International Journal of Sciences & Applied Research

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ENVIRONMENTAL IMPACTS OF QUARTZ SAND MINING AT BARA LOCALITY, SUDAN

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ABSTRACT

Quartz sands have a wide variety of application and play a key role in global economic development. However, the activities of mining and minerals processing have vital positive and negative environmental impacts. The environmental impacts of quartz sand mining in Sudan, particularly in North Kordofan State, around Bara Locality are poorly constrained. This study was designed to provide guidelines for evaluation of potential positive and negative environmental impacts of quartz sand mining activities. The techniques adopted are: (1) field investigations and detailed explanation for the data collection processes. During this stage, the authors visited most of the exposed silica sands to document the impact of large-scale surface mining on the environment and did some activities include; open bit excavations, Trenching, and Auger drilling; (2) Literature review and document analysis from related researches and books dealing with the problem of quartz sand mining worldwide. The outcomes of this research are valuable solutions to rehabilitation of land where soil is excavated and mitigation of positive and negative effects. This research was also meant to develop a database on potential positive and negative impacts of sand mining around Bara Locality.

Keywords: Quartz sand; Environmental impacts; Bara Locality

1. INTRODUCTION

Geological materials have significantly maintained human civilization's advancement and play a key role in global economic development. However, the activities of mining and minerals processing have vital environmental impacts. They utilize long permanent impact on landscape, ecosystem, and socio-cultural-economic considerations (Mishra, 2015).The developing mining and mineral processing Poses a significant number of challenges. The activities of quartz sand mining are disparity depending on the target of process and ore type throughout all phases of mining and mineral processing which results in positive and negative environmental impacts. Thus, governments and community organizations play a key role in setting the environmental standards to protect the environment for present and future generations. It is important to note that

effective environmental assessment in the early planning stages of mining activities, environmental management, and monitoring are vital to reducing long-term economic costs of environmental degradation and can contribute to the sustainable economic development of a nation.

Sand mining is the abstraction of sand from its natural structure. Quartz or silica sand (SiO_2) is one of the most common minerals found on the earth's surface and represents one of the most important industrial minerals used for the most important raw material in the world (the British Geological Survey (BGS; 2011).

Environmental problems of sand mining occur when the rate of removal of sand, gravel, and other materials exceeds the proportion at which natural processes produce these materials (Ashraf et al., 2011). The morphologies of mining areas confirm the impact of mining with the ability to destroy the cycle of ecosystems. Several types of research have been published concerning these environmental effects. The next step is what to do to reduce, avoid, or precise these environmental effects.

Sand mining is a global activity, approximately in all countries (Kearey, 2009) and it has a considerable impact on the environment (Gavriletea, 2017). However, such mining has not occurred in the history of Sudan; but recently, Sudan has witnessed dramatic increase in the number of sand mining project's offers. The quartz sand is found in many localities in Sudan, and the more important field is in North Kordofan State, around Bara Locality. Some scattered investigations were conducted around Bara Locality to evaluate the silica sand deposits' quality and extensions for different applications (Abdallsamed et al., 2020). However, no research has been conducted to discuss the environmental impacts of sand mining in Sudan especially in the study area. As demand increases for quartz sand mining as industrial raw materials, the present study found that it is necessary to evaluate the environmental impacts of sand excavation, both positive and negative, in pursuit of knowledge and for public good. The outcomes of the research are valuable solutions to rehabilitation of land where soil is excavated and mitigation of positive and negative effects. This research was also meant to provide guidelines for evaluation of potential positive and negative environmental impacts.

2. The study area

The study area is located in Bara Town, North Kordofan State (Fig.1). The study area approximately covered by sand dunes and extensive quartz sand deposits with a low lying, slightly undulating surface (Abdallsamed et al.,2020; Dawelbeit et al., 2019;). A semi-desert climate also characterizes it; annual temperature ranges between 12^o and 40^oC. The dominant wind direction is from NW in summer and from NE direction in winter. The mean annual precipitation is about 367 mm/year. The surface area of the silica sand deposits in the study area is primarily undulated by inactive or mobile sand dunes. These deposits are typical Aeolian sediments, forming gently rolling sheets and fixed dunes. They are composed of well-rounded, fine to medium quartz grains. The sand dunes are believed to be the product of erosion and weathering processes of the rocks in the adjacent northern outcrops; mechanical weathering processes are currently active.

In some places, no clear drainage occurs, but low lands and depressions are found marking drainage systems and covered by silt which is usually used for gardener activities. The isolated villages and the irrigated area were located in these low lands. The sand dunes are of few meters high, of moderate size, and

stable shape. On the other hand, the sand sheets spread for several square meters. Some of them are covered with low dense plants (Fig.2a-c and 3).

