Journal of Environmental Studies and Researches (2021), 11(2):364-378

Environmental Geochemistry Studies To Assess The Ecological Risks Of Gold Mining Activities In Egypt

1 Ahmed Ali El-Sayed Mohamadeen Ata[1], Mobarak Hassany Aly [1], Mohamed Gad Ahmed [1]

[1] Environmental Studies& Researches Institute University of Sadat City

Abstract

For any industry to be successful it is to identify the Hazards to assess the associated ecological risks and to bring the risks to tolerable level. As the part of the Study work, Environmental Measurements for Air Quality, hazard identification and risk analysis was carried out for Sukari Gold Mines (SGM) is located in the south-easterly region of the Eastern Desert of Egypt, The Air Quality Monitoring measurements and Noise Intensity levels were done for all SGM operations at 39 locations were evaluated in SGM by measuring the Risk and Hazards in different workplaces of the site. Particulate Matters (PM10), harmful gases such as carbon monoxide (CO), Sulfur dioxide (SO_2), nitrogen dioxide (NO_2), Hydrogen cyanide (HCN), and ammonia (NH_3) were measured at Work and ambient environment. There are Seven 7 workplaces have noise levels greater than the Egyptian Environmental Low (EEL4/94)-8 hrs. Exposure Limits guideline. The highest noise levels were found in the Power Generators House (107 dB), Control measures to reduce noise levels are considered in these sites by using the PPE and decrease the exposure limits. The PM10 maximum measured value was at 4 locations. The greatest values was in Underground Area (4.6 mg/m^3) are above (EEL4/94)-8 hrs. Exposure Limits guideline, Reduction methods to PM10 have been applied to these sites such as water depression, and Wear the suitable PPE. The concentrations of gases emissions were measured in 39 locations for different activities such as (CO, SO_2, NO_2, HCN and NH_3) all results within EEL4/94)-8 hrs. Exposure Limits guideline except (CIL TANKS 1&2) and in Underground areas (1&2&3) the values of HCN are Consider highly compared with its limits assigned by the (EEL4/94) guideline. Control programs have to be implemented to reduce the concentrations of the gasses emissions to the allowable limits. From the study carried out in the SGM and the Hazard Index and risk rating which was made and analyzed shows that 27 workplaces have Low Risk, 1 workplace have Medium Risk and 11 workplaces have High Risk.

Keywords: hazard Index; Risk assessment; Gold Mining; Ecological Risks; Air Quality; Work Environment.

الملخص

لكـي تـنجح أي صـناعة ، يجـب تحديـد المخـاطر لتقيـيم المخـاطر البيئيـة المرتبطـة بهـا وتقليـل المخـاطر إلـى المسـتوى الـذي يمكـن تحملـه. كجـزء مـن عمـل هـذه الدراسـة ، تـم إجـراء القياسـات البيئيـة لجـودة الهـواء وتحديـد المخـاطر وتحليلهـا داخل منجم السكري للذهب الواقع في المنطقة الجنوبية الشرقية من الصحراء الشرقية لمصر.

تـم إجـراء قياسـات لرصـد جـودة الهـواء بالاضـافه الـي قيـاس مسـتوى شـدة الضوضـاء داخـل جميـع عمليـات مـنجم السـكري للـذهب فـي (٣٩) موقعًـا تـم تقييمهـا فـي المـنجم مـن خـلال قيـاس المخـاطر وتحليلهـا فـي أمـاكن العمـل المختلفـة بـالموقع. مـن خـلال قيـاس جسـيمات الأتربــه المستنشـقة (PM10) والغـازات الضـارة مثـل أول أكسـيد الكربـون (CO) وثـاني أكسـيد الكبريـت (SO2) وثـاني أكسـيد النيتـروجين (NO2) وسـيانيد الهيـدروجين (HCN) والأمونيـا (NH3) في بيئة العمل والبيئة المحيطة.

تـم التوصـل الـى ان هنـاك سـبعة مواقـع عمـل بهـا مسـتويات ضوضـاء أعلـى مـن الحـدود المسموح بهـا فـى قـانون البيئـه رقـم ٤ لسـنه ١٩٩٤ــ٨ سـاعات مـده تعـرض. تـم العثـور علـى أعلـى مسـتويات الضوضـاء فـي محطـات توليـد الطاقـه بـالمنجم حيـث سـجلت اعلـى قـراءه ١٠٧ ديسـيبل ، وقـد تـم الأخـذ فـي الاعتبـار تـدابيرالتحكم لتقليـل مسـتويات الضوضاء في هذه المواقع باستخدام مهمات الوقايه الشخصية وتقليل حدود التعرض لمستوى الضوضاء.

