# Caracterización minero-técnica y ambiental del yacimiento Oasis ll, de Santiago de Cuba

# Technical and Environmental Mining Characterization of Oasis II Granitoid Sand Quarry

**Javier A. Vásquez Hechavarría** jvasquezh@gmail.com (1)
https://orcid.org/0009-0001-4451-325X

**Gianna Banesa Moya Rivera** gmrivera@ismm.edu.cu (2)
https://orcid.org/0009-0003-1910-5550

**Luis Alberto Ramírez Meléndez** lrmelendez@ismm.edu.cu (2)
https://orcid.org/0009-0002-6459-8975
(1) Cementos Moncada Company, Santiago de Cuba, Cuba
(2) University of Moa, Moa, Cuba

**Abstract:** This study proposes conducting a mining characterization of Oasis II construction materials quarry in Santiago de Cuba to evaluate the effects of its exploitation on the environment. To this end, fundamental tasks were defined, such as the analysis of the geological, mining-technical, and environmental characteristics of the area, as well as identifying and characterizing the environmental impacts. To analyze the environmental affect the methodology used was based on cause and effect interaction matrix. The study followed national methodological guidelines for environmental impact studies. Among the main results, negative impacts generated during the clearing, stripping, waste dumps construction, soil deposits, and overburden removal, significantly affecting the atmosphere, soil, geomorphology, and geophysical aspects; meanwhile, the socioeconomic environment was the most positively influenced factor, revealing development opportunities for the community.

**Keywords:** construction materials, natural resources, mineral deposits

**Resumen:** Se propone realizar la caracterización minera del yacimiento Oasis II de Santiago de Cuba para evaluar los efectos que provoca su explotación sobre el medio ambiente. Para ello, se definieron tareas fundamentales como el análisis de las características geológicas, minero–técnicas y ambientales del área y se realizó la

identificación y caracterización de los impactos ambientales. La metodología empleada para el análisis de los impactos se basó en la matriz de interacción causa– efecto. El estudio se desarrolló alineado a guías metodológicas nacionales para estudios de impacto ambiental. Entre los principales resultados, se destacan los impactos negativos generados en las etapas de desbroce, destape, construcción de escombreras, depósitos de suelo y extracción los cuales afectan de manera significativa la atmósfera, el suelo, el relieve y los aspectos geofísicos; mientras que el medio socioeconómico resultó ser el factor más influido positivamente, evidenciando oportunidades de desarrollo para la comunidad.

**Palabras claves**: materiales de construcción, recursos naturales, yacimientos minerales

**Abstract:** A mining characterization of Santiago of Cuba's Oasis II ore deposit, is proposed in this paper in order to assess the mining effects on the environment. For that purpose, the main tasks, such as the geological conditions, mining-technical and environmental characteristics of the area were defined and the identification and characterization of the environmental impacts was carried out. The methodology used to analyze the impacts, was based on the cause -effect interaction matrix. The national methodological guidelines were followed in this research in order to conduct the environmental impacts assessment. Among the main results, the negative impacts caused during the completion of clearing, stripping, overburden deposit construction, soil deposit construction works, as well as the mining works stages, are highlighted, which greatly damage the atmosphere, the soil, the relief, as well as the geophysical items; however, the socioeconomic medium was the most positively influenced, so that development opportunities for the community were evidenced.

**Keywords:** construction materials, natural resources, mineral deposits

## Introduction

The mining activities cause negative environmental impacts on nature and society (Vilela, Espinosa & Bravo, 2020; Bravo-Calle, Osorio-Rivera & Loor-Lalvay 2021; Rodríguez, 2022; Rea-Toapanta, 2023), so that preventive and correcting actions must be implemented in order to minimize the negative impacts.

The mining works carried out at the construction materials quarries, may cause damages to the natural environment (Olivera-Ferrer, Ragnar Medina & Hernández Garcés, 2023;

Suárez-Jalca, Baquerizo & Vásquez, 2024). The works that are carried out change the surrounding ecosystems and may create discomforts at the neighboring communities, due to dust emissions, noise generation, as well as gases emissions (Jatib *et al*., 2015; Aguilar Condori, 2024). However, as Anto (2020) assures, today there are technologies and operational practices, which allow to minimise the mining operations impacts up to acceptable levels, by the society. According to Aduvire (2023) the environmental impact studies must provide the existing environmental conditions, so that they allow to identify the potential environmental impacts and to prevent them. (Marchevsky *et al.,* 2018; Vandana *et al.,* 2020; Lee *et al*., 2024). Besides, the environmental impact assessment is a preventive tool that allows to combine the economic, social and environmental development (Sucari-León, Chambi-Condori & Llanque-Maquera, 2022; Aguilar Condori, 2024; de Almeida *et al.,* 2025). According to Chica & Zaldumbide (2021), one alternative is to identify the generated environmental impacts magnitude, as an action that will allow to control and prevent the negative effects and maximising the positive ones, by carrying out the environmental impact assessment.

