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Environmental Issues in the Extraction of Phosphate Ore from Abu-Tartour Mine, Egypt

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ABSTRACT: The main objective of this paper is to address the environmental issues that arise during the extraction of phosphate ore at Abu-Tartour mining area, Western desert, Egypt. Although the mine locates in the heart of the desert, the mining operations for ore extraction either from the underground mine, or from the surface mining work, do have several environmental impacts that affect the human being, agriculture, and natural resources (groundwater and rare animals). Those impacts are occurring during loading, unloading, mining operations (development, extraction, supporting, ventilation, blasting) and washing ol the ore. Other environmental issues at the same area include the movement of sand dunes with ils impact on the oic transportation via the roads and railroads. The paper addresses the different issues and suggests a monitoring system based on remote sensing and GIS techniques for belter understanding of the environmental problems around the area.

1 INTRODUCTION AND OBJECTIVES

The last two decades have seen a growing concern for the conservation of the natural environment. Industry in general, and mining industry in particular is one among many such activities that can produce significant environmental impacts.

The objective of this study is to address the environmental issues arising at Abu-Tartour mining area in Egypt and suggests an approach based on an integrated methodology of remote sensing and Geographic Information Systems (GIS) in order to aid the regional development in at that area. While the application of remote sensing to other types of surface mining has been well documented, its practical application to the unique problems associated with phosphale mining has been not widely studied and is one subject of this work.

Other objectives are:

- u Identify the environmental and health impacts arise at all stages of the phosphate cycle: extraction, storage, and transportation of the ore at the study area in its present situation,
- j Identity the best combination of remote sensing techniques and GIS on study the environmental impacts of mining industry, especially in desert areas.

2 OVERVIEW OF THE ENVIRONMENTAL IMPACTS OF MINERL EXTRACTION

Minerals can only be worked from where they are found and that is often in the heart of unspoiled countryside. In the past, mineral extraction was at a relatively low level and people were not too concerned about the environment. However, today intensive mining practices and increasing environmental awareness has resulted m a need to find ways of reducing environmental impacts.

The principal environmental impacts and concerns associated with ore extraction are:

a) Surface mines: large scale land use, overburden removal and disposal, noise, blast vibration, fly rocks, dust, transportation/traffic high-wall stability, etc.
b) Quarries: were given permission to work with hardly any planning control. The most obvious feature is the loss of surface vegetation and creation of large hole in the ground.
c) Underground mines: the mining operation themselves, unless they result in extensive subsidence, do not result m surface changes, and sumps are generally much smaller than tor opencast. The major concerns may be the spoil heaps created from waste rock excavated during tunnelling beside mine drainage, ventilation, illumination, supporting and noise.

d) Ore lıasportation: environmental impacts of ore transport may occur during loading, en route or during unloading. All the forms of transport exhibit certain common environmental concerns:
   - j Rail transport and trucks cause damage to buildings and sometimes cause structural damage to main roads.
   - a Air pollutants are emitted from engines powering the transportation facility and noise levels may be high.
   - • Accidents and injuries as a result of collisions between trains and motor vehicles al road rail crossing.

e) Dressing operations: waslcs and tailings of rock to local lands. Also, dust is produced during crushing operations.

f) Human health is at risk due to the dangerous involved in the extraction process.

3 NEW TECHNIQUES FOR MINING ENVIRONMENTAL MAPPING

This paper investigates into the potential of applying an integrated methodology based on two advanced technologies (remote sensing and geographic information systems to assist the preparation of environmental impact assessment for the mining area and demonstrate a case study around a phosphate mine in Egypt. Figure 1 shows the outline ol the idea.

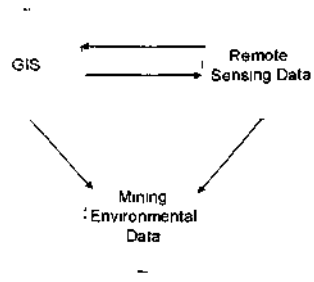

figure I lıtеırelationship between remote sensing and GIS loi envnonmenta! studies

3.1 The role of remote sensing

Remote sensing has been extensively used to monitor eftects ot surface mining. A number of studies have applied satellite remote sensing data to investigate the environmental impacts of mining areas. (Borden *et al.* (1973), Krumwiede (1980), Gupta««/. (1982). Irons *et al.* (1986), Parks«/ *al.*. (1987), Legg (1986, 1990), Ralhore *et al.* (1993), Molhibi (1994) and others).