سـجلت القيمـة القصـوى المقاسـة لتركيـز جسـيمات الأتربــه المستنشـقه PM10 فـي ٤ مواقـع. كانـت أعلـى القيـم فـي منطقـة مـنجم تحـت الأرض (٤,٦ مجـم / م ٣) أعلـى مـن الحـدود المسـموح بهـا فـى قـانون البيئـه رقـم ٤ لسـنه ١٩٩٤ــ٨ سـاعات مـده تعـرض ، وقـد تـم تطبيـق طـرق الـتحكم فـى انبعاثـات الأتربـه فـى هـذه المواقـع مثـل اسـتخدام رش الميـاه ، وارتـداء مهمـات الوقايـة الشخصـية المناسـبة. كمـا تـم قيـاس تركيـزات انبعاثـات الغـازات فـي (٣٩) موقعًـا لأنشـطة التعـدين المختلفـة مثـل (CO، SO2، NO2، HCN، NH3) جميـع النتـائج فـى الحـدود المسـموح بهـا باسـتثناء (CIL TANKS) وفـي المنـاطق التعـدين تحـت الأرض (١ & ٢ & ٣) تعتبـر قـيم HCN عاليـة مقارنـة بحـدودها المحددة بواسطة قـانون البيئـة. يجـب تنفيـذ بـرامج الـتحكم لتقليـل تركيـزات انبعاثـات الغـازات إلـى الحـدود المسموح بهـا.
مـن الدراسـة التـي أجريـت فـي منطقـه مـنجم السـكرى للـذهب ومؤشـر المخـاطر وتصـنيف المخـاطر الـذي تـم إجـراؤه وتحليلهـا يظهـر أن ٧٢ موقـع عمـل مـنخفض المخـاطر، ١ موقـع عمـل بـه مخـاطر متوسـطة، ١١ موقـع عمـل بـه مخاطر عالية.

الكلمات الدالة : مؤشر الخطر- تقييم المخاطر- تعدين الذهب- المخاطر الإيكولوجية- جودة الهواء- بيئة العمل

1. INTRODUCTION

Egypt contains several mineral sites and mines for a variety of minerals, including gold. The Eastern Desert houses about 90 gold mines that go back to ancient ages. Currently, the country is witnessing a revolution in the field of mining, especially gold mining activities.

Our case study was take place at the Sukari Gold Mine (SGM) site, which is thought to be one of the largest mines in the Eastern Desert, with surveys and inquiries revealing a deposit of around 7.7 million ounces of gold in just one of the mine's portions. Mining and ore processing are also part of the plant. The Sukari Gold Mine is situated in the Eastern Desert's central region, about 22 kilometers southwest of Marsa Alam.

Mining Operations and Activities Produced a wide variety of hazards that were not seen in other industries. Complex mining operations and processes may add certain hazards. If these risks are not adequately handled, employees may suffer severe injury, death, or occupational disease. (Castilhos et al., 2015; Jordan and Abdaal, 2013). Since ancient times, the eastern desert of Egypt has been recognized as a gold mining region, with more than 90 sites scattered around the whole area covered by Precambrian basement rocks. (Botros, 2002, 2004; El Ramly et al., 1970; Klemm and Klemm, 2013). The majority of these deposits were found and mined by ancient Egyptians (4000 B.C.) in many locations (Eisler, 2003; Helmy et al., 2004). Sukari Gold Mine (SGM) is now widely regarded as Egypt's first large-scale, modernized gold mine.

SGM Activities contains Several Operations, Open Pit Mine, Underground Mine, Processing Plant, Gold Room and Power Plants in additions to other project services activities. All of these Operations and Activities may lead to produce some Hazards and Gasses emissions pollutants in the work Environments which can cause negative Impacts to the workers in some workplace locations.

Apart from the protection and management concerns that arise while mining, the environmental issues that arise afterward cannot be overlooked. (Xiao et al. 2014a).

One of the most critical issues facing SGM Management is minimizing and eliminating certain forms of hazards and impacts in the workplace in order to comply with Egyptian Environmental Protection Law EEL4/94 limits guidelines.

Different mining operations, such as drilling, blasting, loading, hauling, crushing, and mineral processing, contain airborne particulate matter (Asif and Chen, 2016; Utembe et al., 2015). As a result, it is critical to implement the necessary control measures in order to reduce dust emissions and ensure that there are no dust emissions at workplace.

