



FINAL YEAR PROJECT REPORT

DEVELOPMENT OF A SIMULATION MODEL FOR GAS DISPERSION AND CONCENTRATION IN UNDERGROUND MINES

CASE STUDY: WAGAGAI MINING (U) LIMITED, BUSIA

By

NAMITI AMBROSE KIBUUKA

BU/UP/2021/0467

SUPERVIVORS

MR. BAGOOLE CHRISTOPHER

DR. JOSEPH DDUMBA LWANYAGA

MAY 2025

ABSTRACT

The accumulation of harmful gases in underground mining operations poses significant health, safety, and environmental risks. This project focuses on developing a simulation model to predict the dispersion and concentration of gases in underground mining environments. Gases such as carbon monoxide (CO), carbon dioxide (CO₂), and nitrogen dioxide (NO₂) were characterized using real-time air quality monitors. Initial gas concentrations reached hazardous levels—CO at 80 ppm, CO₂ at 22,000 ppm, and NO at 12 ppm—exceeding occupational safety thresholds. After implementing an optimized ventilation system, concentrations significantly dropped to 32 ppm, 12,000 ppm, and 3 ppm respectively, while oxygen increased from 18% to 20.8%. Using ANSYS Fluent, a Computational Fluid Dynamics (CFD) model simulated gas dispersion across the mine layout. The simulations revealed pollutant hotspots, dead zones, and airflow inefficiencies. Key findings showed that NO accumulated near inlet zones, CO stagnated in poorly ventilated areas, and CO₂ was highest near combustion regions. The designed system required an airflow rate of 10,070 m³/min and a 75-kW fan to maintain safe air quality. A financial analysis showed that implementing the simulation-based system resulted in projected energy savings of UGX 1.5 million annually, with a break-even period of 1.67 years. The results demonstrate that simulation-based ventilation design can significantly improve underground mine safety, operational efficiency, and cost-effectiveness. Adopting such models can revolutionize mine planning and regulatory compliance.

Keywords: Underground mining, Gas dispersion, Gas concentration, ANSYS Fluent, Computational Fluid Dynamics (CFD)

DECLARATION

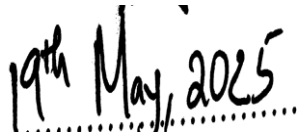
I, NAMITI AMBROSE KIBUUKA, declare that the work in this project proposal is my original work and has not been presented to any higher institution of learning for any academic award.

NAME: NAMITI AMBROSE KIBUUKA

SIGNATURE:



DATE:



Email: namitiambrose186@gmail.com

APPROVAL

This is to certify that this proposal report is under the supervision of;

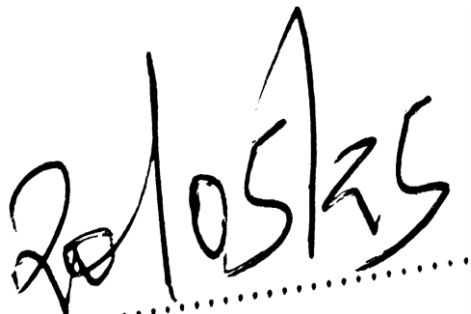
SUPERVISORS:

Mr. Bagoole Christopher

Assistant Lecturer

Department of Mining Engineering

Faculty of Engineering

Signature:  Date: 

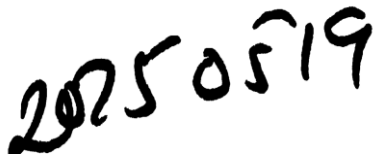
Dr. Joseph Ddumba Lwanyaga

Senior Lecturer

Department of Water Resources Engineering

Faculty of Engineering and Technology

Busitema University

Signature:  Date: 

ACKNOWLEDGEMENT

I would like to express my sincere gratitude to God Almighty for His guidance, protection, and blessings throughout this journey. I am deeply indebted to my parents for their unwavering love, support, and sacrifices, which have made this endeavor possible. My heartfelt thanks go to my supervisors, Mr. Bagoole Christopher and Dr. Joseph Ddumba Lwanyaga, for their invaluable guidance, mentorship, and patience. Their expertise and encouragement have been instrumental in the successful completion of this project. To the staff of the Department of Mining Engineering, I am really grateful for your assistance, cooperation, and provision of necessary resources. Finally, I would like to acknowledge the support and solidarity of my fellow students, who have created a positive and stimulating learning environment, above all.

DEDICATION

I dedicate this final year project proposal to my beloved father, Mr. Lwaya Joseph, whose unwavering support and guidance have been the cornerstone of my journey. To my loving mother, Babirye Rosemary, whose endless love and encouragement have fueled my aspirations. To my dear sister, Nabirye Immaculate, whose friendship and belief in me have always been a source of strength. And to my beloved girlfriend, Nayiga Reginah, whose love, patience, and understanding have made every challenge worthwhile.

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LIST OF ABBREVIATIONS

ANFO:	Ammonium Nitrate Fuel Oil
CFD:	Computational Fluid Dynamics
CO:	Carbon Monoxide
CO ₂ :	Carbon Dioxide
GHGs:	Greenhouse Gases
H ₂ S:	Hydrogen Sulfide
ILO:	International Labor Organization
NO:	Nitric Oxide
NO ₂ :	Nitrogen Dioxide
NO _x :	Nitrogen Oxides
OpEx:	Operational Expenditure
CapEx:	Capital Expenditure
PPE:	Personal Protective Equipment
STEL:	Short-Term Exposure Limit
TWA:	Time-Weighted Average
TVOCs:	Total Volatile Organic Compounds
VNA:	Ventilation Network Analysis
VoD:	Ventilation-on-Demand
WHO:	World Health Organization