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Research Paper

Waste Minimization in Segilola Gold Mine Project, Osun State

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ABSTRACT
The mining industry is the world's largest producer of waste, producing around 70 billion tons annually. The wastes produced in Segilola project during the extraction and beneficiation of gold ores and minerals followed the historic mines, where waste already exists, and is subjected to management rather than minimization. Present day mines can be planned to minimize the amounts of hazardous waste that is being produced. There is the need to develop a better selective strategy solution for mining of wastes in a secured manner.

Generation of waste which is an environmental risk that is associated with mining can be reduced using one or more of these environmental technologies: recycling, mine water treatment, hydrolysis, selective mining, hydro-cyclonic paste backfill, pre-concentration, froth flotation, reducing solid waste discharge, combined filling method, dewatering, crushing, screening and cyanidation. This paper focuses on minimizing mining wastes production that is created during the process of exploiting minerals in Segilola gold mine. The mining and processing of mineral ores result in the production of large quantities of residual wastes; hence there is a huge adverse effects on the financial status as forecasted based on the data reported.

KEYWORDS: *Segilola, Waste, Mining, Mineral, Ores, Rock, Properties, Processing*

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I. INTRODUCTION

Waste minimization is the selective strategy that sidesteps, eradicates, reduces and minimizes waste creation at its origin and grants reusing and reutilization of the waste materials (Michael and Stepan, 2019). Waste in mining is categorized as rock materials that are not commercial or by product effluents from the processing and refining of ore materials (Cross and Stigson, 2002). Waste is consider to mean any material that is rejected, emitted or deposited in the surrounding in such volume, jurisdiction or pattern as to cause a change to the environment; or otherwise abandoned, rejected, discarded, surplus or neglected substance purposed for sale or for recycling, reprocessing, recovery or refining by a different operation from that which produced the substance. Waste management has become a worldwide issue that is based on large and deleterious effects on marine life in waterways which cost exorbitant amount to clean up (Nwadialor, 2011). The wastes being produced by the mining project activities occur during the process of extraction, beneficiation and processing of minerals. Extraction which comprises of initial removal of ore from the earthcrust is done by the process of blasting that results in production of large amounts of waste such as soil sediments, debris and other substance that is rejected and emitted for the industry and stored in big piles within the mine lease area. This is one of the means by which large volumes of waste is produced (Rajdeepdas and ipseetchoudhury 2013).

Waste production in Segilola gold mine has become the main issue and waste quantities in this project is on the increase. The effects of waste on the host communities, water and soil, all has inherent impacts on environment and human health (Vivoda and Fulcher, 2017). Waste produced from this comes in various forms, and ranges from harmless to highly hazardous, and much of it has little or no value commercially or economically.

This paper makes strides to find the utmost selective strategy for waste to reduce its environmental impacts of mining waste in Segilola gold mine, especially bearing disposal in mind the costs of commodities and ofcourse, "what is waste today can suddenly change to a valuable resource tomorrow" (Nilima *et al.*, 2016). The waste produced by mineral extraction in Segilola is solids, tailings, or slurry, with the most obvious being tailings, waste rock, slag, and tails ends. In this environment, vegetation and overburden outcrops are cautiously considered waste too (Pérez, 2016). To avoid negative effects on the environment, waste ought to be kept in tailing ponds or dams, in accordance with the policies of local waste control treatment that is applicable to each mining sites, and possibly on recycling (Hudson-Edwards and Dold, 2015). Furthermore, raising the require for metal that are beneficial is a leading extraction and development of complex finer-grained low-grade ore bodies that produce greater quantities of tailings per ton of products and the content of fines of such tailings (Chryss *et al*, 2012). If this is not properly managed, mining waste can cause remarkable pollution, through water leaching and pathways of air (Lebre and Corder, 2015). However, failure to manage these constantly can lead to costly catastrophic consequences. But one better way to manage mine waste is to reduce its generation from mining through transition from open-pit surface operations equipments (José *et al*, 2018).

The social, environmental and economic impacts of mining waste show that the Segilola mining project company requires waste minimization which will need research expert from many disciplines to make a developmental change as to how her work engages stakeholders in mining waste utilization especially at present and in future projects. Inherent solutions may be deduced from the existing procedures and approaches, such as cleaner production, by-products from waste, re-engineering of processed, closed-loop systems, and product stewardship (Rankin, 2015). Virtually the form of mining gold mineral and processing produce waste materials (see table 1). The size of produced waste depends on the nature of occurrence of the deposit and geography of the area and so on (Maedeh *et al*, 2019). It is also noted that most toxic waste materials are piled up in large stack or dumped in huge ponds. Some of the effects of mining waste include:

- Acid drainage intruded into water supplies.
- Unpleasant landscape visual effects as large piles of waste stand out like mounds.
- Occupies huge expanse of land for the disposal and invariable uselessness and bareness of such land.
- Heavy metal poisoning reduces soil productivity.
- Absence of vegetation makes the site more susceptible to runoff, erosion and Inherently unstable ground.
- Blown dusts and tailings which are sources of air pollution.
- Discharge of pollutants into waterways, break-up of dams, pond and water impoundments which can flood near-by lands (MMI, 2007).

THE BENEFITS OF REDUCING MINE WASTES

The advantages and importance of minimizing waste during mineral exploitation are numerous and highlighted by Fluence, (2020). These includes: lower capital costs, energy savings, lower Carbon dioxide emission, faster start-up with containerized treatment, less maintenance, technical/ operational hiccups.

