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# Environmental Impact Assessment of Mining in Dana Reserve

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*Abstract*—. **Mining and disposal of copper mining waste can threaten the ecosystem and human health in general, and the threats become more severe if they are accompanied by the establishment of copper mining operations within a natural reserve, which constitutes a special and unique case of distinction, such as the Dana Reserve - in southern Jordan. Through this study, research was used that discussed copper mining in different regions of the world, to simulate what would be the case in the Dana Reserve if copper was mined there. It was found that there are significant negative effects on the environment represented in the effect on surface and groundwater, air, plants, animals as well as the resident and migratory birds through this area, and high levels of chromium and nickel were also found. The generation of tailings in the world today is immense, since only less 1% metals are extracted for each ton of ore processed. It was estimated that more than 14 billion metric tons of mining waste were produced yearly in the world. Dana Biosphere Reserve is Jordan's largest nature reserve covering all four bio-geographical zones Springs and groundwater are major sources of drinking water and irrigation activities in Dana's rural communities and visitors' accommodations. Besides promoting public health and reducing environmental pollution, Groundwater contamination risk is a critical point when implementing mining treatment systems. Biosphere Reserve area must include the development of a groundwater monitoring program during the mining.**

*Index Terms*— **GIS, Dana Biosphere Reserve, Copper Mining**

## I. Introduction

Jordan has been ranked 70th among 149 countries in the 2008 Environment Performance Index (EPI). The Kingdom was given an overall score of 76.5 per cent in the study, which ranks 149 countries on 25 indicators tracked across six established policy categories: Environmental health, air pollution, water resources, biodiversity and habitat, productive natural resources and climate change. The Dana region is characterized by high levels of slope, which increases the flow rate, which is reflected in the amount of sediment carried by the flowing water

This feature must be taken into account during the mining process. The main technology to obtain concentrates of valuable metals such as copper and thus generate mining waste from the processing of sulphide minerals on an industrial scale is froth flotation. Tailings are a residue of the froth flotation mining–metallurgical process, usually a very fine mud or powder, left over after the ore is processed and the valuable minerals are extracted. There are different and varied processes for the extraction of minerals used in the current mining industry, where physical and chemical processes for mineral benefit are usually the most used, mainly because they are cheaper to operate [3],[5].

An environmental impact assessment (EIA) is a legally binding procedure for the mining companies to comply with that requires evaluating the environmental impacts of a mining project on the environment . The EIA tools vary depending on the type of mineral and mining technology, usually involving identification, assessment and reporting of environmental impacts and developing mitigation measures. Environmental impacts and risks are quantified based on specific indicators used to characterise the environmental quality. These indicators and their acceptable norms vary depending on the country's legislative frameworks, and international standards and regulations. For open pit mining of mineral deposits, the environmental impacts and risks include but are not limited to pollution of the atmosphere by emissions of gaseous and suspended substances, noise exposure, contamination of surface and ground waters, changes in hydro geological conditions, sewage and waste, impacts on biodiversity, flora and fauna, natural land transformation and loss of habitat, and community and cultural impacts, such as displacement of livelihoods and economic effects.[10]-[11],[20].

The mining of copper and other minerals in the Dana Reserve has been the subject of great controversy between two parties. The first team defends the mining of these important minerals because of their economic impact on the local community and the residents of the region in particular and the Jordanian state in general,also, Copper is one of the most important metals for the world economy, since it is essential for the production of several consumer goods. while the other team defends the environment and the biosystem. Which includes a unique biodiversity in the world and the largest nature reserve in Jordan, extending within four vital and climatic regions, on the edge of the Great Rift Valley within the Rift Valley, which is characterized by stunning landscapes and a pure healthy environment that is a pilgrimage for tourists and visitors to enjoy its stunning beauty Fig.1.