Occupational health is used to identify and bring under control all chemical and physical hazards at the workplace. Risk assessment is the process of identifying hazards and evaluating the risks to health and safety arising from these hazards (Standard, 1996). The risk is the combination of the probability and consequences (harmful impacts) of a specified hazardous event. There are several studies used risk management to evaluate occupational health in the mining industry such as Charles et al., 2013, Hermanus 2007, Pan et al., 2010, Radosavljevic et al., 2009, Simonsen and Perry 1999, and Utembe et al., 2015. Part of our study aims (1) to evaluate the occupational health exposure to physical and chemical hazards in SGM workplaces, (2) to compare the levels of pollutants with the national and international guideline values, and (3) to apply risk assessment using a modified simple model. Our results will give the full recommendations and corrective actions required to eliminate the hazards in workplace to ensure safe work place for all workers and mine staff.

2. MATERIALS AND METHODS.

2.1. Study area

Sukari Gold Mine (SGM) is situated in Egypt's Eastern Desert in the south-east, about 700 kilometers from Cairo and 25 kilometers from the Red Sea coast, and covers 160 square kilometers, as seen in (**Fig. 1)**.SGM started producing in 2009, and by 2017 had increased production to 500 koz (103 ounces) each year. In 2015, the Sukari Processing Plant processed 10.6 million tons (Mt) of ore-rock, up 26% from 2014 (8.4 Mt), and produced 439 kilograms of gold, compared to 377 kilograms in 2014.The estimated number of employees has risen from 900 in 2011 to 1500 in 2019. Traditional open-pit and underground mining techniques are used to extract the deposit. The high-grade gold ore comes from underground operations, while the open-pit mine produces a considerable amount. The traditional crushing, grinding, and flotation methods are used to process the ore. Before being extracted as gold metal, precious metal from the concentrate is leached in a dilute cyanide

According to **clause 6.1.2** in ISO 14001:2015, Chemical Manufacturing Industry is required to conduct identification of environmental requirements Risk (aspects) from its operations according to (ISO 14001:2015), **(Table 1 and Figure 1).**
solution, absorbed into activated carbon, and removed from the carbon. (Oraby and Eksteen, 2016; Pratomo, 2014; Razanamahandry et al., 2016; Van Deventer and Van Der Merwe, 1994).

2.2. Identification of Potential Negative Impacts of Sukari site.

The context and history data on the Sukari site enabled us to assess and recognize possible negative impacts in the workplace and the surrounding environment, as well as the effects of these negative impacts on Sukari employees and staff. From the construction phase to the operation phase. By examining mine operations and processing plant operations all negative impacts, hazards causes, and measurements needed to assess risk and hazards at work could be seen. This research looked at the effect of gold mining operations on air quality at the SGM Site. The sampling was done over the period of a year (2019 to 2020).

Our occupational survey and monitoring will aid SGM management in making decisions to mitigate and remove all risks and hazards in the workplace in order to achieve environmental protection and keep employees and staff safe from any environmental harm.

2.3. Air Quality Monitoring and Measurements.

SGM workplaces were subjected to environmental monitoring and measurements of noise, airborne particulate matter (PM10), and gas emissions. The measurements were carried out in 39 different locations as shown in (Fig.1) of Air Quality Monitoring Points, including working and ambient environments, offices, control rooms, and a workers' camp.

Analyzed Air quality in workplaces was investigated by measuring meteorological data, noise level, dust emissions (PM10), and gases emissions. Measurements of harmful gases included CO, SO2, NO2, HCN, and NH3. Occupational Health and Safety, Environment training and monitoring programs are undertaken in SGM to develop and increase employee awareness of high HSE standards at Sukari site.

Figure 1: Study area and Air Quality Monitoring Points-SGM Site

2.4. Hazard Index and Risk assessment Models.

2.4.1. Need for Risk Assessment

Risk assessments will help the SGM operators to identify high, medium and low risk levels. Risk assessments will help to priorities risks and provide information on the probability of harm arising and severity of harm by understanding the hazard, combine assessments of probability and severity to produce an assessment of risk and it is used in the assessment of risk as an aid to decision making. In this way, SGM Managements and operators will be able to implement safety improvements. Different types of approaches for the safety in mines various tools and appropriate steps have to be taken to make mining workplace better and safer. A Hazard Identification and Risk analysis is a systematic way to identify and analyze hazards to determine their scope, impact and the vulnerability of the built environment to such hazards and its purpose is to ensure that there is a formal process for hazard identification, risk assessment and control to effectively manage hazards that may occur within the workplaces.

2.4.2. Hazard Index(HI)

Hazard Index (HI) is used to calculate the relative safety of exposure for mixtures of harmful substances. For substances that have similar toxicological effects such as harmful gases in the gold production projects (HI) is estimated using (Formula1) (Wilkinson et al., 200

$$HI = \frac{C1}{TLV1} + \frac{C2}{TLV2} + \frac{C3}{TLV3} + \ldots\ldots \frac{Cn}{TLVn} = 1$$

Formula (1)

Where n- is the number of substances measured in the same time at the same workplace. C1 is the concentration of substance 1 and TLV1 is its TLV-TWA, and so on for C2 and C3. If HI equal or increase than unity, the exposure of combined substances is greater than the limit even the individual concentration of these chemical substances are less than its TWA.

