A Quarterly R&D Abstract Service by IIME

MINERALS ENGINEERING

- A Global Alert Service

Issue No. 94, July 2012

Editors:

R. Singh
A. Das
N.G. Goswami

Compilation: A.K. Sahu

INDIAN INSTITUTE OF MINERAL ENGINEERS
C/o Mineral Processing Division
CSIR-NATIONAL METALLURGICAL LABORATORY
JAMSHEDPUR 831 007, JHARKHAND WEBSITE: www.iimeindia.com

INDIAN INSTITUTE OF MINERAL ENGINEERS

C/o Mineral Processing Division

CSIR-National Metallurgical Laboratory

Jamshedpur 831 007, Jharkhand

Issue No. 94, July 2012

Radiation-induced defects in clay minerals: A review

Allard, T; Balan, E; Calas, G; Fourdrin, C; Morichon, E; Sorieul, S
thierry.allard@impmc.upmc.fr

NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH SECTION B-BEAM INTERACTIONS WITH MATERIALS AND ATOMS, Apr, 2012, Vol. 277, pp. 112-120

Extensive information has been collected on radiation effects on clay minerals over the last 35 years, providing a wealth of information on environmental and geological processes. The fields of applications include the reconstruction of past radioelement migrations, the dating of clay minerals or the evolution of the physico-chemical properties under irradiation. The investigation of several clay minerals, namely kaolinite, dickite, montmorillonite, illite and sudoite, by Electron Paramagnetic Resonance Spectroscopy has shown the presence of defects produced by natural or artificial radiations. These defects consist mostly of electron holes located on oxygen atoms of the structure. The various radiation-induced defects are differentiated through their nature and their thermal stability. Most of them are associated with a pi orbital on a Si-O bond. The most abundant defect in clay minerals is oriented perpendicular to the silicate layer. Thermal annealing indicates this defect in kaolinite (A-center) to be stable over geological periods at ambient temperature. Besides, electron or heavy ion irradiation easily leads to an amorphization in smectites, depending on the type of interlayer cation. The amorphization dose exhibits a bell-shaped variation as a function of temperature, with a decreasing part that indicates the influence of thermal dehydroxylation. Two main applications of the knowledge of radiation-induced defects in clay minerals are derived: (i) The use of defects as tracers of past radioactivity. In geological systems where the age of the clay can be constrained, ancient migrations of radioelements can be reconstructed in natural analogues of high level nuclear waste repositories. When the dose rate may be assumed constant over time, the paleodose is used to date clay populations, an approach applied to fault gouges or laterites of the Amazon basin. (ii) The influence of irradiation over physico-chemical properties of clay minerals. An environmental application concerns the performance assessment of the engineered barrier of nuclear waste disposals. In case of a leakage of transuranic elements from the radioactive waste form, alpha recoil nuclei can amorphize smectite after periods of the order of 1000 years according to a worst case scenario, whereas amorphization from ionizing radiation is unlikely. As amorphization greatly enhances

the dissolution kinetics of smectite, the sensitivity of the smectites must be taken into account in the prediction of the long term behavior of engineered barriers. (C) 2012 Elsevier B.V. All rights reserved. 10.1016/j.nimb.2011.12.044

Influence of jig frequency on the separation of coal from the Bonito seam - Santa Catarina, Brazil

Feil, NF; Sampaio, CH; Wotruba, H
norton.feil@ufrgs.br
FUEL PROCESSING TECHNOLOGY, Apr, 2012, Vol. 96, pp. 22-26

The coal from the Barro Branco seam, which is widely used, is situated in the southern region of Brazil. State of Santa Catarina, and it is nearing depletion. The remaining coal from the Bonito seam in the same region is less known and it is characterized by the high percentage of near gravity material and ash content. This peculiarity makes it difficult to treat in the current processing plants, which use jigs for this purpose. This product should have <= 43% ash content for supplying Jorge Lacerda's thermal electric power plant. This study was carried out to investigate other routes and improvements for coal cleaning. Dry processing and jigging tests were conducted in Germany for this purpose. Dry processing was done using an X-ray sorter. Tests were also performed using a batch jig to study the influence of jig frequency on the separation of two coal fractions. It was found that the processing at a specific frequency of pulsation for this coal allows the concentration of a suitable product for the market with yield about 30%. (C) 2012 Elsevier B.V. All rights reserved. 10.1016/j.fuproc.2011.12.010

