internal rate of return (IRR) is 28%. Consequently, it is concluded that the Kottraverchy gold project is economically viable. From the sensitivity analysis, it is inferred that the project will continue to be profitable until the gold price decreases beyond 8% or the operating cost increases more than 12%. It is recommended that Gold Fields Ghana Limited, Tarkwa mine, can resume mining at the Kottraverchy pit, as the project is economically viable with an NPV of US\$ 8.31 M and IRR of 28%.

### **Multivariate Statistical Evaluation of Geochemical Data of Badukrom Style Gold Mineralisation within the Base of the Tarkwaian**

K. P. Osei, C. Kusi-Manu, M. Affam and D. T. Kwapong

#### **Abstract**

The Kawere conglomerates at the base of the Tarkwaian Group in the Iduapriem block appear to show good prospect for hydrothermal gold mineralisation evidenced by major structures mapped from magnetic and AEM geophysical data. Detailed geological mapping and sampling at Badukrom target which lies within the Kawere rocks confirm the presence of multiple structures as well as quartz veins indicative of potential hydrothermal gold mineralisation. Follow up soil sampling conducted within the area revealed a strong anomalous trend from the southern portion. Two diamond drilled (DD) holes pushed to delineate the extent of the anomalous zones returned narrow veins of significant gold intersections. Twenty-five (25) samples of the Badukrom hydrothermal Au mineralisation intersects were sent to SGS for analysis to ascertain the optimum pathfinder element suite for the hydrothermal targets within the Iduapriem concession. A total of fifty-nine elements were analysed via ICP-MS and ICP-OES. Multivariate statistical evaluation was carried out on the results to understand the geochemical associations of Au and the other elements to aid future exploration programmes planned for the hydrothermal targets. Multivariate The analysis of the geochemical data using Pearson product-moment of correlation suggests a stronger positive correlation of gold with Iron, Antimony, Sulphur, Chromium, Vanadium respectively. However, the Spearman Rank correlation data indicates that, the optimum pathfinder elements for hydrothermal Au are: As, Sb and Te. A comparison of the two statistical technique shows that the Spearman rank assumes random variables thereby making it more efficient for major or trace element data and hence best technique for this work.

### **Probabilistic Analysis of Potential Slope Failure in a Typical Surface Coal Mine in Nigeria**

O. B. Akindele, B. M. Olaleye and I. A. Okewale

#### **Abstract**

The study investigates the probability of a potential rock slope failure in Okaba coal mine. The lithology of Okaba coal mine comprises of coal, laterite, and shale. The geomechanical

parameters (uniaxial compressive strength, shear strength, frictional angle, cohesion, young modulus and poisson's ratio) used in the assessment of the stability of the rock slopes were obtained from field and laboratory studies. In this research, finite element analysis method was used for three slope geometries. Phase<sup>2</sup> Rocscience software was used for simulation of all slope geometries. Model 1, 2 and 3 were analyzed according to the slope geometry for the mine. Strength reduction factor (SRF) of 1.33, 1.24 and 1.29 were obtained from finite element analysis respectively. The SRF value depicts the factor of safety of the mine slope and shows that the slope is safe due to high SRF value (greater than 1). Probability of the rock slope was then analyzed with  $3.6 \times 10^{-9}\%$ ,  $9.85 \times 10^{-5}\%$ , and  $2.22 \times 10^{-9}\%$  probability of failure respectively. It further revealed that the mine slope has low probability of failure because of its high SRF value.

## **INNOVATION IN MINING AND PETROLEUM TECHNOLOGY**

### **Hierarchical Mine Planning for a Semi-Mobile In-Pit Crushing and Conveying (IPCC) System Using Discrete-Event Simulation**

J. Villeneuve, E. Ben-Awuah and P. Vasquez-Coronado

#### **Abstract**

Semi-Mobile In-Pit Crushing and Conveying system is becoming more commonly used in open pit operations worldwide. The system allows the continuous transport of ore and waste from the pit to their respective destinations by moving the crushing process near or into the pit with the use of semi-mobile crushers and replacing the majority of the hauling cycle with conveyors. Mine planning for such a system involves different levels of decision-making depending on the time horizon under consideration. The primary objective of this study is to develop a discrete-event simulation model to link long-term predictive mine plans with short-term production schedules in the presence of uncertainty. This research presents a methodology that assesses the interaction and impact of operational delays and uncertainties on the mine plan based on decisions of extraction, conveying, processing, stockpiling, blending, and destination. This was done by considering operational delays and uncertainties and comparing the long-term strategic plan with the short-term tactical plan. The effects of operational delays and uncertainties influencing all components of the production system are evaluated. Arena Simulation Software was used to design, develop, and evaluate a discrete event simulation model representing the life of mine for a bauxite deposit.

### **Incorporating Grade Uncertainty in Oil Sands Mine Planning and Waste Management Optimization using Stochastic Mathematical Programming**

O. Mbadozie and E. Ben-Awuah

#### **Abstract**

The primary purpose of oil sands mine planning and waste management is to provide ore from the mine pit to the processing plant while containing the tailings in an efficient manner in-pit. Incorporating waste management in the mine plan is essential in maximizing the economic potential of the mineral resource and minimizing waste management cost. However, spatial variability such as grade uncertainty results in ore tonnage variations,

which leads to variations in the quantity of waste to be managed. If grade uncertainty is not considered in oil sands mine planning, there may be excess waste than the waste management plan can handle or an over-design of a waste management system to handle less waste than planned. Both scenarios end up with lost opportunities. Conventional approaches to optimizing open pit mine production schedules are based on a single estimated orebody model which does not account for grade uncertainty. Grade uncertainties has profound impact on Net Present Value (NPV) of the mining project as it may induce large differences between the actual and expected production targets. Thus, the aim of this research is to develop an integrated oil sands mine planning optimization framework using Stochastic Mixed Integer Linear Programming (SMILP) to integrate the related domains of bitumen grade uncertainty and waste management. Sequential Gaussian Simulation (SGS) is employed to quantitatively model the spatial variability of bitumen grade in the oil sands deposit. Multiple simulated orebody models are used as inputs for the SMILP model to generate optimal results in the presence of grade uncertainty.

### **Improving Shovel-Truck Productivity through Operational Efficiencies at Gold Fields Ghana Limited, Tarkwa Mine**

E. Apraku and V. A. Temeng

#### **Abstract**

Shovel-truck combination for loading and hauling operations remains the most widely used materials handling system in many surface mining operations worldwide, constituting 50-60% of mining operation costs. The ability to move more material (waste and ore) within a time frame, considering the available resources and constraints, has direct effect on productivity. Numerous challenges are often associated with the loading and hauling operations of the materials handling chain. These include but not limited to truck bunching, material spillages on haul roads, equipment mismatching, operator boredom and payload deficiencies. There have been many researches aimed at improving the shovel-truck materials handling chain but with little or no focus on the aforementioned challenges. This paper presents a research on the effects of truck bunching in haulage, material spillage on productivity and also to determine the effective shovel-truck matching for improving productivity. This was achieved using relevant records from the real time Fleet Management System (FMS) and time and motion studies data on Liebherr hydraulic excavators and Caterpillar/Komatsu rear dump trucks at Gold Fields Ghana Limited, Tarkwa Mine, a major gold producing company in the Tarkwa-Nsuaem Municipality of the Western Region, Ghana. Using time and motion studies, colour coding, field tests coupled with mathematical and statistical analysis, results showed that, the major cause of truck bunching is inadequate tonne kilometre per hour (TKPH) ratings of trucks' tyres contributing about 62%. The truck bunching accounted for a monthly production loss of 101 000 tonnes, which is equivalent to 1.3%. The production loss through material spillage during haulage was about 600 tonnes of ore and waste, over one month period, which was very low. The best pairings of shovels matching to trucks were also recommended.

## **Analytical and Numerical Modelling of Water Influx in Bottom Water Reservoir**

E. T. Brantson, I. C. Madubuike, N. I. Fuseini, M. E. Domeh and A. A. Amoah

### **Abstract**

Nearly all hydrocarbon reservoirs are surrounded by water-bearing rocks called aquifers. It should be appreciated that in reservoir engineering there are more uncertainties attached to this subject than to any other subject. Water influx models are mathematical models that help simulate and predict aquifer performance. In the quest to analyse the cumulative water influx in a bottom-water drive reservoir for an analytical and a numerical model, the following water influx models were used in both cases: Van Everdingen-Hurst model, Carter Tracy model and Fetkovich model. The analytical approach was computed using excel spreadsheet, while the numerical approach was achieved by using specific keywords in the ECLIPSE 100 software. The Van Everdingen model is not found in the ECLIPSE 100 software, therefore, the Carter Tracy model which is an approximation of Van Everdingen model, was used for the comparison since it can be modelled using the Eclipse software. After the cumulative water influx of all the models for both cases (analytical and numerical) were calculated, the numerical approach yielded more realistic field results because of the degree of heterogeneity of the parameters – porosity and permeability. For Carter Tracy model, the results obtained from the numerical and analytical approach after a production period of 720 days appeared to be identical. With the Fetkovich model, there was a considerable difference between the results from the two approaches after the same period of production of 720 days, but after 1460 days of production, the results of the two methods (analytical and numerical) became identical.