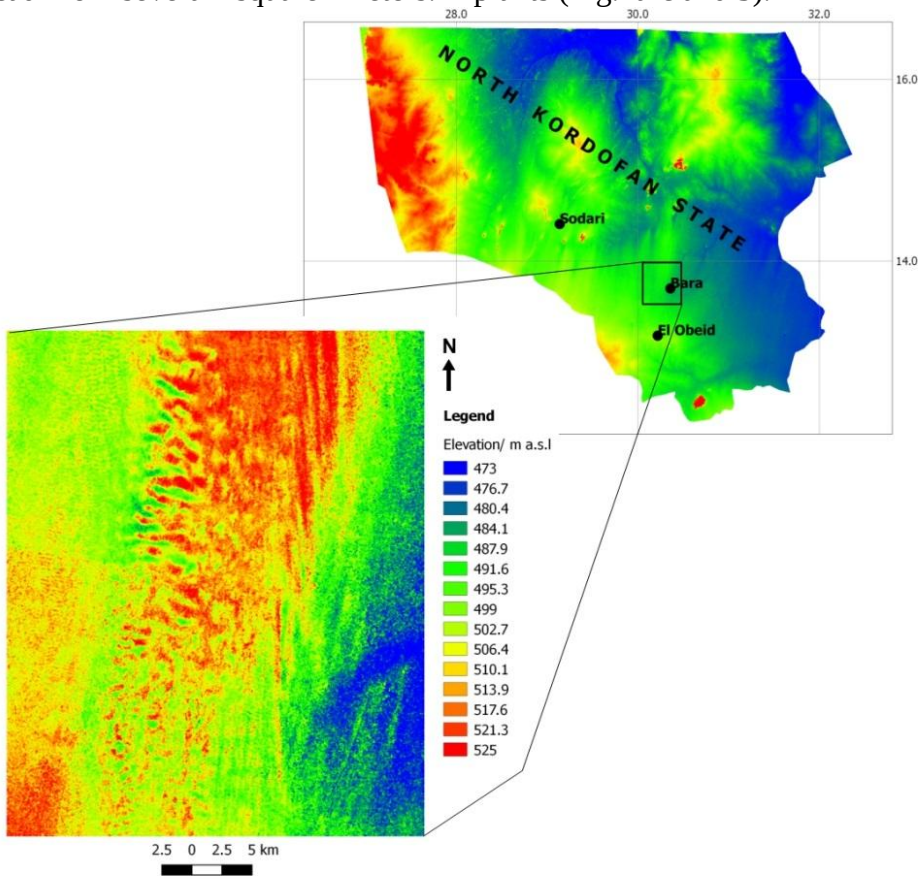

Fig. 1 Location map of the study area showinh.....