Oasis II ore deposit is a main place for the construction material industry in Santiago of Cuba. Its role is to provide quality construction materials, based on excellence, innovation and experience for the construction material industry in Santiago of Cuba. During the visits that were carried out to Oasis II Granitoid Sand ore deposit, the rehabilitation programs that were approved by the competent authorities, as well as the mining operations projects, as well as the environmental researches were not evidenced.

This paper aim is to carry out the mining- technical and environmental characterization of Granitoid Sand Oasis II Ore Deposit, in Santiago of Cuba, which will allow to minimize the negative environmental impacts that are caused by the mining works.

## Materials and methods

The working zone is located at 15 km to the east of Santiago of Cuba City, just at Oasis Community, at the Siboney cartographic 5075-I 1: 25 000, of the Cuban Institute of Geodesy and Cartography.

For the estimation of the measured resources, based on the specific conditions of the subject matter, as well as the morphological characteristics, the geological structure, as well as the methodology used for this exploration stage were used, taking into consideration the degree of the research performed in the sector, which was carried out

in a 100 x 100 m grid, that due to the ore deposit characteristics, the resources may be evaluated as measured category.

On the other hand, the mining works (in the final stage) of the Concession El Oasis, whose mining limits are directly adjacent to Oasis II ore deposit, were taken into consideration. The cut-off sequency shows that the granodiorites, that are modified up to the sandy stage, keep a stable behavior that supports the investigation network, that is used for performing these works, allowing to use the geological block method, that was applied at the prospection and exploration stage, as it is an extended deposit at the horizontal line and at the vertical line, as compared to a continuous solid package of eluvial sand.

**Impacts identification methodology**

The methodology to identify the impacts is aimed at detecting the potential positive effects, (if beneficial effects on the environment are evidenced) as well as the negative impacts (if negative effects on the environment are experienced), which could be generated by the mining works.

The cause-effect interaction matrix was selected due to its simplicity and its easy application (MendozaZapata, Pacheco-Bustos & Certain-Abraham, 2021; Rodríguez & Ramírez, 2023). This tool allowed to evaluate the damages caused by human actions (construction, mining operations, transportation), as evidenced in several components of the environment (soil, water, air, biodiversity). It was used in order to associate the works that generate impacts, with the environmental factors capable of causing damages (Álvarez et al., 2007; Centeno-Bordones, Labrador & Lara, 2021), as it has been supported by the criteria expressed by 20 experts, the checking list and the consultation of other researches for similar projects in the region.

**Description of the methodological stages:**

- Stage 1. Search, selection and analysis of the available information. All the information about the working area was compiled and revised. The existing reports on geological, mining-technical, and environmental assessments on Oasis II ore deposit, were consulted and discussed. The search of current documents providing current environmental regulations in Cuba and worldwide on environmental protection issues, allowed to set the basis to perform the investigation. So that the data were processed and interpreted.

-Stage II. Field work: Travels to the ore deposit were carried out in order to evaluate the mining-technical and environmental conditions. Besides, travels were carried out in order to verify the geological, mining-technical and environmental information on the ore deposit mining, from the previously compiled information, taking into consideration the location, climate, relief, tectonics, hydrogeology, biological life (forestry, animal life and microorganisms), as well as the social and economic issues. The actions required to perform the ore deposit mining operations, were identified, based on travels and consultations with the technicians and engineers of the ore deposit. The actions conforming the ore deposits mining processes were identified, by doing travels and consultations with the technicians and engineers of the ore deposit. Travels to identify the environmental impacts that are generated by the mining of each ore deposit, were carried out in the ore deposit location, as well as the surrounding environment. The air quality, the soil characteristics, the surrounding vegetation, the landscape, the erosive processes, the forestry and fauna, as well as the presence of communities that are close to the ore deposit and that could be influenced directly or indirectly by the mining operations, were discussed.

- Stage III. Office work: The compiled information was processed at this stage.