GEOLOGY OF SEGILOLA MINING GOLD PROJECT

This study targets Segilola Gold Mine Project that is located on Latitude 7.573^{o}N and Longitude 4.678^{o}E and situated approximately 120 km north-east of Lagos, bordering around Iperindo and Ilesha in Osun State of Nigeria. It covers a land area of 16km^2 (3,954 acres).

Segilola deposit type is orogenic and narrow vein which occurs within a regional-scale shear zone. Its host rock consists of high-grade amphibolite-facies metasediments which is an overturned sequence that is intruded by a largely differentiated granodiorite sill-like body.

Results from drilling demonstrated that gold mineralisation occurs in fractured pale to dark-grey coloured and smoky quartz veininig, sheared pegmatite, and alteration of silica/chlorite/carbonate. The presently drilled mineralised zone is between 70m and 200m in depth, between 2m and 20m in true thickness and approximately 2000m in strike length.

The gold is absolutely non-refractory and commonly occurs as visible particles within either foliated biotite selvedges or pegmatic quartz-feldspar veins to the veins.

Metallurgical assaying shows high evidence of copper (250ppm to 300ppm). Minerological studies supported association of gold-tellurium. Litters of sulphide, commonly pyrite, are mixed with the lodes. Native gold is obvious in quartz-feldspar veins and in altered wall rock.

This project seeks to establish and propose waste minimization strategies used by Segilola Gold Mine Project. The study was limited to wastes produced by mineral processing in Segilol gold mining field.

The Segilola Project which is a low risk and low capital is 100% owned by Segilola Resources Operating Limited ("SROL"), which is 100% owned subsidiary to Thor Exploration. It was fully licensed with a 25 year licensed project issued in September, 2016. The limitation is slim budget, limited time and scarce information from the internet. Researcher chose to study waste minimization strategy in Segilola Gold Mine Project as it produces wastes through its interior engineer process. The significance of this work is to address waste minimization strategies in Segilola Gold Mining Project and contribute to raise awareness on its sustainability.

Fig. 1: Geographical Location of Segilola Gold Mine Project and study area (Gillman, 2021).

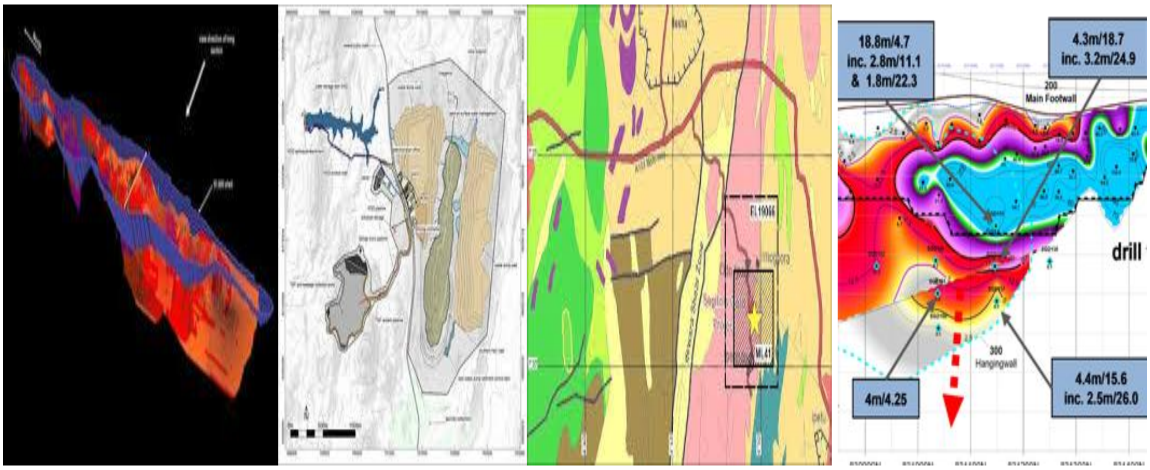


Fig 2: Segilola Open Pit Gold Project (Gillman, 2021).

MINERAL PROCESSING METHODS IN SEGILOLA GOLD MINE

The methods for mineral processing used in Segilola Gold Project are:

- Agitated tank (VAT)
- Elution
- Cyanide (reagent)
- Milling
- Gravity separation
- Carbon adsorption-desorption-recovery (ADR)
- Carbon in pulp (CIP)
- Inclined leach reactor (ILR)
- Solvent extraction and electrowinning

The plant used is fashioned to work continously everyday in the year, with an engineering application of 91.3% for :nominal ore throughput of 81.3 tph; engineer ore throughput of 84.5 tph which results in an average LOM (Life of Mine) annual production of 625,000 tpa.

METHODS OF MINING GOLD PROJECT

The mining method to be applied on the Segilola Gold Project is the conventional open pit mining shovel excavator / loader and truck fleets which will be operated primarily as a contract mining operation. Drilling rigs will be Epiroc T45/50 class top-hammer drills with the capability to drill holes from 89mm to 140mm in diameter. The ore blasting will be conducted on benches of five metre, while waste blasting will be done on benches of 10m where possible. A set of blast patterns ranging in powder factor from 0.43kg/m^3 to 1.07kg/m^3 will be utilized depending on the material type.