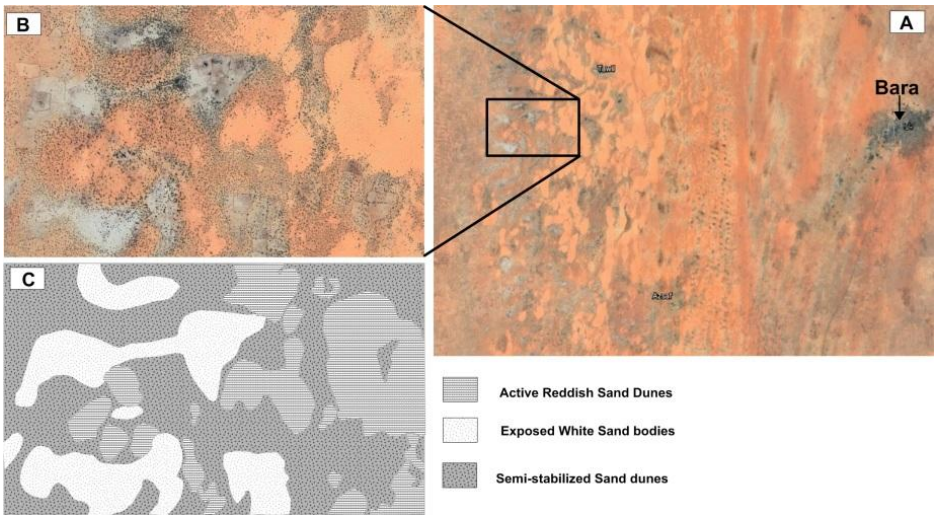

Fig. 2 Shows the morphological features of the study area

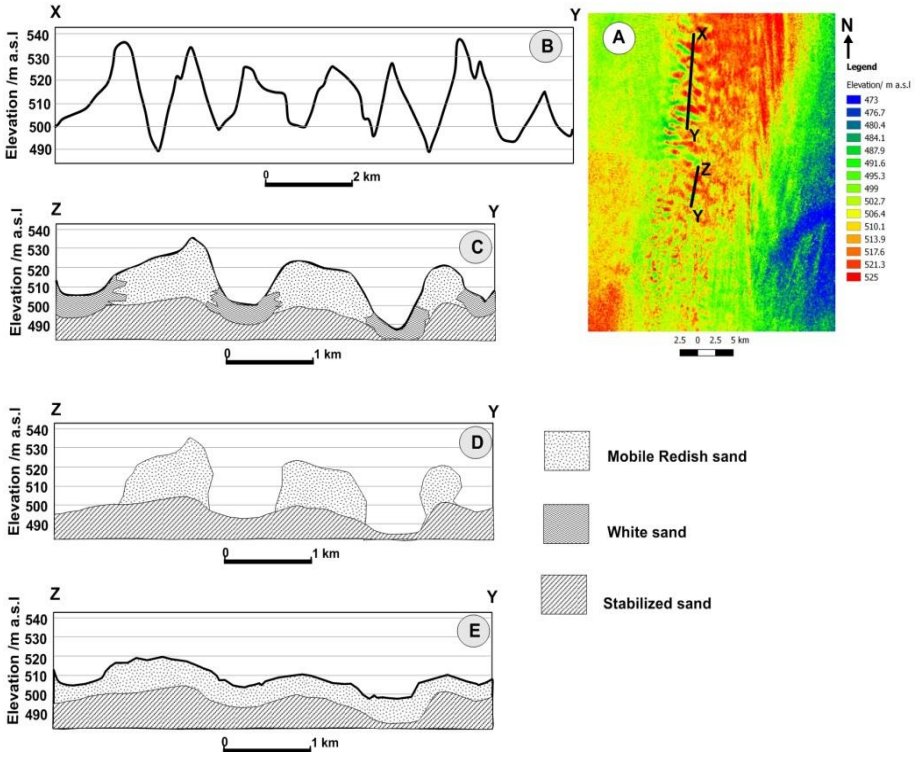

Fig. 3 Shows the topographic profiles of the study area

3. METHODOLOGY

The study of quartz sand deposits in Bara locality was divided into two stages: the first stage is to evaluate the quality quartz sand deposits; and the second stage is to deliberate the expected environmental impact during and/or after sand mining processes as raw materials for different uses. In the first stage the quartz sand samples were collected and subjected to some laboratory tests includes physical and chemical properties. The results of this stage were published in Journal of Advanced Research in Geo Sciences and Remote Sensing (Abdallsamed et al., 2020). However, the current study was designed to discuss the second stage to develop a database on potential positive and negative impacts of sand mining around Bara Locality.

The techniques adopted for this study include: the field investigations and detailed explanation for the data collection processes. During this stage, the authors visited most of the exposed silica sands to document the impact of large-scale surface mining on the environment and did some activities. These noticed activities include open bit excavations, Trenching, and Auger drilling (Plate 1, 2, and 3); the previous studies from the Literature review and document analysis from related researches and books were used to review the previously published data dealing with the problem of quartz sand mining worldwide. Data from existing records helped to come up with a historical background of the achieved work.

Plate 1 showing an Open bit for white sand

Plate 2 showing the Trench that had been made during sample collection

Plate 3 presenting the Auger drilling during the samples collection

4. RESULTS AND DISCUSSION

4.1. Environmental impacts of quartz sand miningat Bara Locality

Sand is a natural resource which must benefit all citizen development of a country. However, the mining activities have adverse effects on the environment (Balanay et al., 2014; Kowalska and Sobczyk, 2014). Their effects are divided into positive and negative impacts an can occur at local and regional scales through direct and/or indirect mining practices (Mobtaker and Osanloo, 2014).

In the Bara Locality diverse expected impacts had been noted due to land structure, morphology and natural drainage system.

4.1.1. Positive impacts

The positive impacts of sand mining activities in the Bara Locality can be resulted in the development of civilization such as construct strong houses, roads and dams, as the sand is cheap and readily accessible resource. There is exploitation of plentiful high quality exposed silica sands and are important building materials when mixed with cement and concrete. In addition, the mixture of silica sand and concrete can also use to improve storm water drainage systems on sides of roads which carry water away during rainy season. Furthermore, sand mining activities are a source of revenue for the country and income to some companies and individuals. The results of some studies worldwide also supported sand mining as an important activity for humanities development and constructions in both urban and rural areas. Moreover, the pits left by mining create rain water catchment points for watering livestock.

4.1.2. Negative impacts

Great attention should be paid to all environmental characteristics related to the sand mining procedure. The procedure is complex and consists of five phases (Table. 1). Each phase affects the environment and creates severe damages. Reestablishing an ecosystem is often very expensive, and in some cases, it cannot be restored to its original status (Gavriletea, 2017). Each phase of the process creates negative environmental impacts (Hámor, 2004; Kuter, 2013).