## Analysis of the results

## Mining-technical and environmental characterization of the Oasis II Ore Deposit

The technological processes that are carried out at the mine, must assure the continuous mining of the ore reserves at the set time, the quality of the process after mining depend on them (Soto-Vázquez, 2025). The mining processes are divided into two types: the main process and the auxiliary ones, within the first ones, the following ones are included: clearing works, stripping works, mining and ore haulage works, as well as the overburden deposit construction works. The auxiliary works include other activities to assure the development of the main processes.

### Mining equipment:

-Loader XLMG ZL–50G
Capacity: 2.5 $m^3$
Length: 1 7.60 m
Width: 2.90 m

- Dump truck SINOTRUCK STEYR 13 $m^3$/20t 2 7.00 2.30 27

- Bulldozer Komatsu D–85A–12
Power: 180HP
Length: 5650 mm
Width: 3060 mm
Fuel: Diesel
Consumption: 18.81l/
Width and length of the blade: 4260 mm x 1060 mm
Maximum cutting penetration (p): 530mm (real 420mm)
External turning radio: 3300 mm

- Scraper
Width (Ae): 2164 mm
Quantity of teeth: 3
Working depth: 650 mm
Distance between (De): 925 mm
Drive: hydraulic
Truck Model: 650 mm

- Truck Kraz Modelo: 256–B
Fuel: Diesel
Power: 215 HP
Fuel Consumption Rate: 0.481 l/km
Maximum Gradeability: 18º (i=32)
Outer Turning Radius: 11200 mm
Minimum Track Width: 2640 mm
Dumping box
Length: 5570 mm
Width: 2480 mm
Capacity: 8$m^3$= 12t

Clearing works: The clearing work means breaking and removing all the surface of the undergrowth and vegetation, covering all the sterile layer, with a thickness of 0.3 a 1.0 m, that enable to carry out the earthing works for the ore stripping and overburden removal works. This zone has few vegetation, so that the work is facilitated.

Stripping works: The stripping work refers to removing the layer of sterile material, that are considered out of the range, because they do not comply with the set mining requirements, regarding the clay content. This operation is also denominated as overburden removal, that begins when the clearing work is completed and it finishes when it reaches the top distance to the ore.

Quarry drainage: According to the geological reports, the ore deposit is hydrologically simple, so that it shows a positive character, with cracks and calcifications allowing the water to be fully drained.

Removal of the useful component: It refers to removing the ore to be hauled to the processing plant, where it is processed to produce the clay-free sand, as it reduces the sand quality standard.

Useful component haulage: It refers to conveying the ore ready to be delivered to the processing plant, as it is provided in the zone in order to reduce the ore haulage distance, so that fuel consumption rates were reduced. The same equipment of the quarry was used.

Ore deposit opening: The quarry mining system, the legacy and the haulage equipment to be used, must be considered in order to select the ore deposit opening method. The zone ore deposit opening shall be carried out by an access mine road, that is located from the main road to the area that is going to be mined out.

Mining system: Due to the ore deposit geological conditions, and its location on the external layer of the soil, they are the two most important characteristics of the ore deposit. In this case, the mining system to be used is the open-pit mining system.

Drilling and blasting works: Considering the physical-mechanical properties of the rocks, the starting process, is carried out by using the drilling and blasting method. These works are carried out by the Geological-mining services (EXPLOMAT), which is provided with the duly qualified personnel and the specialized equipment. In the case of the secondary blasting works, the drilling of the tacos is performed by using manual drilling equipment PR–206 with diameter of 40 to 50 mm. The preliminary breaking of the granitoid sand is carried out by the drill loads, meanwhile the big rocks are reduced by using breaker hammers. A mesh design of 4 × 4 × 6 m is used for blasting, with the use of Trecton explosive. The mining Banks height range between 6 and 8 m, generally

operating at one quarry mining face. The drilling of the 31 drills is carried out i with drilling carts, allowing a controlled and safe performance of the process.

Working system: The Ore deposit Oasis II is provided with a day shift for 8 h during the 365 days of the year but just 332 days are used (the holidays, as well as the maintenance and repair days are excluded).

Auxiliary Works: The auxiliary works are aimed at making the main processes to be carried out with high quality and within the required time. Among them there are the road and equipment maintenance, as well as providing sand to the entities, the reception hoppers foundation and other works to assure that the production plan is complied.