Washability curves for the lower coal seams in Candiota Mine - Brazil

de Souza, KF; Sampaio, CH; Kussler, JAT
karime.ferreira@ufrgs.br
FUEL PROCESSING TECHNOLOGY, Apr, 2012, Vol. 96, pp. 140-149

In Brazil, the largest coal reserve is located in Candiota Coalfield, in the State of Rio Grande do Sul, currently mined by CRM - Companhia Riograndense de Mineracao. The lower coal seams in this coalfield correspond to 30% of the entire coal reserve, but they are not mined. For the purpose of this paper, only the seams 11,12 and 14 will be discussed. These seams have as yet not been characterized for beneficiation purposes. Therefore, washability curves were generated based on sink-and-Float tests to evaluate the main characteristics of such coals for a future gravimetric beneficiation study. From these curves, the average curves were plotted, representing more closely the characteristics of each seam. Based on this, a comparative study was carried out for both selective and simultaneous gravimetric beneficiation of these three seams, without taking into consideration the process efficiency. For an ash content of 42%, the mass theoretical yield obtained was of 33% (selective beneficiation) and 31% (simultaneous beneficiation) for the coarse size

fraction, and 76% (selective beneficiation) and 74% (simultaneous beneficiation) for the fine size fraction. (C) 2011 Elsevier B.V. All rights reserved.
10.1016/j.fuproc.2011.12.026

Statistical methods for segmentation and quantification of minerals in ore microscopy

Kose, C; Alp, I; Ikibas, C
ialp@ktu.edu.tr
MINERALS ENGINEERING, Apr, 2012, Vol. 30, pp. 19-32

Modern electronic image-processing techniques have enabled mineral processing engineers to automate the determination of minerals in ore samples. The automatic recognition and quantification of minerals by light microscopy is one of the most important problems in ore-processing systems because determining the amount and degree of liberation of the constituent minerals in ore is necessary for further processing. Measurement of the size and liberation degree of minerals is also required for automatic control of the grinding process. This paper suggests an automated method for segmenting and quantifying the size and amount of minerals in ore using micrographic images. A simple normalized colour-based statistical segmentation method is proposed to exploit the average value, standard deviation and distribution of RGB colour components of mineral patterns in an ore image. The method also determines the deviations of colour components of the minerals to improve the segmentation. A Naive Bayes classifier is also introduced for segmenting the minerals. The performance of method is examined using micrographs in variety of qualities. The method performs segmentation accuracy over 90%. Additionally, the success rates of the methods were found to be over 85% in measuring the grain sizes in a ground sample, and 86% in measuring liberation degrees of minerals after grinding process. (c) 2012 Elsevier Ltd. All rights reserved. 10.1016/j.mineng.2012.01.008

Uncertainty in silicate mineral weathering rate estimates: source partitioning and policy implications

Futter, MN; Klaminder, J; Lucas, RW; Laudon, H; Kohler, SJ
martyn.futter@slu.se
ENVIRONMENTAL RESEARCH LETTERS, Apr-Jun, 2012, Vol. 7, 2

Precise and accurate estimates of silicate mineral weathering rates are crucial when setting policy targets for long-term forest sustainability, critical load calculations and assessing consequences of proposed geo-engineering solutions to climate change. In this paper, we scrutinize 394 individual silicate mineral weathering estimates from 82 sites on three continents. We show that within-site differences of several hundred per cent arise when different methods are used to estimate weathering rates, mainly as a result of uncertainties related to input data rather than conceptually different

views of the weathering process. While different methods tend to rank sites congruently from high to low weathering rates, large within-site differences in estimated weathering rate suggest that policies relying on quantitative estimates based upon a single method may have undesirable outcomes. We recommend the use of at least three independent estimates when making management decisions related to silicate mineral weathering rates. 10.1088/1748-9326/7/2/024025