2.4.3. Risk Assessment

The risk Management was determined at work place by using qualitative method for the classification of risks (Table 1) and Risk Likelihood which show the evaluation of occupational health to avoid negative effects of workplaces on the employees. This risk analysis model Help us to setup the recommendations and the control measures required to eliminate the risk in the workplace. Moreover, it is used to evaluate

Table 2: Qualitative method for the classification of risks unavoidable risks to detect the risk at the

Risk Rank Likelihood x Consequence	L1 Almost certain	L2 Likely	L3 Possibl e	L4 Unlikel y	L5 Rare
C1 Catastrophic	1	2	4	7	11
C2 Major	3	5	8	12	16
C3 Moderate	6	9	13	17	20
C4 Minor	10	14	18	21	23
C5 Insignificant	15	19	22	24	25

*Hazard Identification and Risk Analysis in Mining Industry 7bed5e49ad9568961ea003cae0e31028400d Risk Assessment.pdf

2.4.4. Air Sampling and analytical methods.

The research plan at the study area is succeed by using some high standards equipment and devices to do the measurements required for air quality monitoring in the work place for work and ambient environment. These equipment and devices already calibrated before the measurements and taken the samples to ensure the sampling of the measurements and the results very accurate and comply with the measurements standards.

3. RESULTS AND DISCUSSION

3.1. Assessment of air quality

Our research and study target to assess the Air Quality at Sukari site in addition to Assessment the environmental pollution at Sukari Gold Mine to discuss the expected environmental hazards, Ecological Risks and the control measures required for safe workplace to achieve the environmental protection in the work place.

Meteorology

The meteorological data taken from the metrology station installed in Sukari site. The Temperature and Humidity data showing the weather condition at Sukari site and working area, from the Annual Temperatures and Humidity Data Values. The Temp. Values Recorded show The Highest Temp. Values (T Max. 48.1 0C) and the lowest Temp. (T Min. 3.4 0C) on the other hand the Humidity values recorded in the same period the Max. Humidity (H Max. 86.2) and the Min. Humidity (H Min. 3). Thus, The Sukari Hill locations consider as hot desert climate. So, the HSE department shall consider the heat stress Management during high temp. To ensure the work environment and workers are safe during summer period.

RISK	RATING
High Risk	**1 to 6**
Medium Risk	**7 to 15**
Low Risk	**16 to 25**

3.2. Noise Intensity Level (dB)

Noise has become a major concern, especially in the mining industry. Most people who work in mining fields have suffered auditory and non-auditory harm as a result of exposure to high noise levels if they do not adhere to the workplace noise management policies. To avoid noise-induced hearing loss of staff, noise assessment and control measures are required. The SGM site is an outstanding example of how to manage noise levels in the workplace. Noise levels were measured in 39 different site locations of working and ambient environments as well as in Control rooms, Offices and camp area. The measured values range from 50.1 dB to 107 dB while the permissible noise level of working areas assigned by EEL4/94 is 90 dB for 8 working hours per day. According to this guideline value, there are Seven 7 workplaces have noise levels greater than the guideline. The greatest noise levels were found in the Power Generators House (107 dB), UG2 Area 2 -Tag board 770 (102.5 dB), Power station stacks Area (95.6 dB), Air Compressor Area (100.4 dB), At Mills (97.8 dB), UG Area 1-740 Access (91.4 dB), and Drill Pattern (91 dB), Control measures to reduce noise levels are considered in these sites by using the PPE and decrease the exposure limits. Noise levels were also measured within the Control rooms, Offices and camp areas and the results are presented and compared with the guideline value of EEL 4/94 (70 dB). Measurements carried out in all offices showed that the noise levels are lower than the allowable limit however, The power plant office noise level nearest to the limit (69.8 dB) it is recommended that the door of this office should be firmly closed at all times, check proper installation of rubber insulators on the door edges and double glasses is required to increase the isolation efficiency.