**Description of the cause-effect interaction matrix**

For performing the double -entry tables or cause -effect interaction matrix, the activities that generate impacts were related to the factors of potential damages, as well as the checking list of possible impacts. The environmental impacts that were considered in the matrix were grouped as follows:

Landscapes and morphology

Soil and relief

Atmosphere

Surface and underground waters

Forestry and fauna

Geophysical items

Socio-economic medium

Oasis II Quarry mining actions, that influenced on the natural and socio-economic factors of the medium are as follows: road construction works, clearing works, stripping works, loading and ore haulage works, as well as the drilling and blasting permits. The results are shown as described in the table 1.

Table 1. Cause-effect interaction matrix of the ore deposit

| Affected factors | Actions | Environmental impacts |
|---|---|---|
| Landscape and morphology | Clearing works. Stripping works. Road construction. Loading and ore haulage. Mining, drilling and blasting works. | 1. Visual quality change<br>2. Damage to the Landscape harmony |
| Soil and relief | Clearing works. Stripping works Road construction. Ore haulage. Mining, drilling Works. | 3. Change of the relief shape and soil composition.<br>4. Increase of the erosive processes<br>5. Soil layer compacting |
| Atmosphere | Road construction. Clearing works. Stripping works. Overburden removal deposits construction and soil deposits construction. Loading and haulage. Mechanical preparation plant. Mining, drilling and blasting works | 6 Dust emission to the atmosphere<br>7. Gas emissions to the atmosphere<br>8. High intensity noise emissions<br>9. Vibration emissions<br>10. Continuous and variable noise emissions |
| Surface and underground waters | Construction of overburden and soil deposits. Ore haulage. Mechanical preparation plant. Mining, drilling and blasting works | 11. Contamination of local water deposits by liquid wastes<br>12.Surface and underground water quality reduction, due to the presence of suspended solids |
| Flora and fauna | Road construction clearing. Clearing works. Creation of waste dumps and soil deposits. Extraction, drilling, and blasting works | 13. Destruction of vegetation<br>14. Migration of species and modification of migration routes |
| Geophysics | Road construction. Clearing works. Stripping works, ore haulage. Mining, drilling and blasting works. | 15. Increase of erosion dynamics, landslides, transportation and sedimentation |
| Socio-economic medium | Road construction. Clearing works. Stripping Works. Construction of overburden deposits and soil deposits. Loading and ore haulage and Mechanical preparation plant. Mining, drilling and blasting works | 16. Creation of new jobs<br>17. Increase of social services demand<br>18. Environmental discomforts |

## Environmental impacts characterization

The environmental impacts characterization was put into practice taking into consideration one criteria, based on the environment care and protection, with the search of suitable solutions and the use of several media in order to decrease the negative effects. In this case, the dangers which may interfere with other information and interests were outlined, in a flexible manner, regarding the above-mentioned discussed phenomena. it was carried out by using the study of the environmental works prepared by GeoCuba Company. Besides, interviews and consultation with experts were carried out.

**Characteristics of the ore deposit environmental impacts**

Visual quality change: The moving surfaces due to the ore deposit mining and the modification of the landscape due to the introduction of other items, were observed. The habitat modification with landscapes value with irreversible losses was evidenced. The rainfall action that contributed to the modification, through a greater erosion that is observe in the mining area, is added to it. Generally, this impact has an irreversible character and it still remains after the mining works are completed.

Destruction of landscape harmony in the natural morphology: The clearing work was totally completed through the quarries mining operations, at the mining faces. The construction of overburden and soil deposits construction works, led to permanent modifications of the natural morphology, with high intensity and long-term appearance. Its recovery capacity is irreversible.

Soil composition change: Slope modifications, due to road construction works, clearing works, stripping, construction of overburden and soil deposits works, as well as mining operations, were evidenced. Also, the way of relieves, mainly due to the intense erosion, occurred through the changes, taking place at the slope and alongside the ore deposit slope. These factors acted directly on the torrent's velocities, which led to soil losses due to laminar erosion. Also, the soil composition was changed and the surface water way was transformed.

Increase of the erosive processes: The activities of road construction, creation of spoil heaps and soil deposits, as well as the removal of vegetation cover and the removal of sterile material carried out for the extraction of the mineral, removed a large part of the vegetation and soil, where climatic factors water, air, precipitation and temperature, caused the increase of erosive processes. The soil erosion process, taking place specially on the edges of the quarry, have been caused due to the rainfall waters that exercised pressure over the crack walls, causing collapses. This is a strong magnitude impact.