Coal deposits as potential alternative sources for lanthanides and yttrium

Seredin, VV; Dai, SF
seredin@igem.ru
INTERNATIONAL JOURNAL OF COAL GEOLOGY, May, 2012, Vol. 94, pp. 67-93

This paper presents data on widespread abnormal accumulations of lanthanides and yttrium (REY) in many coal deposits worldwide. High REY contents (>0.1%) have been found in coal seams and coal ashes, as well as in the host and basement rocks of some coal basins. For a preliminary evaluation of coal ashes as an REY raw material, not only the abundance but also the individual REY compositions were taken into account in this paper. Three REY distribution patterns for high-REY coal ashes are fixed, with LREY- (La-N/Lu-N>1), MREY- (La-N/Sm-N<1, Gd-N/Lu-N>1), and HREY- (La-N/Lu-N<1) enrichment. Four genetic types of REY enrichment in coal basin can be identified: 1) terrigenous type, with REY input by surface waters; 2) tuffaceous type, connected with falling and leaching of acid and alkaline volcanic ash; 3) infiltrational or meteoric ground water driven type, and 4) hydrothermal type, connected with ascending flows of thermal mineral water and deep fluids. It is shown that the main modes of REY occurrence in high-REY coals are in fine-grained authigenic minerals (REY-bearing aluminum phosphates and sulfates of the alunite supergroup, water-bearing phosphates and carbonates) and organic compounds. Stratabound and cross-cutting REY mineralization may occur in the host and basement rocks of some coal basins. There are tuffaceous and hydrothermal types of REY mineralization outside coal seams that are significantly different in geological settings, ore body shapes, and ore compositions, as well as in REY contents and distribution patterns. The data presented indicate that coal deposits should be regarded as promising objects for recovery of REY as economic by-products of coal mining and combustion. As REY are crucial metals for alternative power and energy-efficient technologies, identification of these resources during coal exploitation and utilization may not only increase beneficiation of coal deposits themselves but also will promote humanity's further movement on the "green road". (C) 2011 Elsevier B.V. All rights reserved. 10.1016/j.coal.2011.11.001

Upgrading low nickel content laterite ores using selective reduction followed by magnetic separation

Zhu, DQ; Cui, Y; Vining, K; Hapugoda, S; Douglas, J; Pan, J; Zheng, GL
cuiyucsu@163.com
INTERNATIONAL JOURNAL OF MINERAL PROCESSING, May, 2012, Vol. 106, pp. 1-7

The processing of nickel laterite ore to produce ferronickel is energy intensive, especially when low nickel content ores are processed. The selective reduction-beneficiation of laterite ore to produce high nickel content nickeliferous concentrate and abandon gangue minerals before smelting potentially offers an effective pre-treatment to this process. In this work, the authors conducted selective reduction of nickel laterite ores at 1100 degrees C for 60 min with addition of 6% calcium sulfate and 5% reductant coal. The reduced ore was then wet magnetic separated. The experiments show that high nickel content nickeliferous concentrate containing 6.0%Ni with nickel recovery of 92.1% could be produced with over 75% of the reduced ore, containing low nickel concentration, rejected. The tests indicated that the selectivity of reduction depends mainly on reduction atmosphere and silica level. According to the microscopic study, nickel oxide had been reduced and nickel was mainly enriched into gamma Fe-Ni phase. The presence of sulfur significantly promoted gamma Fe-Ni particle growth, from 5.8 mu m to 16.1 mu m, and improved the Ni enrichment in metallic phases. 10.1016/j.minpro.2012.01.003

Experimental interactions of the Opalinus Clay and Boom Clay with various repository relevant solutions at 90 degrees C under closed conditions