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**Fig. 1 part of Dana's view**

## II. PROCEDURE

### *A. The site*

Dana Reserve is located in southern Jordan, 30 km north of the city of Petra - one of the Seven Wonders of the World - on the edge of the Great Rift Valley and about 180 km southwest of the Jordanian capital, Amman.Fig.2. It covers an area estimated at 320 square kilometers, and contains a biodiversity, rocks, many mineral ores, stunning landscapes, and a group of surface springs that run in the main valleys of the Dana Reserve, in addition to the abyssal waterways of the Canyon. The height of the highest area of the reserve ranges around 1,600 m above sea level in the eastern part of it, descending through highly eroded tectonic formations, representing part of the rift pit, consisting of limestone, sandstone, and granite that have been exposed to wind and water erosion, weathering, erosion, and various sedimentation factors, to reach approximately 100 m. Below sea level in the western part of the reserve, which represents part of the Wadi Araba desert. As a result of this severe erosion, it was affected by four climatic zones, where the Mediterranean basin climate appeared in the eastern part of the reserve with an altitude of about 1600 m, then followed by the Irano-Turanian region, then the Sudanese region, up to the desert region represented in a part of the Wadi Araba region at an altitude About 100m below sea level.[1],[2].

Due to the diversity of climatic regions within a relatively small area, this resulted in a great wealth of plant and animal species, in addition to more than 200 species of resident birds as well as migratory birds, as they are located within an important region where the continents of Asia, Africa and Europe meet.

Two geographical regions meet in one place at a distance of about 8 km, the Mediterranean region and the desert region. This unique meeting gives an additional dimension to these regions and a competitive advantage for the place. In less than 20 kilometers, four regions meet within the Dana Reserve. As the semi-arid Mediterranean region, the Iranian-Turanian region, the Sudanese region, and the desert region meet, and the plant patterns, biodiversity, varying heights, and different topography of the land meet with them.

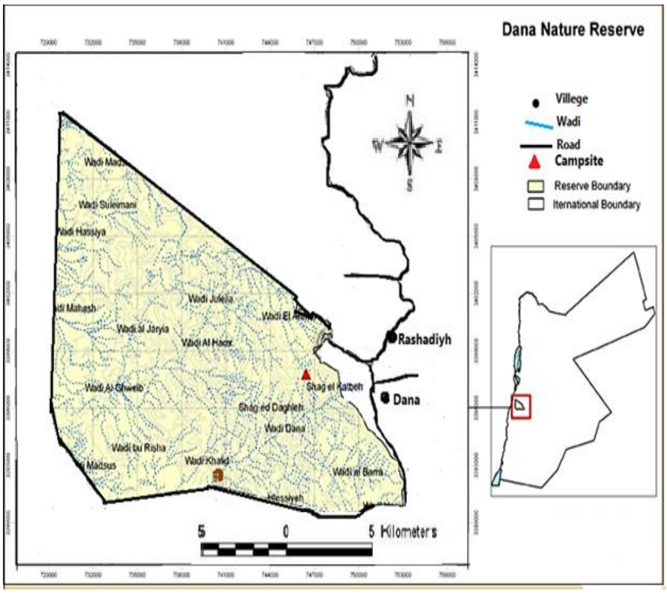


**Fig.2 Dana Reserve site**

### *B. Technologies used*

GIS technology is widely used in all stages of environmental impact assessment, starting from screening and scoping. GIS also helps in collecting and analyzing information, in spatial analysis and spatial modeling, in impact assessment, in all computational operations, in calculating morphometric variables, in describing and tracking work stages. The development of environmental effects during work, placing the project in a geographical context, and setting an environmental baseline that tracks the development and progress of various influences in the ecosystem and contains biophysical inventories such as land uses, vegetation cover, topography, hydrological system, soil, archaeological, historical resources, area topography, streets, and utilities.

### *C. Mining procedures*

The mining process is carried out through several methods and coordinated processes, starting with conducting studies on samples, conducting the necessary tests to determine the reserves of copper ores, choosing the appropriate methods for mining operations, and determining the areas of land on which they will be located. Excavators and crushers were used to dig trenches and wells in separate areas, then samples were taken to find out the amount of metal concentrations. This process is environmentally low impact. As it does not produce new chemical elements and does not use dangerous chemicals in it. As the effect of this process is limited to leaving dirt residues and changing the shape and topography of the land, and thus it is possible to cause damage to the plants and animals in the area, as they are adapted to the current conditions and not to the conditions that will be imposed by the excavation and exploration operations in the place. As for mining operations, they are carried out in several ways, represented by blasting,

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drilling, the use of rock solvents such as sulfur acid, or by removing the surface soil cover." Open Cast Mining", and the most appropriate method is chosen from among these methods according to specific variables such as the hardness of the rock, the concentrations of copper ores, the distance of the metal, and its distance from the earth's surface Fig.4.