3.3. Dust Emissions - Particulate matters (PM10)

It is well established that workers in high-dust environments, such as the mining industry, are more likely to develop respiratory diseases than workers in other sectors (Onder and Yigit, 2008). Measurements of respirable dust (PM10) were carried out in 39 locations working and ambient places. Results of airborne measurements are summarized as follow, The minimum value of the measured PM10 was detected at the new admin Office (0.08 mg/m3), while the maximum measured values was at 4 locations (4.6 mg/m3) at Underground Access No 740, (3.8 mg/m3) at UG2 Area 2 (Tag board 770), (3.6 mg/m3) at UG2 Area 3 and (4.2 mg/m3) Inside Laboratory(Sample Preparation room),According to EEL 4/94 for 8 working hours, all the other measured values are less than the permissible level (3 mg/m3) for 8 working hours. Except the above 4 locations. Reduction methods to PM10 have been applied to these sites such as water depression and firmly close the sources of airborne from the machines in addition to Wear the suitable PPE. For ambient environment the EEL 4/94 assigned 150 mg/m3 as a guideline value for PM10 for time exposure 24 hrs. The measured concentration is less than the permissible level. The source of the dust in these locations is the erosion of land by the wind not from mining activities as they located at least 1 km upwind of the mine. A curtain of trees is recommended to be planted in the upwind location of the camp and Main roads.

3.4. Gasses Emissions (CO, SO2, NO2, HCN, NH3)

The different activities in SGM Operations produce several gases emissions in the work and ambient environment such as CO, SO2, NO2, NH3, and HCN. If Concentrations of these gases greater than their TLV or EEL4/94 limits may be Cause harmful effects to the workers on site.

The concentrations of gases emissions were measured in 39 locations for different activities such as open-pit mine, underground mine, Process plant, and gold room. The measurements showed that gases emissions were not detected in some sites. In other workplaces, one or more gases were detected at the same time with different values of concentrations.

Results of gasses emissions measurements are presented in (Table 2). The maximum concentration of Carbon monoxide (CO) is found in Underground areas and CIL Tanks Area it is not increased than the EEL4/94 limits. SGM deposit is characterized as low Sulfur (SO_2) and Nitrogen dioxides (NO_2) where the detected level of it not increased than the EEL4/94 limits. The source of SO_2 in SGM project is the liberations of sulfur from the host minerals of gold. Nitrogen dioxide (NO_2) source release from power plant is less than its TLV-TWA in all detected locations.

3.5. Hydrogen Cyanide (HCN)

is a Toxic gas, which produced during gold cyanidation (Donoghue, 2004; Yannopoulos, 1991). Occupational exposure to HCN is detected in Carbon in leaching tanks (CIL TANKS 1&2) with concentrations (5.5 ppm) and (5.4 ppm) respectively and in Underground areas HCN was detected (7 PPM) at UG Area1(740 Access), (6 PPM) at UG2 Area 2 (Tag board 770) and (5 PPM) at UG Area (3). The values of HCN are Consider high compared with its limits assigned by EEL 4/94. So, Workers at Underground and CIL Tanks Locations should always have Dose meter equipment with Alarm to detect HCN high concentration, wear a gas mask when the concentration exceeds 10 ppm, and evacuate the area when the level exceeds than 20 ppm.

3.6. Ammonia (NH_3)

was detected in some workplaces at different mining activities. Significant values were found in Underground, Gold Room and CIL Tanks areas with different values. The other locations have lower concentrations and all measured levels are lower than ammonia TWA limits (25 ppm).

Hazard Index (HI) and Risk Assessment Rating Model.

Combined exposures to multiple Gasses emissions, or mixtures, require special consideration in evaluating the occupational health hazard. Hazard Index (HI) is used to calculate the relative safety of exposure for mixtures of harmful substances. For substances that have similar

Toxicological effects such as harmful gasses in the gold production projects, Hazard Index (HI) is estimated using (Formula 1) (Wilkinson et al., 2000) and the results are given in (Table :

$$HI = \frac{C1}{TLV1} + \frac{C2}{TLV2} + \frac{C3}{TLV3} + \ldots\ldots \frac{Cn}{TLVn} = 1$$

Formula (1)

Where n- is the number of substances measured in the same time at the same workplace. C1 is the concentration of substance 1 and TLV1 is its TLV-TWA, and so on for C2 and C3.

If (HI) equal or increase than unity, the exposure of combined substances is greater than the limit even the individual concentration of these chemical or gasses emissions are less than its TWA. In the investigated areas, several sites at where more than one gasses emissions was detected in the same time and consider high risk areas such as Underground areas At these locations, three gasses emissions were measured in addition to PM10. No individual gas increased than its TLV-TWA, while the estimated value of (HI) is more than (1), which shows that the occupational hazard in these locations is greater than the permissible limit for combined exposure. (HI) greater than unity was found also in other three locations in the workplaces. Flotation Tanks and CIL Tanks 1&2. In working environments with HI > 1, control programs have to be implemented to reduce the concentrations of the gasses emissions to the EL limits.