Honty, M; Wang, L; Osacky, M; Uhlik, P; Czimerova, A; Madejoya, J
mhonty@SCKCEN.BE
APPLIED CLAY SCIENCE, May, 2012, Vol. 59-60, pp. 50-63

A temperature increase coupled with other geochemical perturbations is expected to occur during the heat phase of the geological repository due to the presence of heat-emitting radioactive waste and engineered barrier system. To study the impact of a temperature increase on the geochemistry of some candidate clay host rocks considered in Europe, we tried to simulate such conditions by means of batch tests followed by detailed mineralogy analysis and geochemical modelling. The batch tests were performed on whole rock Boom Clay (WRBC) and whole rock Opalinus Clay (WROPA) samples in contact with some representative pore waters at 90 degrees C, the maximum temperature expected as a result of heat-emitting waste. The same experimental settings were applied to run parallel tests on the separated clay fractions (CFBC and CFOPA). The aim was to assess the impact of coupled heat and chemical processes on their mineral stability in the presence and absence of the organic matter and carbonates. At specific time intervals, the solids were separated from solutions and subject to (Q)XRD, FTIR, UV-VIS, TSA and CEC determinations. The whole rock samples were found stable irrespectively of the solution composition with no negative impact on their physico-chemical properties. In line with the experimental observations, the geochemical modelling suggests that minerals are able to reequilibrate relatively fast with the ambient solutions. The clay mineralogy was modified only in the case of Boom Clay deprived of carbonates and organic matter. The clay mineralogical alterations are associated with the increase of the layer charge. TSA and CEC. The experimental and modelling results indicate that

coupled heat and perturbed geochemical conditions did not jeopardise the stability of the constituent minerals in the studied clays. Altogether, the presented work highlights very good buffer capacity of both candidate host rocks towards geochemical perturbations. (C) 2012 Elsevier B.V. All rights reserved.
10.1016/j.clay.2012.02.011

Modelling and optimization of clean chromite production from fine chromite tailings by a combination of multigravity separator and hydrocyclone

Ozgen, S
JOURNAL OF THE SOUTHERN AFRICAN INSTITUTE OF MINING AND METALLURGY, May, 2012, Vol. 112(5), pp. 387-394

In this study, the possibility of beneficiation of chromite tailings in the Uckopru/Fethiye-Turkey region by a combination of hydrocyclone and multigravity separator (MGS) was investigated. The two significant operational parameters of hydrocyclone, which were diameter of the apex and diameter of the vortex, and the three significant operational parameters of the MGS, which were drum speed, tilt angle, and wash water, were varied and the results were evaluated with the central composite rotatable design. In order to produce a chromite concentrate by hydrocyclone and MGS, mathematical model equations were derived by computer simulation programming, applying the least-squares method using Minitab 15. Second-order response functions were produced for the grade and recovery of chromite concentrates.

Beneficiation of nickeliferous laterite by reduction roasting in the presence of sodium sulfate

Li, GH; Shi, TM; Rao, MJJ; Jiang, T; Zhang, YB
liguangh@csu.edu.cn; raomingjun2003@yahoo.com.cn; jiangtao@csu.edu.cn
MINERALS ENGINEERING, May, 2012, Vol. 32, pp. 19-26

In this paper, the reduction roasting of laterite ore in the absence or presence of sodium sulfate was carried out for nickel beneficiation by wet magnetic separation. Sodium sulfate is found to be capable of enhancing the reduction of laterite ore through liberating iron and nickel from Ni/Fe substituted-lizardite, as well as increasing the size of ferronickel particles considerably. When the laterite pellets were reduced at 1100 degrees C for 60 min, the average particle size of ferronickel grains was approximately 50 mu m in the presence of sodium sulfate, which far exceeded the size of 5-10 mu m in the absence of sodium sulfate. Compared with those reduced without sodium sulfate, the Ni grade of ferronickel concentrate increased from 2.33% to 9.48%, and the magnetic separation recovery of Ni increased from 56.97% to 83.01% with the addition of 20 wt.% sodium sulfate. Experimental evidence showed that troilite (FeS) serves as an activating agent to accelerate melt phase formation via a low melting point (985 degrees C) Fe-FeS

eutectic. This markedly facilitated the aggregation of ferronickel particles during reduction, along with the selective enrichment of Ni by suppressing the complete metallization of Fe. (c) 2012 Elsevier Ltd. All rights reserved.
10.1016/j.mineng.2012.03.012