## **Numerical Simulation of Low Salinity Water Flooding in Carbonate Reservoirs**

E. T. Brantson, A. A. Amoah and N. I. Fuseini

### **Abstract**

Low-salinity water (LSW) flooding is one of the techniques that can be used to improve oil recovery and has gained a lot of attention these days because of its advantages over conventional water flooding and chemical flooding. An important factor to consider when planning a water flood operation is the pattern arrangement of the wells to be used. Even though many mechanisms have been recommended for extra oil recovery using LSW flooding process, the mechanism is not fully understood. As such, this work sought to analyze the potential of LSW flooding in improving oil recovery in carbonate reservoirs for secondary and tertiary recovery modes using the Computer Modelling Group (CMG-GEM). A field-scale three-dimensional reservoir model was developed using CMG's GEM compositional simulator. Simulations of 6 different patterns for both LSW and Seawater (SWI) were created using CMG's GEM to obtain the necessary recovery. These patterns were used over a 25-year period of development of the field. Results showed that the patterns flooded with LSW gave the best recoveries. The inverted 5-spot gave the highest recovery factor of 74.90%. The least performed pattern for the LSW flooding was the normal 9-spot with a recovery factor of 71.55%. Also, early water cut in the inverted 7-spot and inverted 9-spot LSW patterns was because of many producer wells used. The primary mechanism of LSW flooding was identified to be wettability alteration due to a change in surface charge. It was concluded that the use of LSW flooding with the inverted 5-spot flood pattern gives the best recovery.

## **Hybridization of Low Salinity Water Assisted Foam Flooding in Carbonate Reservoir for Enhanced Oil Recovery**

E. T. Brantson, H. Osei, J. Essuman, N. I. Fuseini and T. F. Appiah

### **Abstract**

Low salinity waterflooding (LSWF) and foam flooding are recent advances in enhanced oil recovery (EOR) technique where water of a lower salt concentration than the initial connate water and foam is injected into the reservoir respectively. Although a lot of laboratory experiments and tests have shown that LSWF's and Foam flooding have the potential in EOR, there have not been many numerical modelling studies done in this area. In this study, the main mechanisms in these two methods are investigated through simulations of a 3-dimensional synthetic reservoir model using ECLIPSE 100 software. The model is homogeneous with water, oil and gas phases. Standalone models for LSWF, foam and two hybridised models was first created. The first hybridised model was to depict low salinity water alternating foam (LSWAF), the second to represent the simultaneous injection of foam and low salinity water (SLSWF) and lastly selective SLSWF (using dual completion technique). It was an established mechanism that, foam used in the hybridised models prevented early water breakthrough. Results showed that the hybridized models led to a higher recovery efficiency and low water cuts than the standalone models. Also, the SLSWF model is considered the best method since it led to the highest recovery efficiency (58.58%), followed by the selective SLSWF with a recovery factor of 58.45% both having no water cuts.

## **Reservoir Compartmentalisation Study of the "X" Field of the Niger Delta, Nigeria**

B. Takyi, A. Selegah, Udom J. Godwin and K. E. Kouadio

### **Abstract**

Natural gases vary in chemical and isotopic composition as a function of their formation and migration history. Compositional and isotopic variations are often caused by the mixing of two or more compositionally and isotopically different gases. The variations of isotopic properties of gases within a continuous reservoir are generally small but can be significant between fault blocks, baffles of one reservoir, or between unconnected but closely stacked reservoirs. These variations can be utilized to help solve many problems occurring during gas field development and operation. The study aimed at evaluating the availability of flow barriers or compartments within the "X" Field of the Niger Delta. Natural gas samples from 13 producing wells were used for this study. The variations in the molecular and isotopic composition of the gases were used to achieve the aim of the study. The gas samples were heated to their sampling point temperatures and analysed by the Gas chromatographic technique for their molecular composition, using GPA 2286, as a standard test method. The isotopic signatures for methane, ethane, and propane were computed using regression formulas. The results indicate similar molecular and isotopic composition for 11 wells at different locations of the reservoir except for wells S1 and S7. The similarity in the molecular and isotopic composition of the natural gas for the 11 wells suggests that those wells are communicating but there exists a barrier to communication between those wells and wells S1 and S7. The studied natural gases from the "X" Field of the Niger Delta are genetically related and may have been generated by the same source rock. The difference in molecular and isotopic composition between the natural gases from

the 11 wells and wells S1 and S7 infers a baffle, preventing fluid flow between well S1, S7 and the remaining wells.

## **Predicting Oil Production Rate using Artificial Neural Network and Decline Curve Analytical Methods**

S. A. Marfo and C. Kporxah

### **Abstract**

In oil fields where direct measurement of oil production is not feasible, it is always a challenge to accurately predict the rate of production. In such circumstances, oil production rate is estimated through Decline Curve Analytical Methods and Empirical Correlations. In some cases, there may be significant errors inherent in the application of these methods producing inaccurate results. This study focused on predicting oil production rate using Levenberg-Marquardt back propagation algorithm to train the Back Propagation Artificial Neural Network (BPANN) and Decline Curve Analytical Methods (DCAMs). The study considered 1600 data sets, with 70% for training and the remaining 30% for testing. The input parameters used are gas production rate, tubing head pressure and flowing bottom-hole pressure, with crude oil production rate serving as the output. The developed BPANN model predicts oil production rate as a functions of gas rate, production time, flowing bottom-hole pressure and tubing head pressure. The accuracy of the developed BPANN model was compared with the DCAMs so as to determine the best method for predicting oil production rate. The BPANN and the DCAMs (that is Exponential, Harmonic and Hyperbolic) predicts oil production rates with mean absolute percentage errors of 3.18, 9.27, 11.55 and 14.01 respectively. Correlation coefficient of the models were 0.9966, 0.9577, 0.9391 and 0.9578 respectively. The BPANN model predicts oil production rate with higher accuracy as compared the Decline Curve Analytical Methods.

## **The Effects of Spent Synthetic Based-Mud on Terrestrial and Aquatic Lives**

R. Amorin, E. Broni-Bediako and P. Sasu

### **Abstract**

Synthetic Based Muds (SBMs) are the major based fluid used in drilling operations due to the increasing desire to reduce environmental impact of offshore drilling operations associated with conventional oil-based fluids. However, drilling waste generated from the use of synthetic based fluids may still be harmful to the environment if discharged without adequate treatment. Their effects on the environment depend on their toxicity level (Polycyclic Aromatic Hydrocarbon (PAHs)) which may affect terrestrial and aquatic lives. This study was conducted to evaluate the effects of spent hydrocarbon SBMs on the environment using catfish fingerlings, maize grains, cowpea seeds and earthworms as test cases. The catfish fingerlings were exposed to water contaminated with different concentrations of SBMs to determine its lethal effects for 96 hours. Cowpea, maize grains and earthworms were also exposed to soils contaminated with different concentrations of SBMs for 21 days and 96 hours respectively. The concentrations used were 5%, 10%, 15%, 20%, 25%, 30%, 35%, 40%, 45% and 50% mass/mass or vol/vol. The results revealed that higher concentrations of 30% to 50% of the SBMs were 50% and more lethal on the fingerlings. Also, soils containing traces of 5% and more of SBMs were unable to support good plant growth. Earthworms were unable to survive in soils contaminated

with 10% and more of the SBMs. Untreated hydrocarbon synthetic based fluids are therefore harmful to both aquatic and terrestrial lives and should therefore be very well treated before disposal.

### **Natural Gas Dehydration Process Simulation and Optimisation - A Case Study of Jubilee Field**

S. A. Marfo, P. Opoku Appau, C. Morkli and S. Issah

#### **Abstract**

Natural gas has become a popular energy source in recent years due to its environmental merit. The challenge associated with produced natural gas is saturated water vapour among other impurities. These must be removed by gas treatment processes to avert issues like corrosion, hydrate formation and other threats to process facilities. Employing Triethylene glycol (TEG), a dehydrating plant for natural gas from Jubilee Field was designed and simulated by Aspen HYSYS software. The model of the plant was used to ascertain the outcome of varying TEG flow rate, reboiler temperature and various stages of the packing column in the contactor on dry gas water content. The study revealed that a TEG flow rate of 0.5 m<sup>3</sup>/hr was sufficient to dehydrate a 240 MMSCFD from 37.98 lb/MMSCFD water content to 4.84 lb/MMSCF of water in the dry gas stream with 8 contacting stages at reboiler temperature of 204.4 °C.

### **Economic Need for Reviving Coal Mining Industry in Nigeria**

V. E. Chibuzo

#### **Abstract**

This was designed to analyse the economic need for reviving coal mining industry in Nigeria. Over years, coal mining in some countries has proved to be an essential condition for successful economic development. Other reports also have it that coal mining has boosted the social welfare in remote areas especially in developing countries. Relatedly, the high level and rate of unemployment especially among youths in Nigeria has necessitated immediate revival of solid mineral mining especially coal which has been neglected. Even though coal mining was a serious business in Nigeria some decades back, lack of long-term capital investments resulted to the long overdue neglect existing in coal mining business in Nigeria. Therefore, this paper had analytically reported the decayed state of coal mining business in Nigeria and has suggested possible strategies for reviving it.

### **Mining-Caused Unfriendly Ecological Effects in Nigeria**

H. A. Erebebe

#### **Abstract**

Mining has remained an industrial process of accessing and extracting all economically valuable minerals and similar geological materials from the earth surface. This has boosted the economy of countries that have mineral deposit for centuries. However, mining activities unavoidable disorganizes and destroys the ecosystems. Usually, these disturbances release harmful substances into the environment. Notably, some of the major disturbances occur in form of land degradation, water and atmospheric pollution, land tenure, noise and vibrations among others. These negative impacts of mining were reported-

ed to be more in underdeveloped and developing nations. The present paper focused on analyzing some mining triggered unfriendly ecological effects in Nigeria.

## **ADVANCES IN MINERALS EXTRACTION**

### **Sustaining the Minerals Industry of Ghana – A Challenge to Stakeholders**

R. K. Amankwah and R. S. Suglo

#### **Abstract**

The minerals industry in Ghana has been active for several centuries and within this period more emphasis has been placed on the traditional minerals like gold, bauxite, diamonds and manganese. About 98% of the traditional minerals produced in Ghana are exported in the primary state without any value addition. However, there are many other minerals that can be profitably mined and processed at the small and medium-scale levels, which are not receiving the needed official attention and remain undeveloped in many parts of Ghana. This paper discusses the numerous minerals available in Ghana and the challenges involved in their development and how stakeholders (i.e. policy makers, mineral engineers and the business community) can work together to develop them into useful products and thereby maximize the potential benefits of the sector such as job creation, enhancement of revenue generation, rural industrialisation and the sustenance of the minerals industry of Ghana.