Blasting will be conducted with pumped emulsion as water is expected in the blast hole. A 200t hydraulic excavator (12.5m^3 bucket capacity) and 90t payload rear dump trucks will be used. A cumulative of

75% of the Run of mine (ROM) is planned to be re-processed due to the magnitude of stockpiling planned. This will be conduted using a front-end loader (FEL), such as a caterpillar 988, with $6.4m^3$ bucket capacity.

The ROM pad and stockpile sites will be positioned close to the processing plant at the southern end of the west waste dump. All waste rock from the pre-strip period and initial months of mining will be used to create the flat area for the ROM pad and ore stockpile.

Sub-horizontal drains will be applied to promote passive drainage of the pit walls, commonly installed from benches in the pit walls, with a horizontal spacing of 10m to 30m between drains. Drilled diameters will be 75mm to 100mm with a 50mm diameter high-density polyethylene (HDPE) of unplasticised poly vinyl chloride (uPVC) slotted screen installed.

WASTE CAPACITY

There is enough space within the tenements to enclose future possible waste impoundments, tailings storage facilities and processing plant. All stages of the Company's work are subject to environmental regulation in the territories in which it operates, and has set forth limitations on the production, transportation, storage and disposal of solid and hazardous waste.

II. LITERATURE REVIEW

The reliance on mining to produce huge amounts of these minerals to meet present demand has resulted in the processing of high amounts of mineralized substances and subsequently producing great amounts of waste rocks and processing plant tailings (Lottermoser, 2010). It has been discovered that an approximated two grams of mercury are released into the surrounding for each gram of gold recovered (Limbong *et al*., 2003). About 12% of the world's gold production is through illegal mining that provides a remarkable economic gains to miners but also proves harmful and hazardous for the surroundings by causing impacts such as water source land cover degradation, sedimentation, soil degradation, deforestation, and chemical contamination with cyanide, mercury, zinc and nitric acid (Gafur *et al*, 2018). The mechanism of the depletion of resources have intensified with researchers finding antidote to questions such as ''will previously categorized waste rock materials be mined when commodity prices rises and/or mining technology advances?" (Prior *et al,* 2012). In the mining industry, innovation of essential technologies including flotation, new procedures of geophysics, pyrometallurgy, drilling practices and machinery have adanced the extraction techniques and technologies over the past 50 years. (Gordon *et al*, 2006). Tailings impoundments and waste dumps are not usually considered to have privileges for future re-handling or as part of the long term waste management strategy of the mine (Dold, 2008). Considering the rate at which resources are being consumed, the world will require more resources than available in this century (Meadows and Randers, 2005). The waste rock dumps have very large inventories of fine material and are much more permeable to oxygen than tailings dams (Bannister *et al*., 2002). A lot of gold compounds have been prepared but very few have practical use. Most are unstable in solution because gold is quite simply reduced and precipitated as elemental gold (Butterman and Amey, 2005). The collection of waste from rejected mines, for hundreds oof years, poses a serious environmental problem, given its inherent toxicity (Adabanija and Oladunjoye, 2014). Highly mineralized acid drainage solutions are extremely poisonous for the surrounding; they have to be treated, making a neutral pH and the removal of metal and metalloids necessary to reduce inherent hazards (Jung *et al*, 2020).

EXPECTED WASTE TYPES IN SEGILOLA MINE PROJECT

1. WASTE ROCK

Huge volumes of waste rock are generated from surface mining operations, such as open-pit mines (Jadwiga and Irena, 2004). It is typically removed during mining operations along with overburden and often has little or no practical mineral value. Below are some of the properties of gold waste rocks.

- **Gradation:** It is often homogeneous but can vary largely in size from boulders down to gravel, due to differences in ore formation and varied mining techniques. In general, most origins of waste rock can be reduced to a desired gradation by normal crushing and sizing procedures.
- **Shape and texture:** It is coarse, hard, and angular in shape and varies in size from large boulders or blocks down to gravel, to fine sand-size particles and dust.
- **Specific Gravity:** Its average specific gravity is about 2.65 g/cm^3, ranging from (2.4 to 3.6) g/cm^3 depending on the nature of the mineral constituents.
- **Shear Strength:** has angle of internal friction that often exceed 35^o
- **Abrasion Resistance:** It satisfies abrasion loss requirements.

2. MILL TAILINGS

Mill tailings predominantly comprises of extremely fine particles that are eliminated from the grinding, screening or processing of the raw material. Below are some of the properties of Mill Tailings.