Investigation of microwave-assisted concrete recycling using single-particle testing

Lippiatt, N; Bourgeois, F
nicholasrichard.lippiatt@inp-toulouse.fr; florent.bourgeois@inp-toulouse.fr
MINERALS ENGINEERING, May, 2012, Vol. 31, pp. 71-81

Microwave heating stands as a strong candidate for selective liberation of multiphase materials like concrete. It takes advantage of the differences in thermal, dielectric and mechanical properties of each of the components to create stress gradients that can lead to grain boundary fracture and embrittlement. The work and results reported are concerned with selective liberation of concrete's raw constituents for recycling by combination of microwave heating and comminution. A single particle testing approach is presented for detailed analysis of the process. Concrete particles 10 mm in size are treated individually in a single mode cavity microwave (2.45 GHz, 2 kW) test apparatus. The microwave induced effects are quantified by single particle impact testing on a fast Hopkinson bar. Analysis of impact traces reveals a thorough embrittlement of concrete particles from microwave treatment and fragment analysis confirms the potential of microwaves for selective liberation of the raw constituents of concrete. These results validate that microwaves and comminution can be combined to liberate concrete's raw constituents. (C) 2011 Elsevier Ltd. All rights reserved.
10.1016/j.mineng.2011.09.017

Synthesis of pure aragonite by sonochemical mineral carbonation

Santos, RM; Ceulemans, P; Van Gerven, T
Rafael.Santos@cit.kuleuven.be; Tom.VanGerven@cit.kuleuven.be
CHEMICAL ENGINEERING RESEARCH & DESIGN
3rd European Process Intensification Conference (EPIC), JUN 20-23, 2011, Manchester, ENGLAND, Jun, 2012, Vol. 90(6), pp. 715-725

The objective of this work was to promote the formation of the aragonite polymorph of calcium carbonate, which has some valuable applications in industry, via the mineral carbonation route. The combination of ultrasound with magnesium ions promoted the formation of pure aragonite crystals at optimum conditions. It was possible to synthesize high purity aragonite precipitates at temperatures ranging from 24 degrees C to 70 degrees C, with the resulting powders possessing varying particle size distributions (from sub-micron up to 20 mu m) and crystal morphologies (from acicular needles to novel hubbard squash-like particles). Several process

parameters were found to influence the produced calcium carbonate polymorph ratios (aragonite over calcite). Higher values of magnesium-to-calcium ratio, intermediate ultrasound amplitude (60%), continuous ultrasound application (100% cycle), introduction of ultrasound pre-breakage, lowering of the CO2 flow rate, and increase in the relative concentration (g/L Ca(OH)(2)), all promoted aragonite formation. A potential route for industrial production of this material has been identified via a fed-batch process, which effectively reutilizes magnesium chloride while maintaining high aragonite yield. The results presented herein are significantly superior to aragonite formation using only single promoting techniques, typically found in literature, and go beyond by focusing on pure (>99%) aragonite formation. 10.1016/j.cherd.2011.11.022

Heap leach modeling employing CFD technology: A 'process' heap model

McBride, D; Cross, M; Gebhardt, JE
d.mcbride@swansea.ac.uk
MINERALS ENGINEERING, Jun, 2012, Vol. 33, pp. 72-79