### **Acoustic Monitoring of Mill Pulp Densities**

K. B. Owusu, J. Karageorgos, C. Greet, M. Zanin, W. Skinner and R. K. Asamoah

#### **Abstract**

Acoustic sensing measurement technique is of interest as an alternative tool for online monitoring of mill internal operation due to the mill hostile environment. In this paper, acoustic sensor has been utilised in a laboratory batch ball mill operation to investigate the effect of pulp density dynamics (50, 57, 61 and 67 wt. % solids). The results showed good acoustic response with changing mill pulp density. The mill product size distributions were statistically the same for the investigated pulp densities. While subtle differences occur between some selected pulp densities, sudden change in acoustic response occurs at certain pulp density thresholds. Acoustic sensor shows potential and promise for detecting mill internal events, monitoring ball mill pulp density dynamics, and controlling performance.

### **Variations in Mill Feed Characteristics and Acoustic Emissions**

K. B. Owusu, J. Karageorgos, C. Greet, M. Zanin, W. Skinner and R. K. Asamoah

#### **Abstract**

Ore variability such as grade, competence, and hardness is becoming increasingly pronounced in the mineral processing industries. The present study investigates the noise characteristics associated with two different types of ores grind characteristics as a function of changing grind time using the non-contact acoustic sensor. Particularly, iron and quartz ores were used for the study in a laboratory-based Magotteaux ball grinding



mill. The results suggest that the quartz ore grind characteristics are relatively different from iron ore with increasing grind time. An acoustic sensor offers a great opportunity and serves as a proxy tool to monitor and predict mill feed characteristics in real-time for mill stability and optimisation.

### **A Brief Review of Auriferous Sulphide Flotation Concentration: Pyrite and Arsenopyrite Mineral Separation**

P. Forson, M. Zanin, W. Skinner and R. Asamoah

#### **Abstract**

Pyrite, the most abundant sulphide mineral in the earth crust is mostly found in close association with arsenopyrite in most auriferous complex ore bodies. Previous studies on occurrence of gold in these sulphides has shown the preferential preconcentration of gold in arsenopyrite compared with pyrite. Notwithstanding, in the separation of gold bearing sulphides during froth flotation, a concentrate made up of both pyrite and arsenopyrite is obtained due to their similar characteristics and flotation response. Separation of gold predominated arsenopyrite minerals from less economical pyrite phase maximises downstream unit feed and improves financial performance of the operation. This paper briefly reviews attempts made thus far in exploiting subtle differences between pyrite and arsenopyrite for separation. The underlying reported flotation mechanism for both minerals is illustrated.

### **Ascertaining the Potential of Lead Mobilisation into the Geo-Environment by Spent Fire Assay Crucibles**

B. Koomson, W. Cudjoe and R. Nkrumah

#### **Abstract**

With continuous decline in high grade REE ores in Australia and globally, there is an increasing reliance on low grade ores and mining tailings. However, the potential to recover the REE minerals as by-products of primary commodities of host ores has gained significant interest as large volumes of such tailings are generated over a mine life. As a result of the complex low-grade nature and varying characteristics of REE minerals in ores, it is important to expand the knowledge of the chemical and mineralogical characteristics, prior to developing beneficiation protocols for REE. This paper reports on the chemical and mineralogical characteristics of a typical South Australian mining tailings for REE beneficiation. Inductively coupled plasma mass spectrometry (ICP-MS), X-ray diffraction (XRD), and Quantitative Evaluation of Minerals by Scanning Microscopy (QEMSCAN) were used to identify and characterise the REE and associated gangue minerals in the tailings. The results indicate that: (i) light REE (LREE) are more abundant than heavy REE (HREE); (ii) the REE-bearing minerals in the tailings are bastnäsite, monazite, stetindite, stillwellite, and florencite; and (iii) hematite/magnetite association, goethite/limonite association, and quartz are the major gangue phases in the tailings. Correlation analyses conducted on the chemical data was useful in predicting the relationship between the REE and non-REE phases although some limitations were encountered. Liberation analysis indicates that the REE minerals are generally unliberated, forming complex middling associations with the gangue minerals. A combination of the chemical and mineralogical analyses provides comprehensive and accurate information on the deportment of REE, as well as their associ-

ations with gangue minerals. The data obtained is useful in identifying potential methods for recovering the REE from the mine tailings.

### **Characterisation of Mining Tailings for the Beneficiation of Rare Earth Elements Minerals**

G. B. Abaka-Wood, J. Addai-Mensah and W. Skinner

#### **Abstract**

Presently, South Australia has significant amount of rare earth elements (REE) remaining in mining tailings generated from the extraction of primary commodities such as gold, copper, and uranium. As a result of the complex low-grade nature and varying characteristics of REE minerals in ores, it is important to expand the knowledge of the chemical and mineralogical characteristics, prior to developing beneficiation protocols for REE. This paper reports on the chemical and mineralogical characteristics of a typical South Australian mining tailings for REE beneficiation. Inductively coupled plasma mass spectrometry (ICP-MS) and Quantitative Evaluation of Minerals by Scanning Microscopy (QEMSCAN) were used to identify and characterise the REE and associated gangue minerals in the tailings. The results indicate that: (i) light REE (LREE) are more abundant than heavy REE (HREE); (ii) the REE-bearing minerals in the tailings are bastnäsite, monazite, stetindite, stillwellite, and florencite; and (iii) hematite/magnetite association, goethite/limonite association, and quartz are the major gangue minerals in the tailings. Correlation analysis conducted on the chemical data was useful in predicting the relationship between the REE and non-REE phases although some limitations were encountered. Liberation analysis indicates that the REE minerals are generally unliberated, forming complex middling associations with the gangue minerals. A combination of the chemical and mineralogical analyses provides comprehensive and accurate information on the deportment of REE, as well as their associations with gangue minerals. The data obtained is useful in identifying potential methods for recovering the REE from the mine tailings.

### **Decoupling the Effects of Pulp Potential and pH on the Flotation**

L. D. Ayedzi, P. Forson and G. Abaka-Wood

#### **Abstract**

Pulp pH and potential play important role in the flotation of pyrite. Control of pH determines surface species formed on the mineral whereas solution potential favours the oxidation of xanthate to dixanthogen for its flotation. Interesting, changes in pulp pH produces a corresponding change in potential, that is, increase in pH reduces pulp potential and vice versa. This study employs sodium hydrosulphite and sodium dithionite as potential control reagents to unravel the roles of Eh and pH on pyrite flotation. It was observed that, an increase in the potential of the pulp at high pH conditions resulted in pyrite depression whereas at low pulp pH, pyrite recovery was enhanced although the pulp potential was lowered below the reversible potential for the dixanthogen couple. At high pulp pH, the increased surface oxidation product coverage on pyrite would excel the hydrophobicity of adsorbed collector species, thus depressing the mineral in the process. Adsorption of collector as xanthate ion and sulphur from sodium hydrosulphite addition were responsible for the successful recovery of pyrite at low potential conditions.

## **Evaluation the Effectiveness of Combined Dissolved Air Flotation (DAF), Filtration and Activated Carbon Adsorption Processes in the Treatment of Oily Wastewater from Drilling Activities**

R. Amarin, E. A. Agorhom and F. K. Mensah

### **Abstract**

Treatment of drilling waste can be very ambitious depending on the type of waste treatment method and additives used during the fluid formulation. The success of a particular treatment method depends primarily on its ability to address the specific problems posed by the waste. This study evaluated the effectiveness of flotation process in the treatment of oily wastewater. The flotation experiments were carried out in a Denver flotation cell at a constant agitation speed of 600 rpm using different air flow rates of 2, 4, 6 and 8 L/min. The maximum flotation times for each of the air flow rates were also established. The flotation results showed that air flow rate has effect on the ultimate oil recovery, oil volume pull and the maximum flotation time. Air flow rate of 4 L/min recovered 130 ml of oil compared with 110, 110 and 120 ml for 2, 6 and 8 L/min, respectively. However, the flotation process used was not able to meet the EPA recommended oil retention of 10 mg/l for the waste water without further treatment for all the air flow rates. Simple filtration and activated carbon (0.25 g) adsorption of the wastewater produced after the flotation process at the 4 L/min air flow rate reduced the residual oil and grease content of 22.73 mg/l to 9.32 mg/l and 6.12 mg/l, respectively. Increasing the activated carbon concentration from 0.25 g to 0.5 g further reduced the oil and grease content to 4.05 mg/l. Again, addition of caustic solution to the wastewater raised the pH from 0.6 to 7.25. The flotation, filtration, adsorption and neutralisation processes make the wastewater environmentally safe for handling and disposal. A treatment option for an oily wastewater is proposed.