- **Gradation**: They consist of hard, angular siliceous particles with a high percentage of fines. Typically, mill tailings range from sand to silt-clay particle size with 40 to 90 percent passing a 0.075μm (No. 200) sieve (Mary and. Adajar, 2012). It comprises of a solid and liquid component: generally about 20 – 40 weight percent solids. The composition of both is highly site-specific, depending on the ore and gangue minerals and the nature of the water (fresh or saline) and processing chemicals employed.
- **Shape and Texture:** Mill tailings are uniform in particle size, shape and texture character. It commonly consists of hard, angular, siliceous particles with a high percentage of fines.
- **Specific Gravity:** Its specific gravity ranges from about 2.0 to 3.5, depending on the mineralogical composition.
- **Absorption**: The water absorption values for its ore are commonly higher than the usual maximum limit of 1.0 percent for fine aggregate (Ahmad *et al*,2017). It has optimum moisture content values that range between 10 to 80 percent (Mary and. Adajar, 2012).
- **Unit Weight:** It commonly has unit weight values as high as 2750kg/m^3 (170lb/ft^3). Its weight when dry-rod ranges from 1450kg/m3 (90 lb/ft^3) to 2200kg/m^3 (135lb/ft^3), which is comparable to that of most natural aggregates, which are approximately 2000kg/m^3 (125lb/ft^3) to 2300 kg/m^3 (140lb/ft^3) (FHA, 2016).
- **Stripping Resistance**: Mill tailings form should be evaluated for stripping using potential engineer procedures.
- **Cohesion:** It has less frictional angles that ranges from 28^o to 45^o.
- **Density:** It has maximum dry density value that ranges from 1600 to 2300kg/m^3 (100 to 140lb/ft^3).
- **Moisture content:** It has an optimum moisture content value that ranges between 10 to 80 percent (IAEA, 2004).
- **Permeability:** It has a permeability value that ranges from 10^{-2} to 10^{-4} cm/sec.

3. WASH SLIMES

Wash slimes are by-products of mineral production (Krishana *et al*, 2013). They are generated from the processes in which large volumes of water are used, which results in slurries having low solids content and fines in suspension, even after long time of drying. Because of the difficulty encountered in drying from where they are stored in large ponds, there are no definite uses for wash slimes. Thus, safe disposal and utilization of such vast mineral wealth are posing big challenges to mineral engineering in the country.

4. MERCURY AMALGAM

Mercury is used to separate gold from ore and is leaked to the environment in many ways during the amalgamation process which includes: unintentional spillage, discharge with other wastes into inadequate tailings ponds, direct discharge into rivers and waterways, or vaporization into the atmosphere. The extent of mercury lost depends on which of a variety of mining and amalgamation methods are applied, along with the fate of intoxicated tailings and Au-Hg separation procedures. When mercury is placed on sluice boxes or spread on the ground to amalgamate the whole ore, losses can be 3 times the amount of gold recovered. The difference in density or specific gravity (gold is 19.3; mercury is 14.0 and lead is 11.4) enables gold to be concentrated by gravity and permits the separation of gold from clay, silt, sand, and gravel by various agitating and collecting devices such as the gold pan, rocker, and sluice box). When just the gravity concentrates are amalgamated, the mineral portion is separated from the amalgam by panning, forming an amalgamation tailing which is then commonly dumped directly into a water stream creating a "hot spot" of mercury contamination (Esdaile, 2018).

5. MINE WASTE WATER

This is the waste water produced after water is used in many of the mining processes, operations and treatments within the mine and in the processing plant. Some processes like milling can use large volumes of water and inadvertently contaminate it with metals and other harmful elements. Example is AMD (Acid Mine Drainage) water which originates from the oxidation of sulphide minerals, which is an autocatalytic reaction, and is very hard to stop when it has started. In extreme cases, it may continue for a millennium (Lottermoser, 2003).

6. CYANIDE CHEMICALS WASTES

The chemicals used in processing are in much lower volume than the other types of wastes, but can be very hazardous and poisonous even in small concentrations. A common chemical used in gold extraction is Cyanide which a cost-effective technique. The properties of Cyanide include:

i) It is organic
ii) It is highly poisonous and lethal
iii) It contains the chemical group CN - one atom of Carbon (C) and one atom of

Nitrogen (N)

iv) It reacts readily with living organisms (Earthworks ,2019)

7. ACID MINE DRAINAGE

Is highly acidic, rich origin of sulphate and heavy metals (Bhupinder, 2018).

SOLUTION STRATEGIES ON WASTE MINIMIZATION

Minimization of mine waste is the most accepted alternative, whereas treatment, disposal and storage are the least accepted. Reuse and recycling are amongst the top feasible alternatives in waste management (Lottermoser, 2010). However, the most common approach used in conventional mining and waste management is the treatment, disposal and storage options. Technological advancements in the mining industry inherently improve the economic value of most mineral deposits. These improvements lead to higher efficiencies in milling and refining processes that invariably raises the inherent extraction of minerals in mining operations (Hatayama *et al*, 2014). As extraction economics and technologies advances, materials that were previously considered waste can be mined and processed. With the increasing demand for minerals and materials in the global market, the recovery of valuable minerals and reuse of waste rock materials are becoming increasingly enticing and essential (Lottermoser, 2010). In the past, gold recovery efficiencies were in the ranges of 35–60%, depending on the ore properties and extraction techniques. In recent times, gold recovery efficiencies are in the ranges of 92–97%. Based on technological advances in recovery techniques, most previously abandoned mineralized mine waste are inherent resources for reprocessing.

1. RECYCLING

Waste materials could culturally be employed either by reprocessing, to recover additional minerals as economic condition becomes more favourable, or by using them for internal construction purposes.

i) Mine waste could be used in the construction of impoundments, dykes and haul roads on mining property, and in mine rehabilitation, such as cemented mine backfill.

ii) Some origin of waste rock or coarse mill tailings may be preferred for use as portland cement aggregate, asphalt aggregate, granular base/sub-base, rail road ballast, flowable fill/fill aggregate, and engineered fill or embankment.

2. MINE WATER TREATMENT

Mine water must be treated before been released into the environment. This treatment can be categorized into active or passive treatment.