The process of extracting copper from Sulphide minerals and generation of mining tailings in Chile and Peru. Copper sulfide minerals are being exploited both, since sulfide minerals predominate over oxides minerals. Chalcopyrite ($CuFeS_2$) is the main sulfide ore of copper, also containing variable amounts of unwanted and invaluable pyrite ($FeS_2$). On an industrial scale, copper sulfide minerals are concentrated using froth flotation processes . Froth flotation uses chemical reagents (collectors, foamers, and modifiers) to control the wettability of solid surfaces, solution electrochemistry, solid particle dispersion and aggregation, and foam generation [4]. In this way, it is possible to recover mineral species of interest and avoid the flotation of unwanted gangue minerals[10]. The average concentration used in 2012 in both Chile and Peru was 50 g/ton of ore and 30 g/ton of ore, respectively. Conventional flotation cells consist of a tank with an agitator designed to disperse air into the suspension, as shown schematically in Figure 3,[6]. typically assembled in a multi-stage circuit with cells rougher and cleaner . Finally, the copper concentrate obtained is taken to a recovery plant, and the tailings obtained are normally dewatered using thickeners and stored in the tailings storage facility.

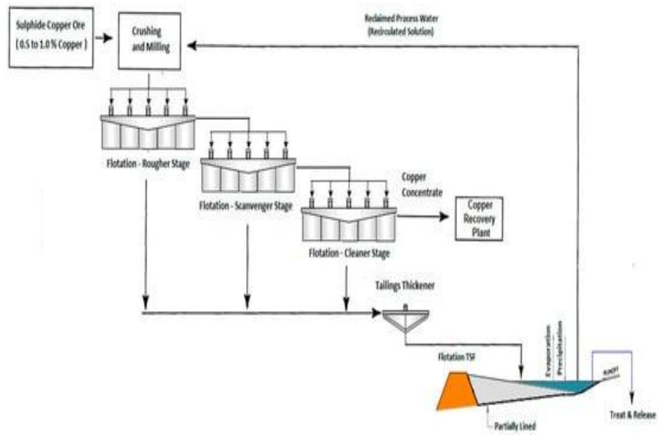
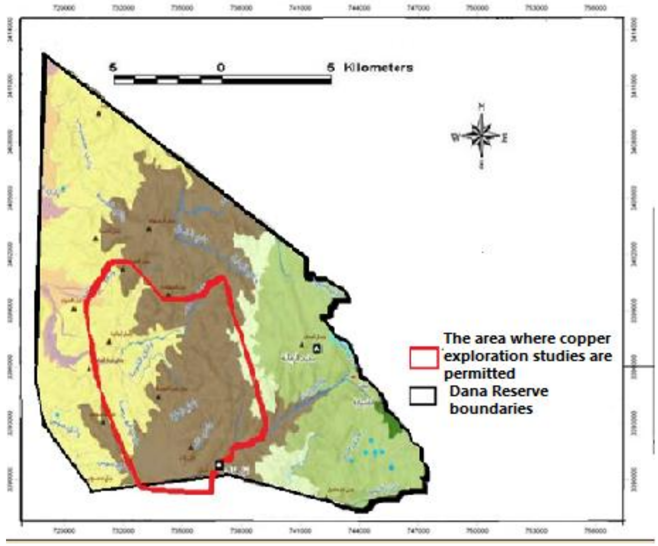



**Fig.3**. **Copper Ore Sulphate Process**

Copper tailings storage facilities are generally partially lined. To prevent seepage through the foundation and core of the dam, the following are installed: 1- a stop-leak trench and a grout curtain control system along the foot upstream of the dam 2- geomembrane with geotextile. The liner is placed on the upstream face of the dam. This means that the dam has a continuous impermeable barrier that runs the length and width of its upstream face, which waterproofs this part of the reservoir

The mining process may have a significant impact on the environment or a small impact, depending on the materials and technology used, but preventing an environmental impact is not practical at all, as the process of controlling the movement of elements and materials resulting from mining is difficult to achieve; The fact that these materials are already present in the environment, and the mining process will allow these minerals to move from one place to another, and interact with other elements, and the process of crushing and fragmenting the rocks will make these materials that are already present in the rocks more vulnerable and easy to leak, especially with air and rainwater, so it is possible to enter the soil And vegetation cover, groundwater and water bodies, and it is transmitted to the existing vegetation cover in the region and enters the food cycle and harms humans.