So, in addition to (HI) applied the risk assessment (Quantitative method Table 1) to calculate the risk rating for occupational health. A case study of the modified risk assessment model is implemented for the workplace in SGM as shown in (Table 2). And the results are recorded in the last column of (Table 2). In this table, 27 workplaces have Low Risk, 1 workplace has Medium Risk and 11 workplaces have High Risk.

Also, we can note some of workplace has High Risk, has also Hazard Index (HI) more than unity, and the site of medium Risk have Hazard Index (HI) values more than half. Despite (HI) determines if a workplace has an occupational hazard on worker's health or not, it doesn't explain which Gasses emissions contribute this hazard. While the risk assessment model gives an adequate explanation about the source/s of such hazards. Therefore, The High and Medium risk locations shall be classified as the most risk and Hazards areas in the work place and all workers will be work at these locations must wear the required PPE during work time at these locations as shown in the high / medium risk locations in (Table 3) below.

Also, we can note some of workplace has High Risk, has also Hazard Index (HI) more than unity, and the site of medium Risk have Hazard Index (HI) values more than half. Despite (HI) determines if a workplace has an occupational hazard on worker's health or not, it doesn't explain which Gasses emissions contribute this hazard. While the risk assessment model gives an adequate explanation about the source/s of such hazards. Therefore, The High and Medium risk locations shall be classified as the most risk and Hazards areas in the work place and all workers will be work at these locations must wear the required PPE during work time at these locations as shown in the high / medium risk locations in (**Table 3)** below.

Table 2 : Gasses Emissions, Hazard Index(HI) And Risk Rating At Site Locations

ID/No.	Location Name	CO	SO_2	NO_2	HCN	NH_3	PM10	HAZARD INDEX (HI)	RISK RATING
	WORK ENVIRONMENT EEL LIMIT(PPM)	25	3	2	4.7	25	3	> 1 High < 1 Low	Low Medium High
	AMBIENT ENVIRONMENT EEL LIMIT(μg/m3)	400	350	NIL	NIL	NIL	150		
AMBIENT ENVIRONMENT (Time exposure 24 hrs.)									
#1	Main Road	0.27	0.1	0.1	ND	0.1	85	0.0015	Low risk
#3	Camp Area	0.1	ND	ND	ND	ND	93	0.0003	Low risk
WORK ENVIRONMENT (Time exposure 8 hrs.)									
#2	Security Office	0.24	ND	ND	ND	ND	1.26	0.01	Low risk
#4	Batch Plant Area	0.1	0.1	0.6	ND	ND	0.58	0.34	Low risk
#5	LV Workshop	0.72	0.1	0.4	ND	2.75	0.77	0.37	Low risk
#6	Warehouse	0.36	ND	ND	1	ND	0.85	0.23	Low risk
#7	Clinic	0.1	ND	ND	ND	ND	0.09	ND	Low risk
#8	New Admin Office	0.5	ND	ND	ND	ND	0.08	0.02	Low risk
#9	Mining Check Point	0.1	ND	0.1	ND	1	0.98	0.09	Low risk
#10	Drill Pattern	1.2	ND	0.1	ND	ND	1.51	0.10	High risk
#11	Digging Face	0.8	ND	0.1	ND	ND	0.59	0.08	Low risk
#12	Blast Pattern	1.3	ND	ND	ND	1	0.39	0.09	Low risk
#13	Room Pad	0.35	ND	ND	ND	ND	0.25	0.01	Low risk
#14	Waste Dump-Grade Control Area	0.92	ND	ND	ND	ND	0.37	0.04	Low risk
#15	Waste Dump-Pit Containers Offices	0.12	ND	ND	ND	ND	0.47	ND	Low risk
#16	UG Area 1(740 Access)	6	0.37	1.9	7	23.67	4.6	3.75	High risk
#17	UG2 Area 2 (Tag board 770)	3.91	0.23	1.8	6	15.7	3.8	3.04	High risk
#18	UG2 Area 3	2.8	0.12	1.6	5	7	3.6	2.30	High risk
#19	Mobile Maintenance Workshop	2.9	0.1	0	ND	ND	0.4	0.15	Low risk
#20	Area In front of power plant	ND	0.1	0.1	ND	4.67	0.37	0.27	Low risk
#21	Power Generators House	2.9	0.1	0.1	ND	10	0.99	0.60	High risk
#22	Power station stacks Area	2.8	0.1	0.1	ND	4	0.99	0.36	High risk
#23	Power Plant Office	0.1	ND	ND	ND	ND	0.89	ND	Low risk
#24	Inside Laboratory(Sample Preparation)	0.5	0.1	0.1	ND	1	4.2	0.14	High risk
#25	Outside laboratory	0.6	ND	0.1	ND	1	1.98	0.11	Low risk
#26	Carbon Regeneration area	2.2	0.1	0.1	ND	1	0.45	0.21	Low risk
#27	Air Compressor Area	0.1	0.1	ND	ND	2	0.86	0.12	High risk
#28	Plant Workshops	2.1	0.1	0.3	ND	ND	0.99	0.27	Low risk
#29	At Mills	1.5	0.1	0.5	ND	2	0.37	0.42	High risk
#30	Cyanide Area	0.1	ND	0.3	1	3	0.20	0.49	Low risk
#31	Floatation Tank Area	1.37	ND	0.9	4	1	0.27	1.40	Low risk
#32	Gold Room	0.47	0.1	0.9	0.1	2.8	0.99	0.64	Low risk
#33	CIL Tank Area 1	2.1	0.1	1.9	5.5	15.5	0.12	2.86	High risk
#34	CIL Tank Area 2	3.9	0.1	0.7	5.4	14	0.18	2.25	High risk
#35	At Regrind Area	2.1	0.1	0.5	ND	4	0.89	0.53	Low risk
#36	At Lime Area	0.1	0	0.1	ND	1	1.10	0.09	Medium
#37	Plant Control room	2.1	0.1	0.2	ND	1	0.20	0.26	Low risk
#38	Crusher Control Room	0.1	0.1	0.2	ND	ND	0.25	0.14	Low risk