- **Active Water:** Water is treated inside a water treatment facility which include raising the pH of the water with the addition of limestone or caustic soda, which in turn cause metals to precipitate and settle. This can be conducted in certain settling or sedimentation ponds. In some cases, flocculants are added to make the process faster. The treatment can also be supported with other methods, such as sieve.
- **Passive Water:** Water is treated without active involvement, sometimes called “walk-away-option”, often using natural, physical, chemical or biological processes. Typical techniques for passive water treatment are using plants that uptake contaminants or using soils that filters the intoxicants and deposits them in a controlled area (Bern, 2003).

3. THERMAL HYDROLYSIS

All complexes of cyanide are denatured when liquid phase are maintained at 400-450^{o}F (204-230^{o} C) at high pressure (300 -500 psi/20 – 35 bar) during speed up reaction (Robey, 2004).

4. ALTERNATIVES TO MERCURY AMALGAMATION OF GOLD BEARING CONCENTRATES

Table 1: Almagamation of gold process and limitation

SIMPLE PROCESSES	LIMITATIONS OF PROCESS
Panning	Only usable for coarse gold
Magnetic separation & panning	Only applicable for magnetic materials
Blowing	Small quantities
Friction-separation on inclined rough surface	Small quantities of flaky gold
MORE ADVANCED PROCESS	
Direct smelting	Require highly enriched concentrates
Cyanide leaching	Health, safety and environmental problems; slow process
Leaching with other reagents (Cl, Br, etc)	Technical complexity; high cost; health, safety & environmental problems; slow process.
Gold/oil agglomeration	Require highly enriched concentrates; technical complexity; high costs; health, safety and environmental problems.

(Source: Wotruba, 2003).

5. CHEMICAL TREATMENT OF HIGHLY TOXIC ACID MINE DRAINAGE

Biological treatment has emerged as efficient, cost-effective and eco-friendly alternative for its remediation. It involves use of microbes such as bacteria and fungi. Bioreactors and wetlands designed with microbial attachments aid in abatement of metals, sulphates and generating alkalinity (Bhupinder, 2018).

6. SELECTIVE MINING METHOD

This applies segregation of ore and waste in the excavation process. It employs the principle of reusing method of stoping, where ore and waste are disintegrated in separate cycles to segregate them right from the outset within the stope (Bern, 2003). The waste can then be left within the stope. This prevents waste minerals or other deleterious substances to downstream. Selective mining can also be essential for separating contaminants such as reactive sulphides that propagates acid rock drainage. Selective mining then presents the opportunity to be proactive in anticipating waste management.

7. HYDROCYCLONIC PASTE BACKFILL

Backfill of paste is a recombined form of tailings formed by separating the fine and coarse -grained fractions of the tailings in a hydro-cyclonic. The fine-grained fraction (the cyclone - overflow) is dewatered in thickeners or by filtration and the coarse-grained fraction (the cyclone - underflow) is permitted to drain by gravity. The two size fractions are then recombined with cement and other coarse-grained materials that are added to reduce water retention and enhance strength. This results into a viscous material that can be relatively moulded simply into desired forms. Paste is commonly considered for use as backfill support in underground voids and to reshape surface landforms near mining sites (Bern, 2003).

8. PRE-CONCENTRATION OR ORE SORTING

The aim is to separate waste from ore and in order to direct materials to optimal processing or disposal destinations waste and to increase feed grade, lower ore throughput and operating expense and reduce environmental impact (Laurie R., 2016).

9. REDUCING THE DISCHARGE OF SOLID WASTE

Reducing the discharge of solid waste tailings is an essential pathway of comprehensive disposal and utilization of solid waste. This is carried out by reducing control ore dilution ratio; increasing processing recovery ratio; reducing stripping ratio and reducing the amount of excavation in rock.

10. RECOVERING SAND FROM ORE DRESSING

Tailings are usually mined out and classified to different size from tailings reservoir for reuse. The product materials gotten after this extraction processes is later safely disposed.

11. COMBINED FILLING APPROACH

In order to advance the absolute utilization ratio of solid wastes, when waste rocks or tailings were utilized for land treatment and rehabilitation; admixture of waste rock and tailing was used in filling the mined out area, subsidence area and other area for this purpose. Tailings, as a kind of fine size material, could fill in the interstices of waste rocks effectively and increase the utilization amount of solid waste. It could also enhance the density degree and decrease the coefficient of permeability of backfill materials. When the combined filling approach was used in construction of dam, such as tailings pond, it can meet the requirement of anti-liquefaction (Zengxiang and Meifeng, 2012).

12. DEWATERING

Mill tailings may have to be dried to reduce the moisture content, or may require selective screening and dewatering prior to being introduced into a hot mix asphalt plant. One method of reducing the water content in tailings is electro-osmotic dewatering which involves electro- synthetics (EKGs) as electrodes for in situ dewatering (Andy *et al*, 2007)

13. CRUSHING AND SCREENING

Screening and/or crushing may be required in some cases to produce a suitable aggregate like product from mill tailings or to meet gradation specifications. Some fine-sized tailings, such as gold mill tailings, can be classified before disposal in order to separate the coarser fraction of the tailings for further reuse (Zengxiang and Meifeng, 2012)

14. FROTH FLOTATION

Finding an effective solution to recover mineral values from slimes is a great problem facing mineral technology. Efforts have been made to recover mineral values from slimes using inverse flotation (Krishana *et al*, 2013). The flotation process is also widely used in industrial waste water treatment plants, where it removes fats, oil, grease and suspended solids from waste water (Dan, 2012). These units are called dissolves air flotation (DAF) units. Froth flotation is a process for separation taking advantage of differences in their hydrophobicity which is improved through the use of wetting agents and surfactants. Slimes have higher surface area, which increases the reagent consumption and they can increase flotation residence time resulting in high froth volumes (Fornasiero *et al*, 2017).