Table 1 Stages in the life of sand mine (modified after Gavriletea, 2017).	
Mining phases	Procedure Description
Precursors to mining	
Prospecting	Searching for sand resources using multiple exploration techniques (Lodhia and Hess, 2014)
Exploration	Determining the possible size and value of the sand deposit using different evaluation techniques (Lodhia and Hess, 2014;Jones and O'Brien, 2014)
Mining proper	
Developing	Setting-up and commissioning facilities to extract, treat and transport sand (Greber, 1979; Lodhia and Hess, 2014;Jones and O'Brien, 2014)
Exploitation	Large scale sand production (Lodhia and Hess, 2014)
Post mining	
Closure and reclamation	Returning the land to its original state (Bing-yuan and Li-xun, 2014;Kuter, 2013; Lodhia and Hess, 2014)

As stated by the human activities, field observations, and topography of the study area, the negative environmental impacts of silica sand mining at Bara Locality could affect the erosion, contamination of soil, surface water and groundwater aquifers depleted by mining processes. The key environmental problems related to silica sand mining activities are addressed below:

4.1.3. Land degradation

Land degradation is one of the substantial impacts of mining activity. The silica sand mining at Bara Locality causing the alteration of land structure, morphology destruction, and remove the topsoil layers. Subsequently, the erosion will be activated on the exposed lands, producing land losses to lose its efficiency. Moreover, the top several inches of soil provide nutrients and increasing space for plant life and its quality can be changed through a range of forces, nutrients and growing area for plant life. Its quality can also be altered through a range of influences including human activities. Therefore, the human activities can lead to the pollution and compaction of vital topsoil as well as dilution due to mixing with lower layers of overburden and the loss of crucial beneficial microbial communities. Furthermore, natural vegetation plays systems eco-balances a key role in balancing the local ecosystem, and fast vegetation cover loss has promoted the region's eco-balance and erosion. The soil texture can also be substantially modified in disturbed sites, leading to plants' community changes in the area.

4.1.4. Deterioration of natural drainage system and groundwater

Water is essential during all mining activities from exploration to reintegration such as mineral processing, cleaning, transportation and dust control. Itis also significant for sustaining life, agricultural, industrial, and domestic use. Water of high quality can generally be defined as the physical, chemical and biological characteristics. Negative impacts of water quality and

quantity from mining can affect the regional water supplies and contaminate water resources. In the expected silica sand mining at Bara Locality, water can be used in large amounts for washing which is affect the groundwater and underground wells. The mining operations withdraw the volume of water and affect the groundwater quantity by lowering the water table elevation and therefore, may reduce the aquifer's safe yield leading to food shortages and hardships for people. The natural drainage system is also getting disturbed due to surface run-off, accumulation of mud, silt, and sand in the natural channels.

4.1.5. Physical and chemical Pollution:

The pollution is a major negative impact of sand mining in areas surrounding the mining activities. The Suspended Particulate Matter (SPM) generated by silica sand mining can endure accumulated on plants and thus posing risks to the local plant's environment. The SPM pose a health hazard to the surrounding population residing in the nearby villages. Operation machines can contribute to air pollution, while crushing and separation methods using water and chemicals are a source of possible water contamination. Mine tailings also pose a risk to drainage systems and subsequent water contamination. Besides, the rainwater pounded in unfilled mines percolates downward, thereby contaminating the groundwater.

The raw materials for silica sands are all dusty material and are delivered either as a powder or as a fine-grained material. Systems for controlling dusty materials tend to be challenging to maintain, and given the large amounts of material moved each day. Therefore, from the mining process, large quantities of pollutants are emitted into the air as particulates such as the SPM. There are also many occupational health hazards that miners face; many miners may suffer from various respiratory and skin diseases. In urbanized environments, mining may produce noise pollution produced by the working machines, dust, and visual pollution.

Mining processes: chemicals solutions increase the potential to contaminate the ground and surface water, especially which the water table in the study area is only five to seven meters below the ground surface. One of the most widely cited environmental concerns associated with industrial sand mining is air quality, especially as it pertains to particles of crystalline silica small enough to be inhaled, particles measuring below 10 micrometers in diameter. Air emissions from sand mining can affect the surrounding areas and the surrounding areas influence regional and global air quality. Because of this vulnerability, air pollution and SPM emissions should be controlled and decreased at the source to reduce negative impacts on nearby communities, local flora and fauna, and the global environment.

5. CONCLUSION

The current study shows that at several phases of sand mining, the role of the government is very little. It’s essential for the government to regulate such singularity and arrange for long and short-term resolutions to save the environment and its biodiversity. This could be completed by approving the essential measures to control and combat the practice of sand mining. Such measures could include the involvement of the government or the involvement of organizations and agencies.

Acknowledgments

The authors wish to thank all team members of field work and Department of Geology, Faculty of Science, University of Kordofan Sudan.

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