Table 3: High / Medium Risk Site Locations at SGM Site.

No.	Location Name	HAZARD INDEX (HI)	RISK RATING		High Risk Parameters	Control Measures
1	**Drill Pattern**	0.10	6	High risk	Noise,PM10	The Suitable PPE required for all workers work at these locations in addition to HCN alarm Gas detector at high HCN locations
2	**UG Area 1(740 Access)**	3.75	6	High risk	Noise,PM10, CO,HCN,	
3	**UG2 Area 2 (Tag board 770)**	3.04	6	High risk		
4	**UG2 Area 3**	2.30	6	High risk		
5	**Power Generators House**	0.60	6	High risk	Noise	
6	**Power station stacks Area**	0.36	6	High risk	Noise	
7	**Inside Laboratory(Sample Preparation)**	0.14	6	High risk	PM10	
8	**Air Compressor Area**	0.12	6	High risk	Noise	
9	**At Mills**	0.42	6	High risk	Noise	
10	**CIL Tank Area 1**	2.86	24	High risk	HCN	
11	**CIL Tank Area 2**	2.25	24	High risk	HCN	
12	**At Lime Area**	0.09	23	Medium	PM10	

#39	**Process and Mining Office**	0.1	ND	0.1	ND	1	0.35	0.09	Low risk

***Hazard Identification and Risk Analysis in Mining Industry**
7bed5e49ad9568961ea003cae0e31028400d Risk Assessment.pdf

4. CONCLUSION

Defining and analyzing hazards is the first step in assessing Ecological risks and maintaining a safe workplace. Although all hazards should be addressed, resource constraints usually prevent this from happening all at once. Environmental measurements, hazard analysis, and risk assessment should all be used to determine targets such that the most risky conditions are dealt with first, followed by those that are less likely to occur and cause significant problems.

The analysis conducted at the SGM Site, as well as the hazard index and risk rating that were created and evaluated, revealed that there are a variety of high risks in the workplace due to a lack of control measures that must be implemented in a proper manner and under oversight to ensure a safe workplace.

Owing to some of the usual procedures that produce a lot of noise, improper use of personal protective equipment should be controlled to reduce risk and exposure at high risk locations.

Since dust emissions (PM10) can harm people in an accident, roads in mining areas, especially underground locations, must be carefully and uniformly spaced for safe and comfortable machine movement, as well as proper traffic signals and boards installed over a certain distance.

The environmental measurements taken for some gasses emissions, such as CO, SO2, NO2, HCN, and HN3, at work in various site locations reveal high-risk workplace environment, with only hydrogen cyanide concentrations above the allowable limit in some workplaces. In these workplaces, continuous detection of HCN levels is needed to prevent immediate harmful effects on workers' health, as well as the installation of a dose meter warning detector for all workers employed at high HCN locations.

The updated risk assessment model's performance was compared to the Hazard Index's expected value (HI). They both came up with the same outcome, proving the high risk rating at work.

Acknowledgement

The authors gratefully thank SGM Management for their help; facilitate the visiting of Sukari Gold Mine, and implementing the required measurements in the workplaces. Also, the authors thanks Department Evaluation of Natural Resources, Environmental Studies and Research Institute, University of Sadat City for their help to successes the study. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Refrences

Botros, N.S., 2004. A new classification of the gold deposits of Egypt. Ore Geol. Rev. 25, 1e37. http://dx.doi.org/10.1016/j.oregeorev.2003.07.002.