## **Effects of Entrained Biomass of *Phanerochaete Chrysosporium* on Carbon-In-Leach Operations**

A. Benson, P. C. O. Adu, S. B. Woeko and G. Ofori-Sarpong

### **Abstract**

Carbon-In-Leach (CIL) is one of the conventional methods employed in the hydrometallurgical recovery of gold from its ores, especially where the ore contains natural carbonaceous matter that pre-robots dissolved gold. CIL is also employed in the recovery of gold from refractory ores that have undergone oxidative pretreatment. Oxidative pretreatment may be achieved using fungi, which biotransforms carbonaceous matter to reduce its ability to pre-rob gold. Such biotreated materials may be entrained with fungal-biomass, which can affect the activity of activated carbon introduced purposefully to adsorb dissolved gold. Previous works using cell-free extracts of *Phanerochaete chrysosporium* to treat activated carbon reported a decrease in its ability to adsorb gold, and a general improvement in the adsorption process when the treated carbon was washed before it was contacted with standard gold solution. This paper presents the findings of a follow-up research, in which an oxide ore was contacted with cell-free extract of *P. chrysosporium* for 68 hours to mimic fungal-treated refractory gold ore. The as-received ore and fungal-treated ore were each leached with and without activated carbon to ascertain the effect of entrained fungal biomass on oxidised gold ores, and the rippling effect on activated carbon during the CIL process. This paper reports that, at the end of the 24-h

cyanidation process, the activated carbon in the as-received sample adsorbed an average of 20% more auro-cyanide than the activated carbon in the sample treated with the cell-free extract. In the absence of activated carbon, both the as-received sample and the treated sample recorded almost the same gold in solution. It can be concluded that transportation of fungal extracts into CIL operations can reduce the adsorption capacity of activated carbon, and such treated ores require proper water-washing prior to CIL.

### **Predicting the Extent of Preg-robbing based on the Maturity of Carbonaceous Gold Ores**

F. K. Darteh, A. Mamudu, A. Boateng and G. Ofori-Sarpong

#### **Abstract**

Sulphides and carbonaceous materials are among the major materials considered to cause refractoriness in the processing of gold ores. The presence of carbonaceous materials in gold ores is a source of worry to gold mining companies due to its ability to interact with and adsorb auro-cyanide complexes during cyanidation, with a consequent decrease in overall gold recovery, termed as preg-robbing. The degree of preg-robbing is reported to depend on the type of carbonaceous materials and the extent to which the precursors have undergone maturation. This paper builds on a previous research which investigated the degree of preg-robbing of different carbonaceous materials with standard gold solution. The present paper simulated carbonaceous gold ores by dosing varying percentages (0%, 1%, 2%, 3%) of various carbonaceous materials (woodchips, charcoal, activated carbon) into oxide ores and leaching the ores by cyanidation process. The results show that the ores with no carbonaceous materials had very high cyanidation recoveries (>90%), more than 10 folds with respect to the ores dosed with activated carbon. In general, the simulated carbonaceous ores recorded recoveries ranging from 10% to 90% lower than the control without carbonaceous inclusions. The wood chips which had the lowest maturity imposed the lowest degree of preg-robbing, and thus recorded the highest gold recovery after the control. The preg-robbing ability decreased in the order of activated carbon (88-100%), charcoal (64-86%) and wood chips (10-42%), which individually depended on the amount of carbonaceous material present. The results affirm a high degree of dependence of preg-robbing potential of carbonaceous gold ores on the degree of maturity of the resident carbonaceous materials.

### **Heavy Metal Distribution in Contaminated Oil – Based Mud from a Selected Oilfield in Ghana**

E. P. Amenyah Kove, W. K. Buah and O. K. Dankwa

#### **Abstract**

Heavy metals are one of the parameters that are considered during disposal of contaminated drilling mud. The oil and gas industry generates huge volumes of solid and liquid waste per well that require treatment prior to disposal. These could be drilling mud, drill cuttings, produced water etc. Heavy metals are toxic to both human and animal life forms and have therefore attracted widespread attention in relation to waste disposal. These metals are carcinogenic and teratogenic. Two drilling mud samples, INV and ENV, from an offshore oilfield in Ghana were analysed for the concentration of heavy metals in the solid and liquid phases. The solids were dried, digested and spectrophotometrically analysed

for six (6) heavy metals (Cadmium, Chromium, Lead, Copper, Zinc and Manganese). The results showed ENV recorded the highest concentrations of heavy metals in the liquid phase; Lead (39.78 mg/L), Manganese (19.37 mg/L), Zinc (4.82 mg/L), and Copper (4.54 mg/L) in that order which far exceeded regulatory limits by United States Environmental Protection Agency (USEPA). Heavy metals in the liquid phase of INV ranged between 3.45 mg/L (Manganese) and 4.70 mg/L (Lead) for samples that showed appreciable concentrations of heavy metals. Solid phase concentration was highest in both ENV and INV mud. Cadmium and Chromium concentrations were less than 0.002 mg/L in both solid and liquid phases of INV and ENV. There is a possibility that these spent muds will lead to increased levels of some of these heavy metals in aquatic environments. Therefore, disposal of these muds into offshore environments should be highly discouraged. Treatment to reduce contaminants to acceptable levels is required before disposal.

### **Gold Phytoextraction by *Alocasia Macrorrhizos* (Giant Taro): Implications in Phytomining**

A. K. Saim, R. Ntiri-Bekoh, H. Orleans-Boham and R. K. Amankwah

#### **Abstract**

Gold phytoextraction has over the years drawn much attention from various researchers as an alternative to conventional extraction methods to recover metals from low-grade ores or mineralised soils. Although various plants species have been employed to recover gold from mineralised soils, the literature is silent about the use of giant taro. Therefore, to examine the feasibility of gold phytoextraction from gold ore, laboratory scale experiments were carried out using *Alocasia macrorrhizos* (giant taro) without chemical inducement of the ore. Bioaccumulation (BAF) and Translocation Factors (TF) as well as gold accumulation by the plant in the roots, stem and leaf tissues were evaluated. BAF and TF were 13.65 and 1.46 respectively. This work has shown that *Alocasia macrorrhizos* demonstrates high ability to uptake and accumulate gold and it is efficient in translocation of gold to its above-ground tissues. Averagely, 14 mg/kg, 220 mg/kg and 10.7 mg/kg of gold were accumulated in the roots, stem and leaves respectively. In addition, dissolved gold across the setups after weeks 3 and 4 were 0.384 mg/L and 1.097 mg/L respectively. The results demonstrate that giant taro can solubilize and sorb gold and is a potential candidate for recovering gold from the tailings environment, low-grade stockpiles and heaps as well as mineralised soils in an eco-friendly and cost-effective approach.

### **Carbon Re-Adsorption of Gold from Eluate as an Alternative to Gold Electrowinning**

A. Intarmah, D. Amankwah, G. Ofori-Sarpong and R. K. Amankwah

#### **Abstract**

A number of metallurgical techniques have been adopted for the recovery of gold from eluate solution in the mining industry. Prominent among them is the electrowinning and fine zinc dust cementation techniques. However, due to its fast recovery and fine doré production, the electrowinning process has received much industrial application over the cementation process. The electrowinning process is facilitated via the application of current (electricity) to recover gold from eluate. A partial operating cost estimate of the electrowinning and smelting processes in gold recovery asserts that 73% of the operating cost is attributed to electricity used in the electrowinning stage. One of the business

improvement approach towards reducing operating cost is finding ways to cut down electricity cost. This paper thus assessed the possibility of economically recovering gold from eluate using carbon re-adsorption technique. This process, contrary to the conventional electrowinning and zinc cementation processes, is devoid of stimulators such as direct current (electricity) and fine zinc dust in respect of recovering gold from the eluate. After using fresh carbon to re-adsorb gold from the eluate, ashing the loaded carbon, and smelting the ash, the partial operating cost for recovering gold was estimated to be \$10,580, with the cost of fresh carbon accounting for more than 50%. The cost of recovering gold using electrowinning technique was, however, \$3,260. The estimated net revenues from the sales of gold using the carbon re-adsorption and electrowinning techniques were \$1,711,527 and \$1,638,951 respectively, with the difference stemming from corresponding purities of 92.9 % and 88.59%. A total of \$ 72,576 per week increase in revenue, representing about 4.24% profit margin was therefore realised from the carbon re-adsorption process. This paper shows promising results, which sets the platform for further investigation into decreasing the cost of re-adsorption by using less expensive carbon-base materials.

### **Bioremediation of Nitrates from Selected Water Bodies within the Tarkwa Nsuaem Municipality**

E. P. Kusi, V. Anni, G. Ofori-Sarpong and R. K. Amankwah

#### **Abstract**

Nitrate-containing compounds in the soil are generally soluble and readily migrate into surface and ground waters. Though they act as nutrients in soils, streams and rivers, excess concentration causes eutrophication, while oxidation of nitrites ( $\text{NO}_2^-$ ) to nitrates ( $\text{NO}_3^-$ ) in fresh water causes oxygen depletion in the water. Some water quality studies in the Tarkwa Nsuaem Municipality have reported high concentrations of nitrate, exceeding the WHO guideline value of 50 mg/L. This paper therefore set out to identify the potential sources of the nitrates and nitrites in the Tarkwa Municipality, and to stimulate a denitrifying environment using the bacteria, *Thiobacillus denitrificans*. This was achieved through field visits and water sampling from Bediabewu River and around an explosive manufacturing plant, followed by incubation with *T. denitrificans*. The sources of nitrates were identified as handling, manufacturing and use of explosive materials for mining activities, as ammonium nitrate is the major raw material in the explosives. The residue from explosive manufacturing plants flowed from active sumps with an average concentration of 22180 mg/L into nearby water bodies like the Bediabewu River, which had an average concentration of 380 mg/L. The bacteria required an adaptation period of 7 to 8 days, with denitrification activity observed on the 8th and 9th days of incubation. A batch treatment of standard and field samples resulted in about 90% denitrification within 8-9 days. The bacteria were active at a temperature range of 27 °C - 30 °C and pH values above 5. The results demonstrate the ability of *T. denitrificans* to denitrify nitrates in the environment. With further investigations, the bacteria can be adapted, in combination with phytoremediation, to treat excess process water from the manufacturing plants and through the discharge routes into the nearby water bodies.