Currently, the availability of low cost and high-resolution data has focused increased attention on the use of satellite data for monitoring mining activity. The use of this technique is based on the fact that there are differences in reilection between surface materials at different electromagnetic (EM) wavelengths. It is therefore, possibly to classify surface cover types and map their distribution. Due to the sensor's wide field of view, satellite data can prove extremely cost-effective over large areas.

Remote sensing can be useful during the planning stages either of a new mine, or for extension of an existing mine. It can also be of assistance during mining operations to update thematic maps of the mining district, and assist in monitoring changes related to mining activities. Other global phenomena around the area that is hardly to be noticed in a short term monitoring programme can be recorded and studied using remote sensing.

3.2 The vole of Geographic Information Systems (GIS)

A CIS is a system that facilitates the description of real world entities in terms of their location position, non-location attributes and their inter-relationships with each other and their topographical setting, Burrouıgh (1986).

Geographic Information systems are relatively new computer tools, which combine various forms of spatial geographic data into one master database. This lacilitates ease of interpolation between the various types of data. GIS provide the means capturing. storing, checking, integrating, manipulating, analysing and displaying the data. GIS have also been used for many applications related to mining industry and its environmental impacts.

For environmental mapping related with mining aspects, GIS could be applied for the following investigations, Bernard *et al.* (1995):

1. The application of GIS to environmental impacts assessment in the mineral industry.
2. Integrating GIS and remote sensing for environmental management at the mining areas.
3. Using GIS techniques to provide a sensitivity environmental map showing the areas of highest and lowest environmental impacts.

3.3 Computer aids

For the constantly changing environment, it is important to be able to monitor the effects of development and land-use as well as document natural changes. By digitally combining satellite data from different years or seasons, the location and

extent of changes (e.g. the movement of sand dunes or difference in land usage) can be mapped. The computer allows changes to be determined rapidly over large regions, and information to be updated frequently using new imagery. Note that the same exercise undertaken by conventional techniques might lake years of groundwork and be out of data even before completion.

3.4 Mining environmental maps

Each company may map ils operations at a different scale: or use a different classification system for land-cover types. There is often a requisite, either fiom the government agencies or public relation purposes; to produce maps showing current land-cover and its changes every two or five years. If the final product is to be at scales of between 1:25,00 and 1:100,00, this task can readily be undertaken using remote sensing. Image processing techniques can be used to obtain quantitative measures of the proximity of environmentally significant land-cover classes to propose mine-sites or transport route. This allows a choice of the best sites for mine dumps or access roads, based on the maximum possible distance between new developments and areas of en vi i on mental importance.

3.5 Monitoring and map updating

While surface mining operations are in progress there is often a need for both relevant planning authorities and mine operations to monitor activities within sites. General surveys of sites are often undertaken using aerial photographs, which may be oui of date. For relatively large sites and for studies involving numerous sites over large administrative districts, satellite remote sensing data could be used to provide updated land-cover maps and derivative change maps, at relatively low cost.

3.6 Restoration quality assessment

Once mining is complete, there is commonly a requirement to restore the land surface to its pre-minmg use. Remote sensing can play an important and cost effective role in assessing the quality of restored land, as well as in comparing the sue and shapes of fields in restored and un-mined areas.

4 A CASE STUDY: ABU-TARTOUR MINE

Abu-Tartour phosphate project is one f the largest phosphate mines in the Middle East. The mining area is located in the Western desert of Egypt (60 km from El-Kharga City, and 10 km from the main road between the two Oases El-Kharga and El-Dakhlah), Figure 2.

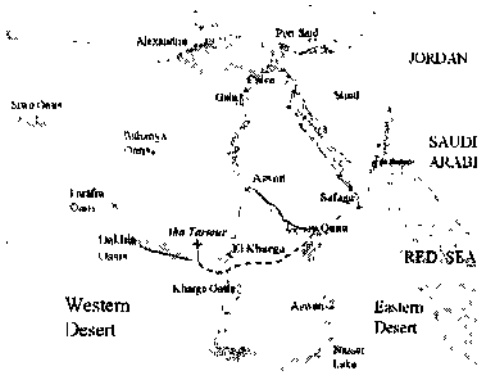

Figure 2. Location map of the study area

The ore reserves have been estimated as 100 million tons of phosphate (200 million tons as proved ore). The mine has started to export the ore since 1995. The exploration and experimental studies were started in 1975 and recommended the following:

- Extraction of the phosphate layer from two zones, underground mine, where the thickness of the overburden (shale's) is 60m in average, and a surface mine, where the overburden is small.
- a Construction of a railway for exporting from Safaga port at the Red Sea,
- Constructing a small town at the mining area for 10,00 people.
- o Use trucks for transporting the ore to Assiut factory,
- a Drilling 10-water wells near the mining area.
- a Long-wall retreating method with hydraulic support as the best solution for mining.