Reduction of surface water and underground water quality, due to the presence of suspended solids: The mine road construction, the clearing works, the stripping works, overburden removal deposit, as well as and the soil deposit construction, the mining works, the loading and material haulage works, as well as the dust emission caused by the mechanical preparation plant, have led to an increase of suspended solids, so that they have caused the waters turbidity and damages to marine fauna, due to the

deposition of dust particles in the fish's gills. Also, removing the material on the bottom, changed the underground water quality, due to variation of the infiltration. This impact is irreversible due to its recovery capacity and it is of long-term permanent appearance.

Destruction of vegetation: Road construction, clearing, soil removal, creation of spoil heaps and soil deposits, as well as material extraction, caused the destruction of vegetation and plant cover, leading to the loss of the soil's agrochemical properties. This impact is significant, irreversible, permanent, of high intensity, and long-term.

Migration of the species and migration routes modification: The mine roads construction, mine clearing, stripping, the construction of overburden deposits works and solids deposits, as well as the mining works and the increase of the human presence in the area, have caused damages due to the noise, dust generation, vibrations as well as the loss of the ecosystems, which also damages the natural habitat of several species. The response to it was migration in many cases. Other migratory species suffered from the modification of the migration routes. So, this is an irreversible and temporary impact, that is manifested at a medium-term.

Increase of the erosion dynamics, landslides, transportation and sedimentation of the particulate material: The activation of the erosive and sedimentation processes, showed a punctual occurrence probability and high intensity, due to the earth cuts with inclined slopes at the access and circulation ways leading to sedimentation and activation of the erosive processes during the rainy periods. Due to the blasting effects, the earth surface that is close to blasting operations, suffered a displacement and its magnitude depended on the energy generated by the explosives and the local geological conditions. Consequently, the erosion and landslide processes appeared.

Generation of new employments: The ore deposit mining operation works have turned into positive impacts, because a great number of jobs are available.

Increase of social services demand: The ore deposit mining works, have implied an increase of social services demand, such as transportation, education, services, due to the ore deposit mining works social services that are required.

## Conclusions

The technical-mining and environmental characterization of the granitoid sand ore deposit Oasis II, showed the occurrence of negative and positive impacts. The study of the geological, mining-technical and environmental characteristics of the ore deposit, enabled to determine the environmental factors that are subject to receive impacts.

The environmental positive or negative impacts were identified and characterized by using the cause-effect interaction matrix. It was proved that the actions that generate more negative effects and the greatest damages to the environmental components, are as follows: the clearing works, the mine stripping works, the construction of overburden removal deposits construction works and soil deposits construction works, as well as the mining works. The socioeconomic medium was the one with most positive impacts.

## Bibliographical references

Aduvire, O. (2023). Gestión ambiental en minería: certificaciones para iniciar y finalizar la actividad minera. *Revista de medio ambiente minero y minería, 8*(1), 31-39. http://scielo.org.bo/scielo.php?script=sci_arttext&pid=S2519-53522023000100004&ing=es&tlng=es

Aguilar Condori, P. (2024). Evaluación de los Impactos Ambientales en la Cantera Taparachi Generadas por la Explotación de Materiales Empleados en la Construcción. *Ciencia Latina,* 8(2), 1306-1326. https://doi.org/10.37811/cl_rcm.v8i2.10568

Álvarez, J.N., Rodríguez, A.Á., Pompa, N.P., Reyes, A.M., & Franco, E.D. (2007). Impacto ambiental de la industria petrolífera de Santiago de Cuba. Caracterización. *Tecnología Química, 27*(2), 83-91. https://www.redalyc.org/pdf/4455/445543753013.pdf

Anto, M.P. (2020). Impacto de la minería y tala ilegal en el desarrollo y Seguridad Nacional. *Revista de Ciencia e Investigación en Defensa,* 1(2), 50-60. http://recide.caen.edu.pe/index.php/recide/article/download/23/22

Bravo-Calle, O.E., Osorio-Rivera, M.A., & Loor-Lalvay X.A. (2021). La calidad del desarrollo industrial y su impacto en el medio ambiente. *Polo del Conocimiento, 6*(9), 153-167. https://doi.org/10.23857/pc.v6i9

Centeno-Bordones, G., Labrador, H., & Lara, G. (2021). Aguas agrias en el procesamiento de crudos pesados: caracterización fisicoquímica y prognosis de su impacto ambiental. *Novasinergia, 4*(1), 115-135. https://doi.org/10.37135/ns.01.07.07