## **Detoxification of Cyanide Waste Water using Sawdust and Charcoal Pieces**

A. Mamudu, F. K. Darteh, E. Tawiah and G. Ofori-Sarpong

### **Abstract**

Cyanide, halides, thiosulphate, thiourea, and thiocyanate are some of the lixivants used in the mining and metallurgical industries for gold and silver extraction from their ores. Cyanide remains the universal ligand for gold extraction because it is less costly as compared with the above-mentioned lixivants. However, cyanide is toxic to plants, animals, aquatic life and humans, and hence, waste cyanide solutions need to be detoxified before disposal. Sawdust and waste charcoal pieces contribute immensely to waste disposal problems in Ghana, and there are efforts to remove them from the environment. This paper assesses the use of sawdust and charcoal pieces in the detoxification of cyanide wastewater in a bid to solve a two-fold problem; waste and environmental problems. Different masses (0 g, 2 g, 5 g and 10 g) of as-received sawdust and charcoal pieces were contacted with different concentrations of standard cyanide solutions (50, 100, 200 ppm) for up to 24 hours. The control experiment, which had no carbonaceous material in 1 L of 100 ppm of cyanide solution, recorded 20% detoxification, ascribed to natural decomposition of cyanide. On the contrary, 90% and 82% detoxification of cyanide were achieved when 2 g of sawdust and charcoal pieces respectively were contacted with 1 L of 100 ppm cyanide solution for 24 hrs. In general, over the 24-hr contact time, the extent of detoxification was not influenced extensively by the mass of carbonaceous material used, and the rate of detoxification was higher with higher concentration of cyanide solution. Sawdust performed generally better than the charcoal pieces, and this was attributed to the finer particle sizes of the as-received sawdust (80%-150  $\mu\text{m}$ ) as against charcoal pieces (10%-150  $\mu\text{m}$ ), though the initial detoxification rate was higher with the charcoal pieces. The result opens avenues for further research in the two-fold clean-up of liquid and solid waste from the environment.

## **A Study of the Relative Impact of Particle Size Distribution on Gold Recovery**

N. Ofosuhenne and G. B. Abaka-Wood

### **Abstract**

With the continuous decline in high-grade gold ores in Ghana and globally, there is an increasing reliance on low-grade ores. Hence, over the past few decades, the processing of low-grade gold ores has gained significant attention in the mining industry and is associated with high plant throughput to meet production targets stipulated by stakeholders. Leaching is a major unit operation associated with gold ore processing, which is significantly affected by particle size distribution. This paper assesses the impact of changes in particle size distribution on gold recovery from a low-grade ore using sodium cyanide as a lixiviant. A gold oxide ore from a Ghanaian mining operation was used in this investigation. The ore was milled and prepared into feed sizes ranging from 50–90% passing 106  $\mu\text{m}$  and leached over 24 hours using conventional bottle roll test. The differing ore size fractions were leached individually in a well-mixed pulp (55 wt.%) at pH, ranging 10.5–11. In the bottle roll tests, the sodium cyanide concentration was maintained at 250 ppm at a room temperature. An Atomic Absorption Spectrometer (AAS) was used to characterize the leachate and residue samples obtained from the leaching tests. The present paper highlights that the changes in leach feed particle size has significant effect on gold recovery, suggesting that increasing plant throughput to compensate head grade decline requires subsequent review of leach feed particle size to meet operational targets.

## **Performance Assessment of Cycled Carbon at Gold Processing Plant: A Case Study Jopaf Goldfields Limited, Nkawkaw, Ghana**

J. Obiri-Yeboah, F. Larbi, K. Adjei and P. N. Sarpong

### **Abstract**

In this research, cycled carbon without regeneration performance has been assessed by means of batch cycled activated carbon adsorption test. The research work quantitatively established the adsorption strength of the plant carbon as activity values of 95.38% to 55.33% within the twelve month gold adsorption period, without regeneration. Also, the research pointed out that, the 146.2 to 307.9 ppm gold on barren carbon as call for reviewing the parameters of the elution process towards efficiency enhancement. The inverse functional relation dependency of solution losses on activity level carbon in process was revealed by the research. The approximately zero relationship between the activity of barren carbon and solid losses shown by this study authenticates fact that carbon adsorbs only gold in solution. For effective implementation, the study recommends further research works of tradeoff and financial appraisal assessment to be done on the use of regeneration Kiln in the Jopaf Mine Ghana limited, Processing Plant circuit. Statistically, at 95 % confidence limit, the error limit was 0.034(i.e. 3.4%) with the standard deviation was 12.80.

## **Effect of Collector Type and Blends on Mixed Pyrite and Arsenopyrite Flotation**

P. Forson, M. Zanin, W. Skinner and R. Asamoah

### **Abstract**

Sulphydryl collectors have received wide applications in sulphide value mineral flotation. Blends of this group of collectors have shown the existence of synergism in collecting action when utilized in flotation. In this study, sodium isobutyl xanthate and sodium alkyl dithiophosphates at different mixing ratios are employed in flotation. Results for single mineral flotation show that better flotation response was achieved for collector admixtures compared with singular uses. The highest recovery of 87.78% and 67.74% respectively for pyrite and arsenopyrite was achieved with a blend ratio of 20:80 SIBX to DTP.

## **Selecting Key Predictor Parameters for Regression Modelling using Modified Neighbourhood Component Analysis (NCA) Algorithm**

B. Amankwaa-Kyeremeh, C. Greet, M. Zanin, W. Skinner and R. K. Asamoah

### **Abstract**

Selecting the most useful features for the purpose of regression modelling is very critical in ensuring good prediction. In this research, modified Neighbourhood Component Analysis (NCA) Algorithm in MATLAB Simulink r2020a has been used as a feature selection criterion for selecting the most relevant parameters from 25 flotation feed elemental assays and operating parameters. Predictor parameters selected to be relevant for regression modelling included throughput, feed particle size, frother addition, xanthate addition and froth depth as confirmed in literature. This result is a clear indication that modified NCA Algorithm is a capable of selecting relevant features for the purpose of regression modelling.



## Predictability of Rougher Flotation Copper Recovery using Gaussian Process Regression Algorithm

B. Amankwaa-Kyeremeh, C. Greet, M. Zanin, W. Skinner and R. K. Asamoah

### Abstract

Complex nonlinear relationship existing among flotation parameters make it difficult to predict overall recovery using conventional techniques, leading to lower process efficacy for some complex ores. In recent years, machine learning algorithms are promising in predicting complex chemical system performance of which froth flotation is of no exception. In this paper, Gaussian Process Regression (GPR) Algorithm in MATLAB Simulink R2020a has been used to train and fit a predictive model for predicting rougher flotation copper recovery. The predictive model which has 10 rougher bank flotation parameters as input variables and rougher recovery as output variable has been cross validated using a hold-out technique of 70% training set, 15% validation set and 15% testing set. Evaluation of model performance on validation and testing set using correlation coefficient ( $R$ ), coefficient of determination ( $R^2$ ) and root mean square error RMSE have been carried out. Predicted rougher copper recovery values and its corresponding true values using the validation set showed  $R$ ,  $R^2$  and RMSE values of 0.98, 0.96 and 0.4238 respectively. Predicted rougher copper recovery values and its corresponding true values using the testing set had the same  $R$  and  $R^2$  values as the validation set with a RMSE value of 0.4212. This result confirms that the GPR algorithm can make good rougher flotation copper recovery prediction given a set of useful flotation parameters as input variables.

## Phyto Production of Manganese Nanoparticles using Stubborn Grass (*Eleusine indica*) – A Preliminary Study

A. Amesimeku, L. Ayedzi and R. K. Amankwah

### Abstract

The production of nanoparticles from biomass is known to be a low-cost technique and also generates purer products in an environmentally friendly manner. This study investigated the manganese sorption capabilities of some plants that grow on manganese stockpiles and selected one with high manganese content as material for the production of manganese nanoparticles (MnNPs). The plants, including *Centrosema pubescens*, *Mimosa pudica*, *Stubborn grass (Eleusine indica)* and *tiwa* (local name) were harvested from manganese stockpiles at the Ghana Manganese Corporation. The plant extracts were obtained and manganese in solution was determined by Atomic Absorption Spectrometry (AAS). *Stubborn grass (Eleusine indica)* had manganese content of 68 mg/g while others had manganese content below 30 mg/g. Manganese nanoparticles were produced from extracts of *stubborn grass*. The manganese nanoparticles were characterized by the UV-Vis spectrophotometry. The UV-Vis spectrophotometry indicated a maximum absorbance of 2.343 at a wavelength of 230 nm.

## Quality Assessment of Steel Balls for Improved Grinding Circuit Performance

C. K. Kuutor, S. Kwofie and R. K. Amankwah

### Abstract

The quality of cast iron and steel balls utilised in milling circuits have the potential to influence grinding efficiency and comminution circuit expenditure. Thus, processing plants

may have to assess the quality of such balls before and during the supply process. In this study, quality assessment of steel and cast iron balls was conducted as part of studies to improve mill circuit performance. Samples of steel and cast iron balls sourced locally from various mines suppliers, were sampled and prepared for hardness, elemental and metallographic investigations. The balls included three forged steel (A, B and S) and high chrome cast iron balls of various diameters. The assessment involved chemical composition, hardness profile and microstructural analysis. Chemical analysis indicated that the high chrome balls contained about 20% Cr, 2.5% C and 75% Fe with surface hardness above 55 HRC and microstructure consisting of chromium carbide and pearlite which make them very resistant to abrasion and corrosion. The forged balls had concentrations of Cr, Fe and C above 0.6%, 96% and 0.6% respectively making them high carbon, low alloy steel. The hardness was similar to the high chrome balls and above 55 HRC, and the phase seen in photo-micrographs for Forged ball A was martensite which is hard but may be brittle. The phases in Forged balls B and S were troostic pearlite and martensite which combine toughness with hardness while the hardness ranged from 45 to 55 HRC. This information provides a good basis for selection of quality steel balls for improved grinding performance.