The aim of demonstrating this case study is to identify the environmental and health impact arise at all stages of the phosphate cycle: extraction, storage, and transportation of the ore at Abu-Tartour mining area in its present situation (2003).

4.1 Environmental impacts

Environmental impacts of the phosphate ore occur during loading, unloading and mining operations and cap be classified as:

a) Surface mine

- Dust created during operations causing respiratory problems
- Blast effects.
- Noise and vibration effects from machinery.

- Creation of large hole in the ground.
- Waste materials leading to the pollution of groundwater.

b) Underground mine

- Waste rocks excavated during tunnelling.
- Subsidence, (surface stability due to change in the underground excavations).
- Machine dangers.
- Water consumption.

c) Ore transportation

The transportation of phosphate ore at Abu-Tartour mining area is carried out by the following utilities:

- Conveyors, belt conveyors are used to transport the ore from the mines to the loading points.
- Truck (lorry): used to transport the ore to Assiut laclory (300 km).
- Railway: to export the ore through Safaga port at the Red Sea.

All the above forms of phosphate transportation exhibit certain common environmental features such as.

- Dust clfecls during operations.
- Trucks and rail transport will cause damage to building inside the town.
- Road damage, by haulage trucks is a major environmental cost (Abu-Tartour - Assiut).
- Losses of ore during the loading and unloading processes in the form of dusts, which affect the human health.
- Air pollution from engines powering the transportation facility.
- Noise as a result of engine, horn, and wheel-rail intei section.

d) Oilier issues at the study area

Beside the above points, the ore transportation is lacing a major problem due to the movement of the sand dunes over the main roads and railways. Therate ot advance and direction of movement are beyond the scope of this paper, however, the over it is believed that remote sensing would contribute in the study of this phenomenon.

5 SUGGESTED APPROACH

The paper suggests an approach for enviroiimentalimpact assessment that integrating i emote sensing data and environmental information into a geographic information system (GIS) as illustiates in Figure 3.

Among all the environmental impacts associated with the extraction of phosphate ore at the study aiea, the most important factors that could be identifying by using remote sensing techniques are subsidence and ore transportation.

5. / Subsidence:

Remote sensing data has been used to delect and delineate areas of subsidence as a result of mining. A wide variety of surface manifestations can appear due to collapse of underground mines and can be detected using remotely sensing data. Recently, Volk *et al.* (1990), have used Landsat-TM data to determine environmental effects of subsidence in the Ruhr region of Germany.

At Abu-Tartour mine, one of the main problems obstructing the last development and extraction of the ore is the supporting system due to the presence of subsidence. The rate of advance and the limits of this subsidence is still causing a problem and the mine has suffered from a high collapse I n 1987. It is suggested that satellite remote sensing data are used for the detection of the rate of subsidence in the mining area.

5.2 Ore transportation:

The movement of sand dunes, around the railways and the roads, in the Western desert of Egypt can be studied as a part of the investigation. Satellite remote sensing can play an important role in this task. The socio-economic effect due to the present ot the new mining industry is another task that can be achieved through the suggested study.

Remote sensing can also used to detect the changes in the movement of the sand dunes around the study area; a scene or more of suitable remote sensing data is required for different years to study the rate and direction of advance of the sand dune. Having succeeded to define such technique a further work is needed to prevent the railroads and main roads for the effect of sand dunes.

5.3 Input Data:

- *Q* Satellite imagery (1978 - 2003) Landsat TM and SPOT PAN
- a Topographic maps,
- ü Digital elevation models
- Iso-gradc maps (PiOs distribution)
- a Geological maps
- u Wind direction map in the different seasons
- a Water wells distribution and characteristics
- Transportation scheme (trucks, trains, others)
- Storage areas
- a Layout of the mining area
- a Artificial lack
- u Mining plant
- a Administration zone
- Green areas
- a Residential city
- Others

Attributes

- a X. Y coordinates (using GPS)
- a Noise level at different zones
- u Water quality parameters
- Others

5.4 Output Data:

- Sensitivity maps for the environmental zones.
- The best storage place for the waste materials.
- Static water level maps.
- Future expansion of the residential city.
- Determining the areas of the most environmental impacts.
- Future studies for the expansion of the mining works:
- Socio-economic studies of the project;
- Updating maps; and
- Statistical analysis.