Castilhos, Z., Rodrigues-Filho, S., Cesar, R., Rodrigues, A.P., Villas-Boas, R., de Jesus, I., ^ Santos, E., 2015. Human exposure and risk assessment associated with mercury contamination in artisanal gold mining areas in the Brazilian Amazon. Environ. Sci. Pollut. Res. 22 (15), 11255e11264. http://dx.doi.org/10.1007/s11356-015- 4340-y

Charles, E., Thomas, D.S., Dewey, D., Davey, M., Ngallaba, S.E., Konje, E., 2013. A crosssectional survey on knowledge and perceptions of health risks associated with arsenic and mercury contamination from artisanal gold mining in Tanzania. BMC Public Health 13, 1e8. http://dx.doi.org/10.1186/1471-2458-13- 74.Frederick Ato Armah, Samuel Obiri, David Oscar Yawson, 2013, Mining and Heavy Metal Pollution:

Hassan M. Helmy, Reinhard Kaindl,The Sukari Gold Mine,2004 Eastern Desert— Egypt: structural setting, mineralogy and fluid inclusion study. https://www.researchgate.net/publication/226196044

Hazard Identification, Risk Assessment and Control Procedure, 2008, University of western Sydney, http://www.uws.edu.au/__data/assets/pdf_file/0020/12917/Hazard_Identification_Risk_ Assessment_and_control_Procedure_2008.pdf http://www.novamining.com/mining-database/state-wise-data/india-miningjharkhand/%20noamundi-iron-ore-mine/

Helmy, H.M., Kaindl, R., Fritz, H., Loizenbauer, J., 2004. The Sukari Gold Mine, Eastern DesertdEgypt: structural setting, mineralogy and fluid inclusion study. Miner. Deposita 39, 495e511. http://dx.doi.org/10.1007/s00126-004-0426-z. Hermanus, M., 2007. Occupational health and safety in mining-status, new developments, and concerns. J. South Afr. Inst. Min. Metall. 107, 531e538

Rabeiy, RagabElSayed-g.E., et al., Occupational health hazards in the Sukari Gold Mine, Egypt, Journal of African Earth Sciences (2017), http://dx.doi.org/10.1016/j.jafrearsci.2017.04.023

Razanamahandry, L.C., Andrianisa, H.A., Karoui, H., Kouakou, K.M., Yacouba, H., 2016. Biodegradation of free cyanide by bacterial species isolated from cyanide contaminated artisanal gold mining catchment area in Burkina Faso. Chemosphere 157, 71e78. http://dx.doi.org/10.1016/j.chemosphere.2016.05.020. Reinhold, K., 2006. Chemical risk assessment in manufacturing. In: European Safety and Reliability Conference (ESREL 2006), Estoril, PORTUGAL, Sep 18-22 2006. Proceedings and Monographs in Engineering Water and Earth Sciences. Taylor & Francis Ltd, London, pp. 823e828. Reinhold, K., Tint, P., 2005. Implementation of a simple risk assessment method in the work environment of manufacturing. In: 6Th International Conference Environmental Engineering, vols. 1 and 2, pp. 234e238.

Reinhold, K., Tint, P., 2009. Hazard profile in manufacturing: determination of risk levels towards enhancing the workplace safety. J. Environ. Eng. Landsc. Manag. 17, 69e80. http://dx.doi.org/10.3846/1648-6897.2009.17.69-80.

Sabah Ahmed Abdul-Wahab1, Fouzul Ameer Marikar,The environmental impact of gold mines: pollution by heavy metals. https://www.researchgate.net/publication/257909458

Tint, P., 1998. Risk assessment in the working environment in Estonia. Int. J. Occup. Saf. Ergonomics 4, 237e248. http://dx.doi.org/10.1080/ 10803548.1998.11076392. Tint, P., Kiivet, G., Reinhold, K., 2005. Improvement of the Safety Culture at Estonian Enterprises. Manchester.

Utembe, W., Faustman, E.M., Matatiele, P., Gulumian, M., 2015. Hazards identified and the need for health risk assessment in the South African mining industry. Hum. Exp. Toxicol. 34, 1212e1221. http://dx.doi.org/10.1177/ 0960327115600370.

Wilkinson, C.F., Christoph, G.R., Julien, E., Kelley, J.M., Kronenberg, J., McCarthy, J., Reiss, R., 2000. Assessing the risks of exposures to multiple chemicals with a common mechanism of toxicity: how to cumulate? Regul. Toxicol. Pharmacol. 31, 30e43. http://dx.doi.org/10.1006/rtph.1999.1361

Hazard Identification and Risk Analysis in Mining Industry7bed5e49ad9568961ea003cae0e31028400d Risk As