## **Reducing Uncertainties in the Grindability of Rocks in Gold Plant Design and Operations**

C. Amoah, G. Ofori-Sarpong and R. K. Amankwah

### **Abstract**

The conventional way of designing a plant is to determine the characteristics for rocks in terms of crushability, grindability and other properties that affect the mill throughput. These properties are most of the time determined from drill cores obtained during the exploration period. Such initial exploration campaigns drill to levels shallower than the real pit that will be developed. Thus, as mining pits become deeper, situations are encountered where modification of the plant becomes necessary because the ore characteristics have changed and begins to impact negatively on the expected mill throughput. The first intervention most of the time is to supplement the initial energy input with additional size reduction equipment to achieve the required throughput. This then calls for a new thinking into the initial inputs that goes into the determination of the plant selection to avoid set-backs during the operational period. To help reduce uncertainties and develop a predictive tool, this study considered a greenfield drilled up to 273 m and the core samples obtained were tested to ascertain the variations in Bond work index to depths beyond 500 m. The study showed that within the section of the Asankragwa belt investigated Bond work indices increased from 10.3 kW/t at the surface to 16.5 kW/t at a depth of 273 m. The Bond work index was established as a function of vertical depth in a pit (x) with the relation  $BWI = 6E-05x^2 + 0.0071x + 9.8816$ . The predicted value at 280 m was 16.3 kW/t while that of the blend was 15.8 kW/t giving an error of 4%. The use of the novel Bond work index and depth relationship will eliminate the uncertainty beyond the drilled depth and give a clear understanding of what the rock characteristics will be as pits become deeper. In addition, a savings of US\$62,500 per diamond drill hole and US\$25,000 per one reverse drilling after the 250 m depth can be made by the use of the model. This can result in massive savings considering the number of holes that would have to be drilled across the length of the pit.

## **Pyrometallurgical Recovery of Aluminium Metal from End-of-Life Beverage Cans**

J. R. Dankwah, A. Amponsah, P. C. O. Adu, J. Dankwah and P. Koshy

### **Abstract**

This project was experimentally carried out to recycle these end-of-life beverage cans into premium grade metals production. Ten cans each were taken from a group of cans that were received from the various restaurants and drinking spots in Tarkwa. These groups of cans received are the end-of-life Bavaria drink cans, end-of-life Coca-Cola / Fanta drink cans and end-of-life Malta Guinness drink cans. Their respective masses were taken, with the end-of-life Bavaria drink cans giving 126.70 g, Coca-Cola/ Fanta drink cans giving an average mass of 131.60 g and the end-of-life Malta Guinness drink cans also giving 126.70 g. These cans were then squeezed and placed in fireclay crucibles that were heated by a palm kernel shell fired custom-made furnace. The melts obtained were poured in a bowl of water for quenching to take place after which the solidified metals were recovered. The weight recovered from each end-of-life beverage can was noted and samples of metals so produced were characterised by XRF and SEM/EDS analyses. The results showed the mass of recovered metals as 125.45 g, 122.71 g and 101.80 g for Bavaria cans, Coca-Cola/ Fanta cans and Malt cans, representing 99.01%, 93.24% and 80.35%, respectively. XRF and SEM/EDS analyses revealed the recovered materials as being of high purity, up to 92.73 wt% aluminium metal. It was concluded that waste beverage cans are readily available sources of metals, the exploitation of which can conserve naturally occurring ores.

## **Calcination Behaviour of Nsuta Pyrolusite Ore in the Presence and Absence of End-of-Life Polystyrene**

B. N. P. Asante, K. O. Nimako, K. Mensah, P. Koshy and J. R. Dankwah

### **Abstract**

Pyrolusite ore from Ghana Manganese Company usually has a manganese composition ranging from 40 – 50 wt%. This work sought to investigate the calcination behaviour of Nsuta pyrolusite ore in the absence and presence of polystyrene. Pulverised samples of the ore with labels A, B, C and D with an initial manganese composition of 42 wt% were placed in fireclay crucibles and calcined in the absence of polystyrene in a gas fired furnace for 30, 40, 50 and 60 min, respectively, and the maximum temperature in the fireclay crucible was measured using a digital thermocouple. The samples were then calcined in the presence of polystyrene at the same duration and firing conditions. The change in colour, maximum temperature in the crucible and percent weight loss were recorded after calcination. It was observed that samples changed from greyish black to brown and this transformation was accompanied by a weight loss of 13-14.2% and 10.8-14.8%, in the absence and presence of polystyrene, respectively. Maximum recorded temperature in the fireclay crucible was in the range 584-611 °C and 732-756 °C for calcination in the absence and presence of polystyrene, respectively. These measured temperatures were above the thermodynamic equilibrium temperature (~500 °C) required for the transformation  $\text{MnO}_2\text{-Mn}_2\text{O}_3\text{-Mn}_3\text{O}_4$ . Therefore, it can be concluded that, calcination of pyrolusite ore above 500 °C would increase its manganese composition.

# ENVIRONMENT, SAFETY, CORPORATE SOCIAL RESPONSIBILITY, SMALL SCALE MINING, AND OTHERS

## Environmental Impacts of Illegal Small-Scale Mining Activities on the Aboabo Stream, Ahafo Region, Ghana

B. A. Bofo, B. Koomson and O. F. Agyemang

### Abstract

The Aboabo stream serves as a source of drinking water to the Krapoo village in Ahafo region, Ghana. The presence of illegal small-scale miners around the stream poses health threats to the inhabitants as there have been concerns about physical changes in the water body, death of fishes and skin infections by community members. This study was carried out to assess the impacts of illegal small-scale mining operations on the water quality of the Stream. Levels of physico-chemical and microbiological parameters were determined by standard methods. Three plant species growing within the stream; *Alchornea cordifolia*, *Chromolaena odorata* and *Spigella anthelmia* were taken to assess their bioaccumulation to aid in possible remediation measures. The result of the study revealed that, turbidity, total suspended solids, faecal coliforms and E-coli readings exceeded Ghana's Environmental Protection Agency (GS 1212) and World Health Organisation (WHO) permissible guidelines for drinking water. The pH values were within GS 1212 guidelines. However, levels of total dissolved solutes and dissolved oxygen recorded, were below GS 1212 and WHO guidelines. The mean temperature and electrical conductivity readings were within the permissible limits. Heavy metal concentrations in both sediments and stream waters were generally higher than the GS 1212 and WHO recommended guidelines for drinking water. All the three plants species had bioaccumulation factor (BF) greater than 1 for cadmium. *Alchornea cordifolia* also had bioaccumulation factor greater than 1 for mercury. The general trend in the levels of the parameters from the stream suggests negative environmental influence from the small-scale mining activities on the Aboabo stream. The plants species are potential hyper accumulators (BF > 1) for mercury and cadmium hence are suitable for phytoremediation.

## Characterisation of Kitchen Solid Waste at Senior High Schools in Tarkwa

P. O. Amoh, S. Fosu and W. K. Buah

### Abstract

Solid Waste Management has become a predicament in most developing countries across the globe of which Ghana is no exception. Solid waste if remains unattended leads to numerous environmental nuisances such as aesthetic degradation, offensive odour, breeding ground for vermin and a waste of resources. Presently, Kitchen Solid Waste (KSW) management in Senior High Schools (SHS) within the Municipality is attained chiefly by incineration or landfilling, a method that has caused untimely deterioration of incinerators due to the high moisture content of the kitchen waste, leachate production and uncontrolled release of greenhouse gases. This study aimed at characterising and quantifying solid waste generated in the kitchen of selected SHS in the Tarkwa-Nsuam Municipality. The effectiveness and willingness of waste segregation assessed at source and production of primary data for forecasting to enhance waste management would be

ascertained. Well-lined waste bins coupled with other materials, enabled sorting and segregation of the KSW at source. Also, well-structured questionnaires and in-depth interviews with relevant stakeholders were undertaken for the purpose of data acquisition over a two-week period. The outcome of the study revealed a per capita waste generation rate of 0.0920 kg/cap/day at Tarkwa SHS (Tarsco) with a biodegradable and non-biodegradable generation rates of 0.0896 kg/cap/day and 0.0024 kg/cap/day. Also, the willingness of segregation was 94.44 % while its effectiveness was 50 %. Fiaseman SHS (Fiassec) on the other hand recorded per capita KSW generation rate of 0.0477 kg/cap/day, with a biodegradable and non-biodegradable generation rates of 0.0440 kg/cap/day and 0.0036 kg/cap/day. Also, the willingness of segregation was 100 % while its effectiveness was 26.67 %. Conclusively, the per capita KSW generation rate at Tarsco outweighs Fiassec hence it is envisaged that biogas and compost would be readily produced at Tarsco due to the availability of more resources while ensuring environmental sustainability.

### **Mining and African Environment: Bridging the Gap between Legislation, Enforcement and Compliance**

L. K. Salati and J. T. Adeyemo

#### **Abstract**

Mining in Africa has come a long way in the annals of history of civilization and raw materials production for industrialisation. The continent is home to many varieties of mineral resources more than other continents thereby globally offering diverse market opportunities for industrial utilisation. However, in spite of its contribution to global demands, mining activities in many African countries have wrecked immeasurable havoc and left profound negative impacts on the natural environment, leading to loss of lives, environmental degradation, extensive pollution and other hazards. Although laws have been enacted across the continent to regulate the mining industry, wide gap still exists between enforcement of mining legislations by governments and compliance by the operators most of whom are unlicensed, artisanal or small-scale and environmentally destructive. This paper, therefore, discusses the unfolding scenarios surrounding the violation of mining laws amidst environmental destruction in the African mining industry. The paper identifies and characterises the main causes of lapses in mine environmental regulations as well as the imbalance between law enforcement and compliance. Possible panaceas to address the identified problems are also proffered.