15. THE CENTRIFUGAL GRAVITY CONCENTRATION

This may also be employed, though it is subjected difficult industrially, due to high pulp volumes involved. It can be utilized to recover free and coarse gold from ores (La abrooy *et al*, 1994). This can be conducted ahead of flotation and/or Cyanidation which produces maximum net smelter return and increases overall gold recovery (Huang and Mejiab, 2005).

16. CYANIDATION/LEACHING

Cyanidation is widely used by several gold mining companies globally. An Appropriate treatment employed to remove this pollutant/waste is done by combining ozone (O_3), hydrogen Peroxide (H_2O_2) and activated Carbon (AC), under alkaline conditions of pH of 11.0 (Pauker, 2019). Sodium cyanide solution is commonly used to leach gold from ore in two different ways which are:

a. Heap Leaching

Cyanide solution is sprayed in the public, over huge heaps of crushed ore that is spread on top of giant collection pads. The cyanide dissolves the Gold from the ore into the solution as it trickles through the heap. The pad collects the resulting impregnated metal solution which is stripped of Gold, and re-sprayed on the heap until the ore is depleted (Earthworks, 2019).

b. Vat (Or Tank) Leaching

The ore is combined with cyanide solution in large tanks in a controlled manner. The resulting waste, known as tailings, is stored behind large dams called tailing impoundments (Earthworks, 2019).

DATA MINING

a. Economic Data

A combination of extensive documentary reviews together with qualitative explorative research approaches were used in this study. We performed a retrospective study of all challenges reported from Segilola gold mine.

b. Data Collection

Data about Segilola were extracted from the internet. All data was gotten from documents of Thor Exploration Limited (Gillman, 2021) and (Keers and Sppedy, 2017).

c. Data Analysis

Data were analyzed with Microsoft Excel. Firstly, four parameters were used for analysis which are: Property/Plant/Equipment, Exploration and Evaluation Asset, Shareholders' Equity Reserve, and Accrued Liability. Also, Production tonnages for mined and milled were applied.

THOR EXPLORATIONS LIMITED: STATEMENT OF FINANCIAL POSITION [IN CANADIAN DOLLARS (AUDITED).

