

FACULTY OF ENGINEERING

DEPARTMENT OF MINING AND WATER RESOURCE ENGINEERING

FINAL YEAR PROJECT


**TITLE: DESIGN OF A TAILINGS IMPOUNDMENT DAM FOR ARTISANAL AND SMALL
SCALE MINERS.**

CASE STUDY: TIIRA GOLD MINES-BUSIA DISTRICT

BY

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A report submitted to the department of water resource and mining engineering for the partial fulfillment of the award of bachelors of Science in mining engineering.

ABSTRACT

Mineral processing involves the separation of valuable minerals from gangue minerals through crushing, grinding and concentration. During gravity concentration, huge amounts of tailings are discharged to the environment causing pollution of surface and underground water sources. The main objective of this study was to design an impoundment dam to contain the tailings. The methods of Tailings disposal, types of impoundments, Tailings discharge methods, basic structures for retaining tailings in impoundment, embankment construction methods, Tailings impoundment design and basic design concepts, major components of dams have been described in the literature review.

The tailings were characterized by analyzing the samples from the study area in the laboratory for geotechnical and geochemical parameters and MS Excel sheet 2010 was used in analyzing the collected data. To know the quantity of tailings being discharged to the environment per year the volumetric flow rate was determined from the field which helped in getting the mass flow rate of the tailings and then the volume to be contained per year was determined.

The design of the tailings dam was done using the relevant formulas and equations. The tailings dam was designed using ANCOLD, 1999 guidelines for dam design and AutoCAD 2016 software was used in generating the design drawings. The size of the impoundment area will accommodate the tailings that will be discharged for a given dam life.

Finally, economic evaluation of the system was done using benefit cost ratio approach and the project seemed to be economically viable and thus should be implemented to reverse the current trend of open tailings disposal which is subjecting the environment to land degradation and water pollution.

DECLARATION

I Kobusingye Debrah, REG NO- BU/UG/2014/142, hereby declare that this submission is my own work towards the award of B.sc in mining engineering and that, to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree in another University, except where due acknowledgement has been made in the text.

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APPROVAL

This is to certify that the project report under the title “design of a tailings impoundment dam for artisanal and small scale mines” has been submitted to the department of Mining and Water Resources Engineering for examination with approval from the following supervisors

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DEDICATION

I dedicate this piece of Work to my dear Parents Rev. Harrison Gad Twesigye and Mrs. Lydia Peace Twesigye for being a source of inspiration and encouragement throughout these challenging times and for the unceasing prayers and financial support that has brought me this far. Thank you so much.

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LIST OF ACRONYMS.

AAS: Atomic Absorption Spectrometry.

FAAS: Flame Atomic Absorption Spectrometer

AMD: Acid Mine Drainage.

PPM: Parts Per Million.

S: Sample number

ANCOLD: Australian National Committee on Large Dams

FEMA: Federal Emergency Management Agency

EPA: Environmental Protection Agency

USEPA: United States Environmental Protection Agency

CDA: Canadian Dam Association.

ICOLD: International Commission on Large Dams

MAC: Mining Association of Canada.

HDPE: High Density Polyethylene

1 CHAPTER ONE: INTRODUCTION.

1.1 BACKGROUND.

Mining involves production of large quantities of tailings which result from mineral processing after the minerals of value have been extracted from the ore (ICOLD, 1982). Typically, the ore percentages within the raw material are between 0.3 to 0.4%, which means massive amounts of mined materials are disposed of daily as wastes in form of tailings (Zardari, 2013). In gold mining, it is estimated that only 0.00001% (that is one hundred thousandth of 1%) of ore is actually refined into gold everything else is waste (Anon, 2006). Thus, tailings disposal is a significant part of the overall mining and mineral processing operation at most hard rock mining projects.

According to (Hurdson-Edwards, 2015), tailings represent a major environmental liability for a mine site, occupying vast surfaces of land and containing heavy metals and contaminated process water, they therefore need to be eventually managed well during operations or after Closure. Tailings are currently used as backfill in underground mines, stored in open pits, dried and stacked, or pumped into tailings dams on site. (Hudson Edwards, 2011).

The mining industry in Uganda reached peak levels in the 1950s and '60s when the sector accounted for up to 30% of Uganda's export earnings and is mainly characterized by artisanal and small scale mining (UNEP, 2010). However after the mineral of interest has been separated from the gangue mineral, many artisanal and small scale miners carelessly discharge their tailings to the nearest convenient location including nearby environment that is land, wetlands or rivers thereby impacting the environment negatively (Hinton, 2002).