For environmental mapping related with mining aspects, **GIS** could be applied for the following investigations:

Integrate GIS and remote sensing for environmental management at the mining areas.

Use GIS techniques to provide a sensitivity environmental map showing the areas of highest and lowest environmental impacts.

6 COMMENTS

1) The choice between surface and underground mining as the optimum mining method can no longer be based primary on mining, geo-lechnical, and economic considerations, environmental impacts should be considered.
2) The working methods and restoration should be controlled to a much higher degree so that mines and quarries case less environmental harm. This stems from two sources: general concern about environmental matters and specific concern be local residents not to have their lives and enjoyment of the countryside spoiled.
3) Reclamation of land-use after the mining compilation is a must.
4) Mining safety regulation (M.S.R.) should be changed for more safely and environmental consideration.
5) The monitoring of sand dunes movement could he done using suitable remote sensing technique and has to be assisting the ore transportation.
6) It is recommended that the company starts to protect the residential area from dusts and other hazards by constructing green fans around the residential area.
7) Groundwater wells need continuous monitoring for more safety and better control of the contaminants.

- The company is advised to establish a GIS system to monitor its progress.

7 CONCLUSIONS

The environmental impacts of mining operations have briefly listed and a case study was demonstrated to develop an environmental monitoring system using GIS, remote sensing and computer aids,

The study recommends the following steps to take place in the near future at the Abu-Jartour mining area in order to monitor its environmental impacts:

- a Design and implement a suitable technique for rapid low-cost production of sensitivity maps by integrated Geographic Information System with digital image processing system to handle remotely sensed data, other forms of map data and associated non-spatial data. Such technique will have potential uses in environmental investigations, particularly lor mining industries.
- a To create a Geographic Information System database for Abu-Tartour mining area, which will facilitate the management of the environmental impacts in the area and to evaluate environmental trends over a 25-year period extending from 1978-2003 and be used for future monitoring.
- a Outline recommendations for monitoring existing projects and also for future projects environmental strategy.

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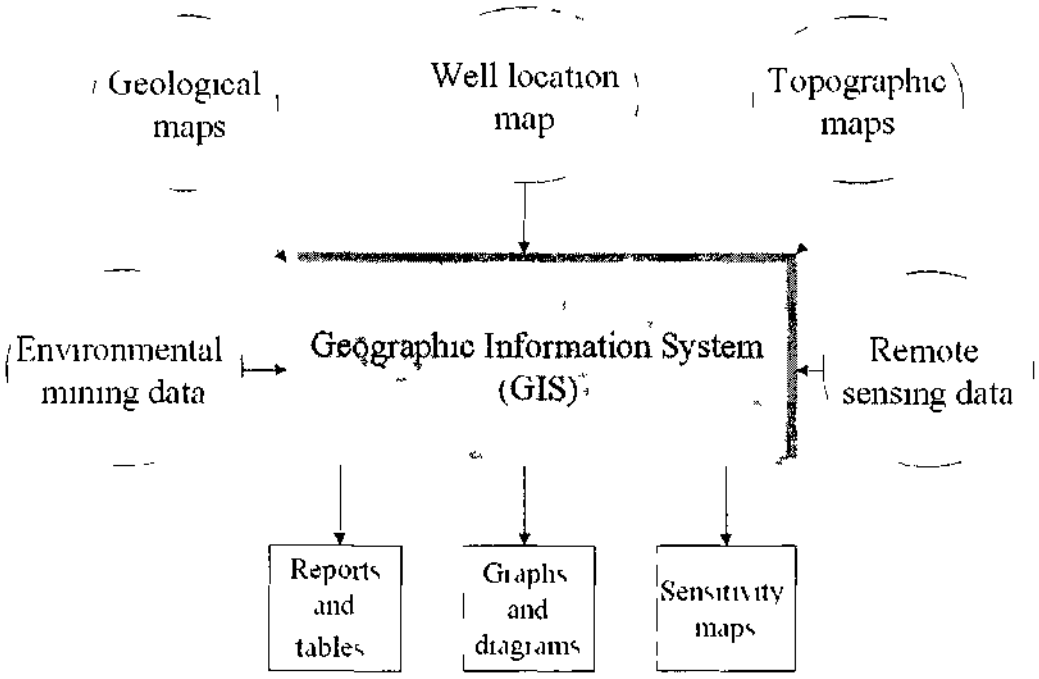

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