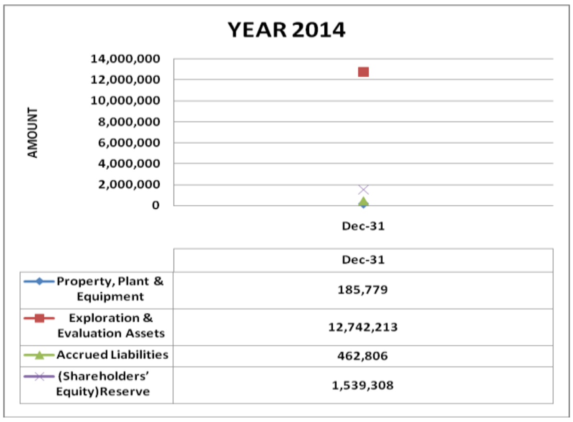


Fig. 3: Reported data for 2014

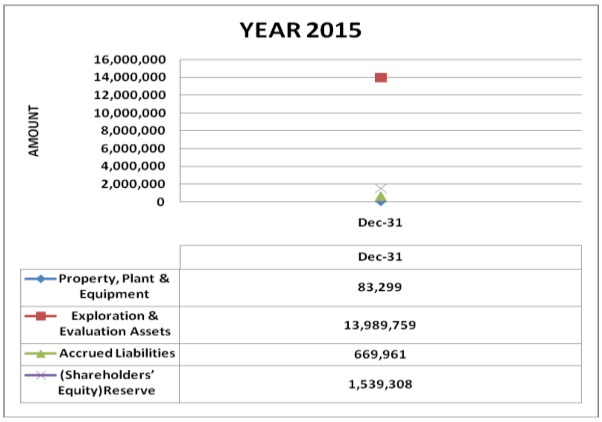


Fig. 4: Reported data for 2015

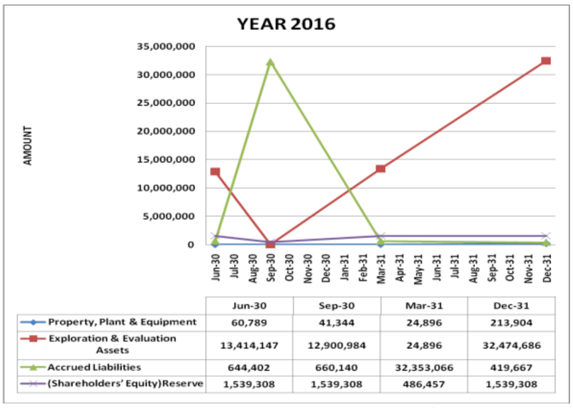


Fig. 5: Reported data for 2016

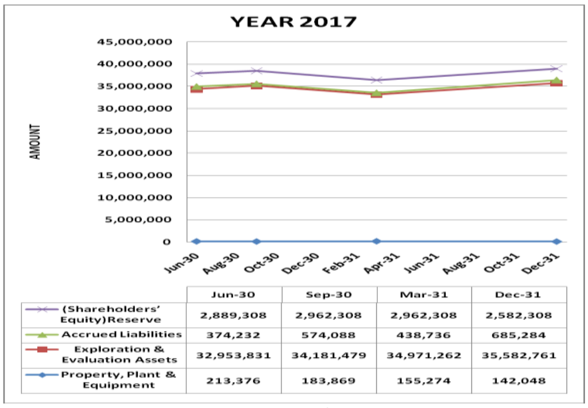


Fig. 6: Reported data for 2017

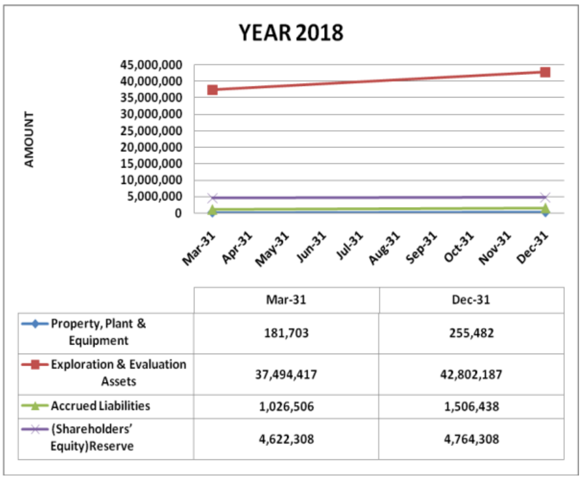


Fig. 7: Reported data for 2018

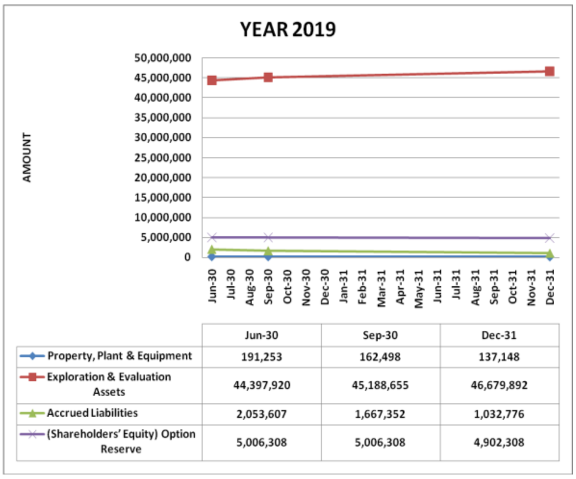


Fig. 8: Reported data for 2019

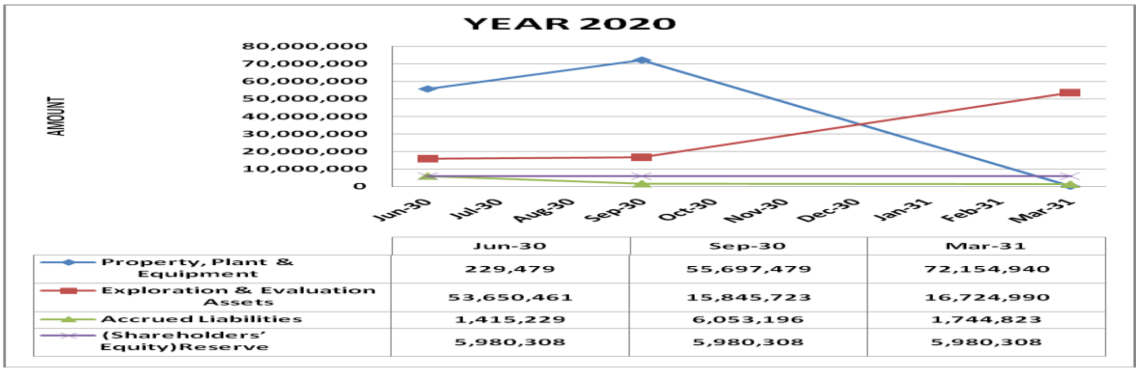
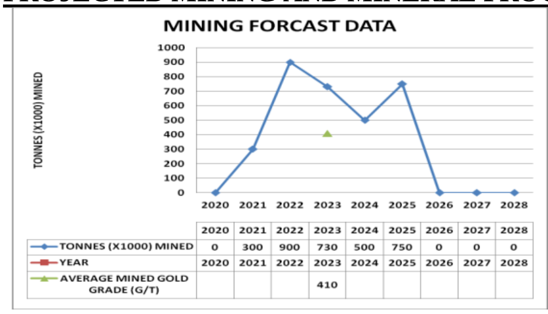


Fig. 9: Reported data for 2020

PROJECTED MINING AND MINERAL PROCESSING FORECAST DATA



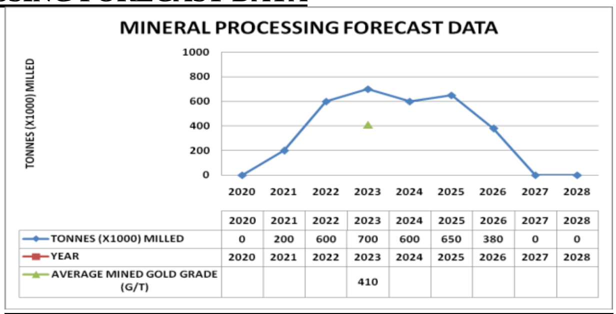


Fig. 10: Reported data for Mining Forecast Data.