Industrial mining through the process of heap leaching of low grade ores can be employed in the extraction of a range of base and precious metals, such as copper, gold, silver, nickel, zinc and uranium. The process involves the percolation of a leaching solution, typically cyanide, sulfuric acid or acidic ferric sulfate, through crushed ore interacting with a range of oxide and sulfide minerals. These systems involve a complex suite of interrelated fluid, gas, thermal and chemical reactions. A comprehensive computational model needs to account for variably saturated liquid and gas flow in porous media together with the transport of many species through a continually growing geometry, plus multi-phase heat and mass transfer arising from a range of phase change and gas-liquid-solid chemical reaction processes. A number of computational modeling tools employing CFD technology have been developed for the analysis of metals recovery through stockpile leaching. This contribution describes some of the technologies developed particularly to address the key challenges of modeling a full scale industrial heap. Specifically, a 'process' heap model is detailed which captures all the key phenomena of a full 3D heap but with significantly reduced simulation times, and so enables rapid analysis by engineers in an operating environment for evaluating a range of 'what if' scenarios in production planning.
10.1016/j.mineng.2011.10.003

Full-text Papers available in NML Eprints (http://eprints.nmlindia.org)

Abhilash, and Mehta, K D and Pandey, B D (2012) *Efficacy of Bacterial Adaptation on Copper Biodissolution from a Low Grade Chalcopyrite Ore by A. ferrooxidans.* International Journal of Nonferrous Metallurgy, 1 (1). pp. 1-7.

A low-grade ore containing ~0.3% Cu, remains unutilized for want of a viable process at Malanjkhand Copper Project (MCP), India in which copper is present as chalcopyrite associated with pyrite in quartz veins and granitic rocks. In order to extract copper from this material, bioleaching has been attempted on bench scale using Acidithiobacillus fer-rooxidans (A. ferrooxidans) isolated from the native mine water. The enriched culture containing A. ferrooxidans when adapted to the ore and employed for the bioleaching at 5% (w/v) pulp density, pH 2.0 and 25°C with three particle sizes viz.150 -76 μm, 76 - 50 μm and <50 μm, resulted in recovery of 38.31%, 29.68% and 47.5% Cu respectively with a maximum rise in redox potential (ESCE) from 530 to 654 mV in 35 days. Under similar conditions, the unadapted strains gave a recovery of 44.0% for <50 μm size particles with a rise in ESCE from 525 to 650 mV. On using unadapted bacte-rial culture directly in shake flask at pH 2.0 and 35°C temperature and 5% (w/v) pulp density (PD) for <50 μm size par-ticles, 72% Cu bio-dissolution was achieved in 35 days. Copper biorecovery increased to 75.3% under similar condi-tions with a rise in bacterial count from 1 × 107 cells/mL to 1.13 × 109 cells/mL in 35 days. The higher bio-recovery of copper with the adapted bacterial culture may be attributed to the improved iron oxidation (Fe2+ to Fe3+) exhibiting higher ESCE as compared to that of unadapted strains. http://eprints.nmlindia.org/5511/

Das, Suchandan K (2012) *Mathematical model to predict effects of fly ash hardness and angularity on erosion response of typical boiler grade steels.* Tribology, 6 (2). pp. 84-92.

A theoretical model has been developed embodying the ductile erosion mechanisms involving cutting wear, plastic deformation and surface temperature on the erosion response of typical boiler grade steels. The parametric sensitivity of erosion response of these steel grades as a function of particle impact velocity, angle of impingement and steel surface operational temperature has been investigated, which also accounts for particle properties such as hardness (silica content) and shape (angularity). The investigation demonstrated that a minor rise in the fly ash hardness can considerably enhance the erosion rate of the steel surface, signifying that the hardness of fly ash can be a crucial parameter for characterising the ductile erosion potential of various boiler grade steels. The effect of fly ash angularity (shape) on the erosion behaviour is also studied. The erosion resistance of the surface is found to be dependent on the steel composition, specifically the

amount of chromium content and tensile properties (yield strength) of the steel. http://eprints.nmlindia.org/6102/

Dey, Sujit Kumar and Vidyadhar, A and Das, Avimanyu (2012) *Processing of electronic waste in a counter current teeter-bed separator.* Journal of Environmental Management, 107 . pp. 45-51.