.**Fig.4 Copper mining area in the Dana Reserve**

## III. MATH METHODOLOGY OF THE STUDY

Through this, the potential for air pollution resulting from mining operations will be estimated, compared with mines similar to gold and copper mining, and the resulting pollution, its levels, and recommendations that can be made in similar circumstances will be estimated.

The water network will also be studied and the impact of mining operations on the waterways will be expected and the expected geomorphological modification and its impact in addition to the expected impact on the water basins in the study area, both surface and groundwater, and the expected water needs for mining operations and simulate that with areas where mining took place under similar conditions. For each hydrogeologic setting, there are many measurable factors related to the DRASTIC methodology. include :

1- Aquifer Media (A): The material of the aquifer determines the mobility of the contamination through it.2 - Depth to Water (D):There is a greater chance for the contamination to reach and pollute the groundwater in shallow aquifers more than in deep aquifers.3- Recharge (R): More recharge to the aquifer causes more possibility of the pollution being transported to the groundwater.4 - Soil Media (S):Soils containing clays and silt will have a large water-holding capacity.5-Topography/Slope(T): Topography of the land surface with a higher slope means low pollution potential due to high runoff and erosion rates. 6-Impact of the Vadose Zone Material (I): The unsaturated zone above the water table is referred to as a vadose zone. The texture of the vadose zone determined how long time would need. 7 - Hydraulic Conductivity (C): The amount of water percolating into the groundwater is determined by hydraulic conductivity. The pollutant travel time is decreased within the aquifer if the soil has high permeability. The DRASTIC model uses a numerical relative rating and weight system.: 8 - Rating: range for each DRASTIC factor has been evaluated; the rating is from 1 to 10.

The impact of mining on changing the landscape will also be studied in the Dana area, which is originally a natural reserve, and the most important characteristic of it is the picturesque landscape overlooking the western façade, where the sun sets, the rock formations, the waterways and the landscape, which is extremely magnificent and beautiful.

## IV. RESULT

Waste Management

produced depends on the type of mineral extracted, as well as the size of the mine. Gold and cupper are among the most wasteful metals, with more than 99 percent of ore extracted ending up as waste. By contrast, iron mining is less wasteful, with approximately 60 percent of the ore extracted processed as waste [7],[9].

Disposing of such large quantities of waste poses tremendous challenges for the mining industry and may significantly impact the environment. The impacts are often more pronounced for open-pit mines than for underground mines, which tend to produce less waste. Degradation of aquatic ecosystems and receiving water bodies, often involving substantial reductions in water quality, can be among the most severe potential impacts of metals extraction. Pollution of water bodies results from three primary factors:

sedimentation, acid drainage, and metals deposition.

In Peru as a similer case,the results of the analysis indicate that the soil samples present high concentrations of Ni, Cu, Zn, As, Pb, and Fe, which are altering the quality of the soil, exceeding the environmental quality standards in the case of As and Pb, and exceeding international standards in Cu, Zn, As, and Pb. Regarding the tailings samples, it can be seen that they are materials with high concentrations of heavy metals, together with concentrations of CN and Hg that do not exceed the mentioned standard [6].

Ground and surface water, in a similar project, the results showed that the long-term effects on water quality, erosion and sedimentation in watersheds were negligible if this was accompanied by reclamation efforts and re-vegetation, but in the short term it is expected that the effects will be negative on the surface water quality, and the accompanying effects depend on the mining plan. The size of the work, the size of the waste rock and the dust accompanying each stage of work, and the time and momentum of the work

Many environmental problems associated with tailings management in both Chile and Peru are related to the potential contamination of soil, water (surface/underground water), and air. , infiltration control from tailings storage facilities, and operational management of mine tailings. However, tailings spill accidents still occur in the world. Failures of tailings occur mainly due to: 1- causes of human origin, inadequate management of tailings/water, etc. 2- natural causes (e.g., floods, earthquakes, alluviums, etc.), which indicates that for these hazardous wastes there is still no degree of safety that allows to provide confidence to vulnerable communities and ecosystems. This has meant that tailings transport and storage activities today represent a matter that requires adequate environmental management and responsible management.