### **Operational Risk Assessment and Management in Dangote Cement Company Ibesse Plant, Ogun State**

O. C. Alaba

#### **Abstract**

The study carried out an operational risk assessment and management in order to identify and analyze the event sequences leading to hazards in Dangote Cement Industry, Ibesse plant using qualitative and quantitative methods. The hazards associated with each work area were identified after which a matrix is created for work areas versus hazards. The likelihoods and consequence of each hazard were determined by a walk-through survey. The ranking of various risk activities was classified into extreme, high, moderate

and low. The use of flammable gases, noise from machineries, dust that can affect human health and equipment were rated high and extreme while radiations from sunshine, slip/trip hazards and falling of objects/structures were rated moderate. Also, exposure to chemical/heat; injury from electrical appliances and mine excavation were rated low. The study therefore concluded that despite the comparatively low identification of risks and hazards in different groups of the work areas, there still some risks/hazards which extremely high that need urgent mitigation attention.

### **Preliminary Inspection for Improvement of Process Plant Operation and Management: Case Study of Jovay Gold Company, Nkawkaw**

J. Obiri-Yeboah and F. O. Somoah

#### **Abstract**

This report covers issues of safety, production, cost and environment units of Akroma Gold Company limited, Process Plant. It aims at identifying the various shortfalls of the unit processes for proactive resolution to enhance improvement. Clearly, the Plant is being run on reactive Mode. At Akroma Gold Company limited, Process Plant, safety is below acceptable standard at all the unit process areas. There is lack of Personal protective equipment for workers of the plant. This is a recipe for workers' health hazard and its associated legislative issues. There is lack of information on performance tracking of the various units of the plant. Whiles oxygen is not measured at the Akroma Gold Company's Processing Plant, pH measurement, based on litmus paper is not reliable since it is a subjective figure. The introduction of carbon regeneration Kiln is paramount as a proactive measure to overcome the negative effect that can result from non-regenerated carbon. Monitoring of electrowining efficiency is another key for predicting final gold to be produce ahead of actual gold production. Daily environmental monitoring report is a needed document to resolve any future legislative problems from the government agency and mischievous community members. Daily monitoring trends analysis are keys to enhance proactive and cost effective production.

### **Assessing the Readiness of Developing Countries in Achieving SDG Targets on Sanitation: Exploring the Factors that Influence Waste Management Practices in Ghana**

J. A. Abane, M. Abubakari, A. Agyekum and E. K. Mills-Abbey

#### **Abstract**

Waste management has become one of the topmost priorities of governments globally because of the potential threat to the sustainability of the eco-system and the environment in general. The United Nations Fact Report suggests that countries in the developing world are more likely to lag on the SDG targets on sanitation compared to the developed world. Also, one of the challenges in the 21st century is how to deal with solid waste globally. Hence, there is an urgent need to provide information on the implementation of goal six targets on sanitation in developing countries and to assess their readiness for achieving the SDGs in 2030. This study assesses the factors that influence waste management practices in MMDAs in Ghana, with a special focus on Tarkwa-Nusaem Municipality. Using a quantitative design, with a sample of 133, which comprised of individual households, Zoomlion and Sanitation Officers from the Muni-

pal Assembly, the findings revealed that, the main sources of waste generated in the municipality were plastic debris. The factors responsible for poor waste management practices were resource availability, implementation plan, and availability of solid waste policy, as well as stakeholder attitude and managerial disposition. The study recommends that deliberate policy on resource allocation and building and strengthening the capacity of implementing agencies to design implementation plans taking into consideration, local conditions on solid waste will aggressively help the country to achieve SDG 6.

### **The Relationship between Leadership and Innovation in Organisational Performance: A Case of Tarkwa Nsuaem Municipal**

H. Osumanu and F. Boateng

#### **Abstract**

The paper seeks to fill the gap in literature on the factors enhancing organisational performance. Literature reviewed focused on the impact of leadership style on innovation management; and the effectiveness of leadership for innovation. This study contributed to making a shift in literature by focusing on the relationship between leadership and innovation and their mutually reinforcing impact on organisational performance. The study population was 261 staff at the Tarkwa Nsuaem Municipal Assembly. Purposive and convenient sampling techniques were employed in contacting 150 staff members at the Assembly. The results showed a positive and significant relationship between leadership and innovation, and these influenced organisational performances. The results were supported by the path coefficient (0.573) and significant p-value of  $0.000 < 0.05$ . Leadership and innovation were established as interdependent variables in the determination of enhanced organisational performance. The two variables influence organisation through its people, systems, structure, mission statement and strategy. The paper further revealed that, building individualised relationship with employees by leaders and considering their needs, aspirations and skills as important drivers of organisational performance. The paper recommended adoption of right leadership style for organisations to deliver their best and be competitive. Organisations must be recognised as living organisms ready to adopt to organisational changes linked to the structure, systems, mission statement, and strategy.

### **The Effect of Social Media Use on the Written English of University Students: The Case of University of Mines and Technology (UMaT)**

C. Addei and E. Kokroko

#### **Abstract**

The social media networks have become very popular among students in recent times. Some students start using social media networks such as WhatsApp, Twitter and Facebook as early as age 10. These social media platforms come with their own type of English which do not follow any rule of grammar, has no respect for punctuation and violates all rules of lexis and syntax. There is a public outcry that the kind of 'new English' that is written by students on these social media networks is likely to sneak into the formal written English of many students. As a result, this study sought to find out whether the type of English written on these social media networks has affected the written English of the users of these media.

## **Assessment of Attitudes of Engineering Students at UMaT Vis-à-vis the Study of Basic French**

J. K. Dumenyah and E. Kokroko

### **Abstract**

The study of Basic French is a core course for all first year undergraduate students at the University of Mines and Technology (UMaT), Tarkwa. The future prospects of a bilingual engineering student are of paramount importance to UMaT hence the conception of the course, for further future development by the students themselves. This study, therefore, attempts to assess the attitudes of students towards the course. Over the years, the fact that the course is not a mainstream engineering programme, it has been eliciting various attitudes from students. The objective of the study is to find out to what extent the attitudes of students towards the course is positive or negative. The first years were sampled principally. A mixed-method approach was exploited for the study. A quota sampling technique was used to select a total of two hundred (200) from Level 100 to 400. That is, ten (10) students were selected randomly from each of the eleven programmes at from Level 100, totaling 110 and the ninety (90) other students from Levels 200, 300 and 400. Two lecturers from the Department of Technical Communication (DTC), shared their experiences of students' attitudes when they are first introduced to the course and by the end of the first year. The results indicate that majority of the students representing about seventy-nine percent (79%) have a very strong positive attitude towards the study of the course. A high percentage sampled will prefer that they study the course for more than an academic year. Students' attitudes towards the course vary due to various influences including the practicality of the course, the kind of atmosphere created at lectures and the future objectives of the individual students and their knowledge of what their prospects are if they can speak another international language in addition to the English Language.

## **INNOVATIONS IN MECHANICAL, ELECTRICAL, MATHEMATICAL AND COMPUTER SCIENCES**

### **Electrical Lighting Load Estimation Prior to Design**

M. O. Oyeleye and T. D. Makanju

### **Abstract**

Electrical load estimation in the preliminary design level is critical prior to real design. In order to avoid a guess work, a reliable estimate is very important. This work assesses lighting estimation load base on scientific approach. The focus of this conference paper is to solve problem of engineering undergraduates, new engineering graduate or experience-acquiring engineer in the estimation of a new electrical lighting load requirement of a project edifice, especially an auditorium lecture theatre or hall. Data of existing lighting designs by undergraduates and post graduate students under the supervision of a leading author of this work were used to established actual lighting load. The data collected is from 2014 to 2019 projects. The actual designs are five in numbers namely: 1000 Seat Lecture Hall, Multipurpose Hall Building, TI Francis Hall, Oluremi Event Centre and Event Centre(un-named). In order to estimate the lighting load, area of the space was obtained



from the actual design to determine the corresponding lighting power allowance. Also, the total lighting design wattage of the space were extracted from the actual design and compared with the estimated lighting wattage. The results show that estimated lighting power prior to design is greater than the actual lighting design in agreement with international standards and that the higher the area of a space, the higher the lighting estimated power required. 50% to 80% estimated lighting demand load is established in this work in accordance to international standards. 80% estimated lighting demand load is on very high side and that 65% estimated lighting demand load is preferred to 80% for a similar project work. This work will help undergraduates, new graduates and even post graduate in theory- practical oriented task application in reliable scientific and economic lighting load estimation.

### **Evaluation of Local Backfill Materials on Earthing Systems**

S. Ohene Adu, S. Nunoo and J. R. Dankwah

#### **Abstract**

Several backfill materials are freely available as industrial wastes or at a low cost in Ghana. However, their long-term performance remains unknown. In this paper, two proposed backfill materials, charred and uncharred coconut coir, were tested against two commercially available and traditionally used backfill materials, tyre ash and palm kernel cake. A reference rod was also buried, without any backfill material, alongside the other four with backfill materials for a period of 12 months. The earth rod used in this research was the copper-coated iron rods. Fall-of-potential method of measuring resistance was used in this experiment, where we took weekly resistance readings for a period of one year. A physio-chemical analysis of samples of the backfill material and soil from the study site was conducted at the Minerals Engineering Laboratory at the University of Mines and Technology, Tarkwa. The pH, heavy metals, and organic content of the samples were determined. The rods that were buried in the four backfill materials under consideration recorded lower resistance values than that of the reference rod, with tyre ash recording the least. This finding confirms the results of other researchers about the efficacy of tyre ash and also indicates the importance of using backfill materials in earthing systems.