Fig.11: Reported data for Mineral Processing Forecast Data.

MODELLING DATA

i) GEMCOM version 6.4 mining software was used for constructing the 3D block model and subsequent grade estimates.
ii) Its initial 2 years of operations of head grade is projected to be greater than 8g/t, with a proposed milling rate of 500KtPa, and Capex (Capital expenditure) of USD 71.4M.
iii) 3.0Mt of ore and 49.0Mt of waste will be extracted.
iv) The life of mine production of mill feed per annum over a period of five years.
v) It possesses average head grade of 4.2 g/t, containing gold of 406,000oz.
vi) The grand size P8 is 106 micrometre.
vii) The modelled processing gravity recovery of 43% (55.7 % of GRG- Gravity Recovery Grade).
viii) Life of mine production of 393,000oz at an average rate of 80,000oz per annum.
ix) Initial 18 months (payback period) processed grade of 5.3 g/t, results in an average production of 100,000oz per annum.

PROJECTED PRODUCTION DATA

Table 3: Mine Life is 5.5 years (as of January 1, 2019)

COMMODITY	UNITS	AVERAGE ANNUAL	LOM
Gold	Koz	66	393

All production numbers are expressed as payable metal.

Table 4: High Grade Gold Resource and Reserve Data

PROJECTED RESERVE	DEPLETION OF RESERVE
PROBABLE RESERVE	3,345,000 t @ 4.2g/t for 448,000oz
SHOWD RESERVE	4,037,000 t @ 4.3g/t for 556,000oz
INFERRED RESERVE	2,030,000 t @ 4.7g/t for 305,000oz

(Keers and Sppedy C, 2017).

III. RESULTS AND DISCUSSION

The results the incidence produced wastes may be increased in Segilola Mine. A number of isolated contamination issues were evident but not considered to be serious enough to have any material effect on the resource estimation. The identification and understanding of this effect does not impact on the overall project economics. Report given for the various years, from 2014 to 2020 is a pointer to the financial and consequential trend and capacity for production which is proportional to produced wastes in mining and mineral processing. The reduction of reserve (although, it is a profit for shareholder as per consequence of cost), and property value as exploration intensifies leads to increase in the amount of waste. Using the property/plant/equipment in Fig. 4-10, the graph down-surged from onset in 2014, went up and dropped again between 2017 and 2018; it later shot up continuously till date, 2020. Applying the exploration and equipment assets in Fig.4-10, the graph trend increased from onset and dropped in 2015; it sky-rocketed thereafter from 2017 till date, 2020, Considering the shareholders' equity reserve in Fig. 4-10, the graph was a uniform trend for 2 years, but up-surged in 2015. It became constant again until 2017 when it nose-dived, but rose thereafter till date, 2020. For the accrued liability in Fig. 4-10, the graph increased from onset till 2016, when it dropped for a year. It rose for subsequent 2 years before it dropped till date, 2020. Fig. 11 and 12 is a prediction projection for mined and milled gold. There was similar trend of graph path which is modelled as zero production of mining and milling from onset, 2020. It later modelled a continuous increase for 3 years till 2023; it produced a little 1 year upsurge in 2024 and a drastic continuous fall thereafter till termination. However, the average gold grade remains the same, pegged to 2023 (410 g/t) for both mining and milling. It is evident from the analysis that waste production is imminent, inevitable and unavoidable. It is hence recommended to adopt options suggested in this paper as means to minimize waste in Segilola Mine Project.

IV. CONCLUSION

It is practicable to reduce waste production or its generation if the salient principles and methods of waste avoidance with processing are put in place and waste itself is conceptually understood. The wastes being produced by the mining industry includes Waste Rocks, Mill Tailings; Wash Slimes, Mine Water, Spent Oil Shale, Chemicals used in processing and Coal Refuse. The generation of waste can be reduced by using the following: Recycling is one of reprocessing of wastes and recovery of minerals, economically; Mine Water Treatment (that reduces harmful or hazardous substances before being released into the environment; Hydrolysis of Aqueous Cyanide during the processing of major minerals like Gold; Selective mining that applies careful segregation or disintegration of mine waste from the ore during excavation process; Hydro-cyclonic Paste Backfill that reconstitutes mineral tailings by the separation of fine-grained and coarse-grained fractions in a hydro-cyclonic process which later moulds into pastes that are used for backfill; Pre-concentration impresses on the rejection or removal of barren wastes judging by the degree of coarseness of particles involved; The Froth Flotation uses the principles of separating of wastes from useful minerals inherent by the use of hydrophobicity; Reducing the discharge of wastes that are solids by considering them for maximum utilization; The combined Filling Approach that applies the admixture of waste rocks and tailings to meet some purpose; Dewatering to reduce moisture content of wastes through evaporation before being applied into a hot mix plant; Crushing and Screening involves size-reduction of oversized particles of coarse tailings. The reduction of waste generation adequately has so much far reaching benefits to mining and mineral processing activities, facilities and plant operations as it saves the industry in terms of energy, costs, emission, maintenance and side-hiccups.

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