Dust, It will be generated mainly from mine blasting, wind and material transportation on dirt roads and topsoil during loading and storage operations. Especially in dry seasons, operations such as topsoil stripping, ore mining, loading, blasting, drilling, material transportation and hauling are future sources of dust though inconsistently. Vehicle exhaust air pollutants: they will be generated from the exhaust of mine machinery operations[7],[8]. It is economically advantageous to locate the tailings storage facility close to the mine, but this imposes limits on site selection. The type of tailings storage facility is generally determined by local seismic activity, process water clarification requirements, tailings properties and physical/geochemical stability; tailings size distribution, hydrological conditions, and environmental factors[9],[10].

Tailings storage increases production costs, so it is essential that disposal be as economical as possible. This requirement initially led to the development of the upstream construction method of tailings dams once commonly used, but some accidents at Barahona tailings dam in Rancagua Chile (1928), the El Cobre tailings dam in Nogales Chile (1965), resulted in a ban on upstream dam construction technique in both countries. Actually, considering conventional tailings technology, the most popular methods applied in copper tailings storage facility are downstream and centerline dam construction methods

Environmental Impacts on the Physical Environment/Air

Mine tailings particles can be resuspended by wind and human activity, where particles < 10 μm, and especially those < 2.5 μm, with metallic species in colloids that can cross the defenses of the respiratory system and enter the lungs One of the most harmful effects of tailings deposits adjacent to towns in Peru the inhalation of particles with heavy metals such as lead, with children and animals being the most vulnerable receptors. No air pollution by particulate material has been documented in this spill case, since most of the particulate material was deposited in the riverbed and the rest remained suspended in the water column [8].

Copper and gold tailings have a typical particle size distribution, where 25% of the total particles correspond to PM10 and 12% to PM2.5. Considering that tailings have a dry density of 1.5 tons/m3, this means that for 1.5 tons of tailings deposited there is an average concentration of 100 × 106 μgr/m3 particles vulnerable to being emitted by wind.

Noise: It is expected to occur during the construction and operation phases of the mine resulting from blasting and mining operations.

To reduce the negative impact on atmospheric air, all measures can be divided intothree groups: 1- replacing existing technology and equipment with more environmentally friendly ones; 2- equipping and retrofitting technological equipment with gas cleaning plants; and 3- more efficient use of the scattering capacity of the atmosphere.To reduce the negative impact on the atmospheric air during mining operations, it is necessary that the following activities are performed regularly: 1- moistening dirt roads, mining ledges and dumps in the dry and hot season; 2- carrying out refuelling and maintenance of mobile equipment at the nearest gas station, or at a slightly remote private base with a hard surface; 3- monitoring the compliance of vehicle exhaust emissions before leaving the construction site in accordance with the established technical standards.

The toxic effects of Mo and Cu are known in agricultural crops, presenting a bioaccumulation of these heavy metals in flora and fauna. Although cyanide reacts rapidly in the environment and degrades or forms complexes and salts of varying stabilities, it is toxic to many living organisms, even at very low concentrations. There are certain bacteria, algae and fungi that naturally produce cyanide. Many species of the plant world naturally produce cyanide [12].

The prospecting or mining process in the reserve will negatively affect the continuation of the optimal use of natural and human resources, while preserving biodiversity and reducing the polluting effects of the environment, which is inconsistent with sustainable tourism. biological and avoid irreversible environmental changes, preserving and protecting the historical heritage of the region, which cannot be achieved with the current prospecting and possible mining.

The most toxic form of CN is gaseous hydrocyanic acid (HCN). The upper threshold limit for HCN in the workplace was set by the North American Conference of Governmental Industrial Hygienists (ACGIH) at 4.7 ppm. At concentrations of 20–40 ppm HCN in air, some respiratory distress may be observed after several hours. Death occurs within a few minutes at HCN concentrations above about 250 ppm in air. For potassium or sodium cyanide, the lethal dose in humans by ingestion or inhalation varies between 0.050 and 0.2 g of cyanide, corresponding to about 3 grains of rice [20]. No HCN-affected people or animals were reported in the area.

A contradiction with the provisions of this law and the system of reserves and national parks. The text of Article 12 of the Environment Law stipulates that: It is prohibited to undertake any activity or any action that would negatively affect the environment in the areas of the national network of protected areas, or negatively affect environmental systems or cause their deterioration or take any action that would disturb the natural balance In any of them, including: 1- Destroying geological or geographical formations, or natural or aesthetic places that are home to animal and plant species and their reproduction, and destroying any of them 2- Mining, paving roads, or practicing any agricultural, industrial, commercial, or service activities. For this text the current copper mining process is against the law

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