Nature is an invaluable wealth and any harm caused to it results in heavy social-economic losses therefore for mining to be environmentally friendly and sustainable the tailings generated should be disposed in an environmentally acceptable and if possible economically viable manner thus the need to design a tailings storage facility which will contain the tailings generated by these miners.

REFERENCES

1. Abdhul-Wahab S, M. F. (2012). *environmental impact of gold mines: Pollution by heavy metals*.
2. Agency, U. S. (2004). *List of Contaminants and Their Maximum Contaminant Levels (MCLs)*. Washington DC.
3. Alsharedah, Y. A. (2015). Slope Stability Enhancement of an Upstream Tailings Dam :Laboratory Testing and Numerical Modelling.
4. ANCOLD. (1999). *Guidelines for Dam Design*.
5. Anon. (2006). *dirty metal mining communities and the environment,earthworks. oxfam,america,washington*.
6. B.R, S. (2010). Essentiality and toxicity in copper health risk assessment: Overview, update and regulatory considerations. *toxicology environmental health*, 114-127.
7. Banister S., V. B. (2002). Development of appropriate procedures for water management when planning underground mine closure. *Proceedings of the WISA Mine Water Division-mine closure conference*, (pp. 23-24). Randfotein South Africa.
8. Barry A.Wills, T. N.-M. (2006). *Mineral processing technology. An introduction to the practical aspects of ore treatment and mineral recovery*. Elsevier science and technology books.
9. Bieber, N. (2015). *Development of a Tailings Management Simulation and Technology Evaluation Tool*.
10. Blight G., F. A. (2005). *Catastrophe revisited-disastrous flow failures of mine and municipal solid wastes*.
11. BRGM. (2001). *Management of mining, quarrying and ore processing waste in the European Union*.
12. Bruins M.R, K. S. (2000). *Microbial resistance to metals in the environment*.
13. Cempel M, N. G. (2006). *A review of its sources and environmental toxicology* .
14. Chakravarty R, B. P. (2008). Morphological changes in an acidophilic bacterium induced by heavy metals. In *Extremophiles* (pp. 279-284).
15. Chalkely. (1989). *Tailings and effluent management*.
16. Edwards K.J., B. P. (2000). *An archaeal iron-oxidising extreme acidophile important in acid mine drainage*.
17. EPA. (2001). *Toxics release inventory*.

18. Franks D.M., B. D. (2011). *Sustainable development principles for the disposal of mining and mineral processing wastes.*
19. G & P, G. (2002). *filter design.*
20. Hamade, T. (2013). *Geotechnical design of tailings dam- A stochastic Analysis Approach.*
21. Hentschel. (2002). *Global report on artisanal and small scale mining, minerals and sustainable development IIED, WBCSD.*
22. Hudson Edwards, K. H. (2011). *Mine waste: past, present, future.*
23. Hurdson-Edwards, K. A. (2015). Mine Waste Characterisation, management and Remediation. *Minerals, 5*, 82-85.
24. ICOLD. (1996). *A guide to tailings dams and impoundments.*
25. Lee M. Thomas, U. e. (1985). *wastes from the extraction and beneficiation of metallic ores, phosphate rock, asbestos, overburden from uranium mining and oil shale.* washington,DC: U.S Government printing office.
26. Matshusa. (2012). Dispersion of metals at Louis Moore gold tailings dam. *proceedings of the International Mine Water Association Symposium*, (pp. 334A-334E). Limpompo province.
27. Pacyna E.G., P. J. (2010). *global emissions of mercury to the atmosphere from anthropogenic sources in 2005 and projections to 2020.*
28. Priscu, C. (1999). *Behavior of mine tailings dams under high tailings deposition rates.* UMI Dissertations Publishing.
29. Rafiei B, B. N. (2010). *Catastrophe revisited-disastrous flow failures of mine and municipal solid waste. .*
30. Rajahmundry, A. (2013). *waste management in minig industry. india: Indian J.Sci.Res. 4(2) : 139-142, 2013.*
31. Ranjard L, E. A. (2006). *Field and microcosm experiments to evaluate the effects of agricultural Cu treatment on the density and genetic structure of microbial communities in two different soils. .*
32. Rout, S. K. (2013). Design of tailing dam using red mud. *Central European Journal of Engineering*, 316-328.
33. Telmer K.H., V. M. (2009). Mercury Fate and Transport in the Global Atmosphere. *World emissions of mercury from artisanal and small scale gold mining* (pp. 131-172). Heidelberg,Germany: springer..
34. USEPA. (2001). *Update of Ambient Water Quality Criteria for Cadmium.* Environmental Protection Agency;. Washington DC.