Chica López, M.G., & Zaldumbide Peralvo, D. (2021). Políticas de mercados verdes y su capacidad de respuesta frente a las nuevas exigencias coyunturales. *Polo Del Conocimiento*: *Revista Científico-Profesional, 6*(3), 1075-1096. http://polodelconocimeinto.com/ojs/index.php/es/article/view/2422

Fernández De Almeida, J.P., Akita-Vitorio, C.V., Ribeiro de Almeida, J., Cardoso-Bispo, L., & de Couto-Pereira, R. (2025). Evaluaciones de impacto ambiental. *Revista Internacional de Ciencias, 15*(2), 221-236. https://doi.org/10.12957/ric.2025.93158

Jatib, N.H., Ulloa-Carcasés, M., Almaguer-Carmenate, Y., & Ferrer, Y.R. (2015). Evaluación ambiental asociada a la explotación del yacimiento de materiales de construcción La Inagua, Guantánamo, Cuba. *Revista Luna Azul, 38*, 146-158. https://bit.ly/39dpcNC

Lee, C., Asbjornsson, G., Hulthén, E. & Evertsson, M. (2024). The environmental impact of extraction: A holistic review of the quarry lifecycle. *Cleaner Environmental System*, 13. https://doi.org/10.1016/j.cesys.2024.100201

Marchevsky, N., Giubergia, A.A., & Ponce, N.H. (2018). Evaluación de impacto ambiental de la cantera "La Represa" en la provincia de San Luis, Argentina. *Tecnura*, *22*(56), 51-61. https://doi.org/10.14483722487638.12907

Mendoza-Zapata, L.A., Pacheco-Bustos, C.A., & Certain-Abraham, W.D. (2021). Evaluación de impactos ambientales asociados a la eventual recuperación ambiental de canteras con residuos inertes de construcción y demolición en Barranquilla y su área metropolitana. *Ingeniería y Desarrollo, 39*(2), 275-295. https://doi.org/10.14482/inde.39.2.628

Olivera-Ferrer, M.C., Ragnar Medina, L. & Hernández Garcés, A. (2023). Determinación del contenido de finos en las Canteras Mariel. *Minería & Geología, 39*(4), 267-276.

Rea-Toapanta, A.R. (2023). Daño ambiental y economía circular en la explotación de los recursos naturales no renovables. *FIGEMPA: Investigación y Desarrollo, 16*(2), 93-105. https://doi.org/10.29166/revfig.v16i2.4104

Rodríguez, D. (2022). Enfoque medioambiental de la minería con visión de desarrollo sostenible. *Revista de Gestión del Conocimiento y el Desarrollo Local, 9*(3). https://cu-id.com/8973/v9n3e0

Rodríguez, J.M., & Ramírez, J.M. (2023). Diseño de matriz como herramienta para la evaluación de requerimientos de calidad, medio ambiente y seguridad. *Project desing and Managament, 5*(1). https://www.mlsjournals.com/Project-Desing-Management/article/view/1129

Soto-Vázquez, R. (2025). Life-Cycle assessment in mining and mineral processing: A bibliometric overview. *Green and smart mining engineering, 2*(1), 73-83. https://doi.org/10.1016/j.gsme.2025.02.01

Suárez-Jalca, M.A., Baquerizo, F.E., & Vásquez, A.E. (2024). Actividad económica Explotación de otras Minas y Canteras (CIIUB08): Análisis social y ambiental en Guayas, Ecuador. *Revista científica de Salud y Desarrollo Humano, 5*(4), 307-347. http://revista.vitalia.org/index.php/vitalia/article/view/367

Sucari-León, A., Chambi-Condori, N. & Llanque-Maquera, O.E. (2022). Evaluación del impacto ambiental en la cantera de roca San Luis de Alba, Puno Perú. *DYNA, 89*(220), 195-202. https://doi.org/10.15446/dyna.v89n220.92992

Vandana, M., John, S.E., Maya, K., Sunny, S., & Padmalal, D. (2020). Environmental impact assessment (EIA) of hard rock quarrying in a tropical river basin-study from the SW India. *Environmental monitoring and assessment*, *192*(9), 1-18. https://doi.org/10.1007/s10661-020-08485-x

Vilela, W., Espinosa, M. & Bravo-González, A. (2020). La contaminación ambiental ocasionada por la minería en la provincia de El Oro. Estudios de la Gestión. *Revista internacional de administración*, (8) 210-228. https://doi.org/10.32719/25506641.2020.8.8