Advanced gravity separation of ground electronic waste (e-waste) in a teeter-bed separator was investigated. It was established that the Floatex Density Seprator (FDS) is a promising device for wet processing of e-waste to recover metal values physically. It was possible to enrich the metal content from 23% in the feed to 37% in the product in a single stage operation using the FDS with over 95% recovery of the metals. A two-stage processing scheme was developed that enriched the metal content further to 48.2%. The influence of the operating variables, namely, teeter water flow rate, bed pressure and feed rate were quantified. Low bed pressures and low teeter water rates produced higher mass yields with poorer product grades. On the contrary, a high bed pressure and high teeter water rate combination led to a lower mass yield but better product quality. A high feed rate introduced en-masse settling leading to higher yield but at a poorer product grade. For an FDS with 230 mm × 230 mm cross section and a height of 530 mm, the process condition with 6.6 lpm teeter water rate, 5.27 kPa bed pressure and 82 kg/hr feed rate maximized the yield for a target product grade of 37% metal in a single pass. http://eprints.nmlindia.org/5339/

Lee, Jae-chun and Pandey, B D (2012) *Bio-processing of solid wastes and secondary resources for metal extraction – A review.* Waste Management, 32 . pp. 3-18.

Metal containing wastes/byproducts of various industries, used consumer goods, and municipal waste are potential pollutants, if not treated properly. They may also be important secondary resources if processed in eco-friendly manner for secured supply of contained metals/materials. Bio-extraction of metals from such resources with microbes such as bacteria, fungi and archaea is being increasingly explored to meet the twin objectives of resource recycling and pollution mitigation. This review focuses on the bioprocessing of solid wastes/byproducts of metallurgical and manufacturing industries, chemical/petrochemical plants, electroplating and tanning units, besides sewage sludge and fly ash of municipal incinerators, electronic wastes (e-wastes/PCBs), used batteries, etc. An assessment has been made to quantify the wastes generated and its compositions, microbes used, metal leaching efficiency etc. Processing of certain effluents and wastewaters comprising of metals is also included in brief. Future directions of research are highlighted.
http://eprints.nmlindia.org/4200/

Nayak, B and Mohanty, Sunati and Bhattacharyya, P (2012) *Heavy Minerals and the Characters of Ilmenite in the Beach Placer Sands of Chavakkad-Ponnani, Kerala Coast, India.* Journal of the Geological Society of India, 79 . pp. 259-266.

Indian beach placer sand deposits are, in general, ilmenite-rich. However, some concentrations are dominated by pyriboles. The Chavakkad-Ponnani (CP) area along the northern Kerala coast is one such deposit. This paper deals with the general character of the heavy minerals of CP with special emphasis on the characters of ilmenite. Most Indian beach sand ilmenites are of good quality. However, our observations on the ilmenites of CP using Optical Microscope, SEM and EPMA reveals that these are mineralogically very complex. The CP ilmenite varies from pure ilmenite to highly impure variety having intergrowths and inclusions of other oxide and silicate minerals. Ilmenite occurs as mix-crystals and forms intergrowth structure with hematite and Ti-hematite/ulvöspinel; contains inclusions of hematite, quartz, and monazite. On the other hand ilmenite also occurs as inclusions within hematite and garnet. The pyriboles are dominantly amphiboles with hornblende-composition. Interestingly an inclusion of gold has been recorded within amphibole of hornblende composition. Garnets are mostly of almandine and pyrope type. Subordinate heavy minerals sillimanite, zircon and rutile. Characteristic morphology, mineralogy and chemistry of amphibole, garnet and ilmenite together indicate that the placer sands of CP area are derived from the amphibolites, granite gneisses and basic igneous rocks lying in the hinterland towards the eastern border of Kerala. Though the overall quality of ilmenite is poor, high-grade ilmenite concentrate can be generated (of course with lower yield), by adopting precise mineral processing techniques. The CP deposit can be considered as a second-grade deposit but it has potential for future exploitation.