### **Design and Development of an Egg Collecting and Sorting System equipped with an HMI for Poultry Farms**

K. Koranteng, J. Kornu, W. Gedel, E. Mensah and I. Aidoo

#### **Abstract**

Poultry production is undoubtedly one of the most lucrative and popularly known agriculture business ventures in the world. The ever-increasing needs have led to the development, adaptation and utilization of new standards and technologies in developed countries. Goal number two of the United Nations Sustainable Development Goals (SDGs) focuses on eradication of hunger. While Goals 8 and 9 focusses on economic growth, and industry and innovation, respectively. These SDGs can be contributed to by the poultry production industries by implementing an efficient and cost effective production chain. However, developing countries like Ghana still deploy traditional method of handpicking of eggs and their separation into various sizes. To address this gap, this paper presents

the design and development of an egg collecting and sorting system with a associated mobile application for poultry farms. It employs the use of sensors combined with servo and conveyor system in its operation. Sorting of the eggs is based on a weight sensing system. The overall system is equipped with a Human Machine Interface for configurational purposes and a remote mobile application for monitoring combined with a statistical data view. The system is modelled and simulated using SolidWorks for optimal design before prototyping it practically. The designed mobile application runs on an android operating system. A battery backup for power support during outages is included in the design for an effective power supply. This designed system is able to sort the eggs in large (56-64.9 g), medium (49-55.9 g) and small (42-48.9 g) size ranges as per to the FAO standards. Periodically, the designed system updates the mobile application with a progress report of the performance of the system. The proposed system is affordable, portable, safe and effective for small- and large-scale production.

### **Design of a Combined Gravity Concentration and Leaching Plant for the Small-scale Gold Mining Industry in Ghana**

E. Yin and E. Quaicoo and E. K. Asiedu

#### **Abstract**

Small Scale Gold Mines (SSGMs) are the mines that use relatively small and low-quality devices to extract ore from the earth's crust by a group of people with little or no technical know-how. These mines provide an important source of livelihood for rural communities throughout the world, and are currently operated by both licensed and unlicensed people (locally referred to as galamsay operators). The mechanization of the mining industry has seen the use of equipment such as sizing trommels and knelson concentrators for gold recovery. On the other hand, gold recovery has been poor regardless of utilisation and employment of the aforementioned equipment. In this work, a method of increasing gold recovery and reducing much losses of the gold to tailings is presented. These objectives were achieved by designing a combined gravity and leaching plant. The recovery techniques described in this work are gravity concentration by sluicing, concentrate amalgamation, cyanide-based leaching and zinc cementation to recover gold. The system design was modelled using CAD software (solidworks). The introduction of this technique in the small-scale gold mines would demonstrate an improvement in gold recovery in a cost-effective and environmentally benign manner. It is therefore recommended that small-scale gold miners adopt this system in order to reduce gold losses, and increase the local production of gold and to boost their profit.

### **Conveyor Chain Links – A Review**

E. Yin, O. Muvengi and J. M. Kihui

#### **Abstract**

Industries such as mills, paper mill, food processing, fertilizer industry, pharmaceutical industry, cement industry, foundry industry, heat treatment units, coal mines etc has roller conveyor chains as one of the important components such that without it in operation, production ceases. As chain links are critical components of many industrial companies, reviewing literature on the progress of research made on it is very crucial to improving the quality of products produced. This paper delves into the various litera-

tures pertaining to conveyor chain links under categories of failure analysis, modeling and simulation as well as wear. The various methods used for analyzes, results and conclusions deduced in addition to the limitations of the various literature are discussed in this paper.

### **Vibration Analysis of a 4-DOF Quarter Truck Model**

K. Eddah, O. A. Dahunsi, A. Simons and S. Nunoo

#### **Abstract**

Modelling of suspension systems in automotive research, in most cases, treat seat suspension, cabin suspension and vehicle suspension independent of each other. However, studies have shown that the dynamics of the individual system and driver biomechanics affects the overall system dynamics and as such, calls for a combined case of seat, cabin and wheel suspension. In this study, a combined seat, cabin and wheel suspension quarter truck was modelled and simulated for response to deterministic and random road disturbance inputs. On simulation, the Root-Mean-Squared (RMS) acceleration values of 0.9525 m/s<sup>2</sup> and 9.173 m/s<sup>2</sup> of the seat were obtained, respectively, for the deterministic and random road disturbance inputs. The frequency domain analysis reveal that the seat mass acceleration response amplifies vibration in the frequency band of 0.154 Hz and 8.69 Hz having a peak gain of 46.8 dB at 1.4 Hz. The frequency response also shows an amplification of vibration in the band of 0.155 Hz and 15.5 Hz attaining a maximum gain of 43.7 dB at 1.4 Hz for cabin and 0.158 Hz and 385 Hz attaining a maximum of 49 dB at 1.46 Hz for chassis. The system is marginally stable and thus require a controller to improve on the system's stability and to ensure RMS values falls at best within the Health Guidance and Caution Zone.

### **Time Series Analysis of Tuberculosis Cases in Mining Communities in Ghana – A Case Study at Tarkwa Nsuaem Municipality**

C. C. Nyarko, P. K. Nyarko and A. Buabeng

#### **Abstract**

The main purpose of this paper was to examine the incidence rate of Tuberculosis (TB) in Tarkwa Nsuaem Municipality, a mining community in Western Ghana and to identify some of the demographic factors that necessitate the spread and trend of the diseases. Monthly reported case of TB from January 2009 to December 2013 was obtained from the Tarkwa Municipal Government Hospital which was analysed using the Box-Jenkins approach. An Autoregressive Integrated Moving Average, ARIMA (1, 1, 0) was found to be the best among the competing models with relatively minimum information loss (Bayesian Information Criteria (BIC) and Akaike Information Criteria (AIC)). A forecast result shows a constant decrease in the number of TB cases in the municipality for the first six months of 2014. Exposure and environment were strongly identified as risk factors necessitating the transmission of TB in the communities. The paper concluded that, the decrease in TB cases in the municipality could be sustained if TB patients adhere to all the rules governing TB medications.

## **Comparative Analysis of ARIMA, ANFIS and GMDH Models using Standard Precipitation Index (SPI) for Flood Prediction: A Case Study Accra, Ghana**

A. Buabeng, H. Otoo and E. Mensah

### **Abstract**

The paper sought to develop an efficient model for predicting flood incident in Accra, Ghana as the city has frequently been suffering from the devastating effect of floods. To achieve this objective, precipitation data obtained were transformed into Standard Precipitation Index (SPI) with a time scale of 12 months which has been known to be very useful in forecasting flood incidents. Thereafter, redundancies (noise) within the transformed data were minimised using the Gaussian Smoothing. One classical and two intelligent models namely: the AutoRegressive Moving Average (ARIMA), the Adaptive Neuro-Fuzzy Inference System (ANFIS), and Group Method of Data Handling (GMDH) were then developed using the denoised data. The resulting models were compared using performance indicators such as R-Squared, Mean Squared Error (MSE), Root Mean Squared Error (RMSE) and Mean Absolute Percentage Error (MAPE). The GMDH proved to be superior to the others; with minimal error (0.00065%) when compared to ARIMA (42.28733%) and ANFIS (1.66090%) models.

## **Effects of Climate Change on Maize Production in Ghana - A Comparative Study of Parametric and Non-Parametric Regression Models**

A. Buabeng, L. Brew, B. Odoi and F. Obiri-Yeboah

### **Abstract**

The devastating effects of climate change on the production of agricultural commodities has become a source of worry for many developing countries and therefore demands due attention. For these reasons, this paper sought to formulate models for analysing the effect of climate change on maize production in Ghana as there has been an alarming fluctuation in productivity across the country. Agroclimatic data such as wind speed, temperature, humidity, carbon dioxide and precipitate were obtained. First, a Multiple Regression Analysis (MRA) was performed using all the variables which resulted in high levels of multicollinearity. To remedy the multicollinearity problem and perform a reliable analysis, Factor Analysis (FA) was employed to transform the dataset into a set of uncorrelated factor scores. Thus, the resulting factor scores were used in developing two models based on parametric MRA and non-parametric Multivariate Adaptive Regression Splines (MARS). The results from the analysis indicate that the MARS model based on factor scores achieved a higher prediction accuracy of 76.59% when compared with the MRA's model (73.73%). Moreover, the MARS model produced the least Mean Absolute Percentage Error (MAPE) of 8.32% when compared to MRA's 12.12% during validation.

## **Exploring the Impact of Augmented Reality (AR) on STEM Education in Ghana**

S. Asare and S. Akpah

### **Abstract**

Integrating essential technologies such as augmented reality (AR) and virtual reality (VR) into educational systems has shown to improve teaching and learning as compared to the traditional teaching aids of textbooks, magazines and bulletins. A much higher AR experience has been captured in many researches where users report higher satisfac-

tion, having more fun, and eagerly wanting to repeat the AR experience. Remarkably, user motivation remains significantly higher for AR systems as compared to the traditional alternatives even when the AR experience is deemed to be more challenging to use. Besides the numerous benefits replete of AR, its application especially in the area of education, remains much to be desired, thus the need to adequately undertake research to provide academic content on the importance of adopting AR to support teaching and learning. The main goal of this study was to develop an AR application focused on providing a rich learning experience and enhance the learning process of STEM students, particularly those studying biology (anatomy of the human skeletal structure) in Senior High School's (SHSs) in Ghana. The study examined learning patterns that motivated students before and after using the AR mobile application. Biomate as it is called, is an android application developed using Unity3D with additional Vuforia libraries. The application used different image targets from the SHS Biology GAST (Graduate Association of Science Teachers) textbook as markers to display augmented educational content. When the application is pointed to the markers in the book, the animated 3-Dimensional models were displayed with links to anatomy videos as well as web articles. The results showed a significant increase in the learning motivation, comprehension and retention of educational content using the AR application by students. AR can thus be used to augment theoretical concepts taught in educational institutions as well as laboratories if explored further.



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