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PROPOSED LIME PLANT

ENVIRONMENTAL IMPACT ASSESSMENT STUDY REPORT

Compiled by:-
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2023

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ENVIRONMENTAL IMPACT ASSESSMENT STUDY REPORT

Submitted by:

……………………………………
HASMUKH K. PATEL, OGW

Director

EXECUTIVE SUMMARY

This report presents finding of an Environmental Impact Assessment Study of a proposed lime plant that is to manufacture of lime. The proposed lime plant will consist of limestone preparation & dosing unit, pet coke grinding, parallel flow regenerative (PFR) kiln for quicklime production, quick lime handling unit, hydrated lime production and handling unit, packing plant for hydrated lime and quality control unit. The proposed lime plant will be constructed on sections of land parcel MN/III/291/2 and MN/III/4391 whose GPS Coordinates are latitude $3^0$44'9.6''S and longitude $39^0$50'43.81''E . This site is located in Kilifi County, Kilifi South Sub-County, Kikambala Division, Takaungu /Mavueni Location at Vipingo off Mombasa-Kilifi Road.

Scope

The proposed project will cover the following; limestone preparation & dosing unit, pet coke grinding, parallel flow regenerative (PFR) kiln for quicklime production, quicklime handling unit, hydrated lime production and handling unit, packing plant for hydrated lime, quality control., a power supply and water supply utilities and services facilities.

Raw materials and products

The main raw material for lime production will be limestone. The limestone will be sourced from existing nearby limestone quarries that supply limestone to Mombasa Cement clinkerlization plant. These limestone quarries are have an EIA license. The expected product from the lime plant is hydrated lime and quicklime.

Stakeholder views and concerns

While stakeholder consulted supported the proposed project, the stakeholders had serious concerns on potential pollution from lime dust and associate negative impacts.

Project cost

The cost of implementation of the proposed project as presented by the Project Proponent is KSH 937,500,000.00. The proponent will be required to pay to the National Environment Management Authority 0.1% of the total project cost being the applicable EIA processing and monitoring fees

Potential negative impacts and proposed mitigation measures

ISSUE CONCERN	POTENTIAL NEGATIVE IMPACT	PROPOSED MITIGATION MEASURES
CONSTRUCTION PHASE		
Loss of vegetation	✓ Direct loss of local vegetation ✓ Diminishing of local carbon sink	✓ Limit vegetation removal to actual proposed project site only

ISSUE CONCERN	POTENTIAL NEGATIVE IMPACT	PROPOSED MITIGATION MEASURES
	✓ Reduced area capacity of carbon sequestration ✓ reduction of ecological derived from the lost floral species ✓ Reduced foliage for local fauna species	✓ Plant trees around periphery of lime plant and in open spaces in the compound of the plant ✓ MCL to support planting of trees in public areas such as schools, Chief Camp, local dispensaries within the project catchment
Noise disturbance	✓ Impaired oral communication among the staff involved in the construction ✓ Reduced concentration for workers ✓ Annoyance to neighbours ✓ Noise induced hearing loss	✓ Comprehensive noise and vibration conservation programme including monitoring, use of noise attenuators, training and use of PPEs ✓ Prompt servicing & maintenance of equipment
Fugitive dust	✓ Throat irritation ✓ Skin irritation ✓ Coughing ✓ Sneezing	✓ Regular sprinkle water on opened up dusty areas ✓ Secure construction site with dust screens ✓ Provide construction workers with PPEs ✓ Fugitive dust monitoring
Injuries and accidents	✓ Injuries to workers ✓ Loss of productive workforce ✓ Loss of man-hours. ✓ Reduced productivity. ✓ Delays in project implementation ✓ Litigations	✓ Only skilled and experienced workers to be involved in the construction ✓ Use only suitable, appropriate, well serviced and maintained equipment ✓ Workers working at height and in confined areas to be provided with appropriate PPEs ✓ Equipped first aid station to be on site with trained and experienced first aiders
Waste generation	✓ Poor housekeeping due to littering and	✓ Reduce generation of waste from cement

ISSUE CONCERN	POTENTIAL NEGATIVE IMPACT	PROPOSED MITIGATION MEASURES
	untidiness ✓ Pollution from oil spills ✓ Flooding due to blocked drains	bags by using bulk cement delivered in bulk tankers as opposed to bagged cement ✓ Collect and recycle all empty cement bags by sending used cement bags to recyclers ✓ Provide waste receptacles for waste segregation
PRODUCTION PHASE		
Lime dust generation	✓ Lung infection resulting from inhaling of lime dust ✓ Skin irritation ✓ Itching of the skin ✓ Irritation of the eyes ✓ Chronic cough ✓ Reduced visibility ✓ Choking of plants	✓ Water sprinkling ✓ Use of bag filters ✓ Deployment of electrostatic precipitators
Increase in greenhouse gasses emission (carbon dioxide, carbon monoxide, nitrogen oxides, sulfur dioxide, and ammonia)	✓ Carbon monoxide (CO) can cause harmful health effects by reducing oxygen delivery to the body's organs and tissues, as well as adverse effects on the cardiovascular and central nervous systems. ✓ CO contributes to the formation of smog (ground-level ozone), which can cause respiratory problems ✓ Nitrogen oxide (NOx) can cause or contribute to a variety of health problems and adverse environmental	✓ Carbon Capture and Utilization (CCU): Carbon capture technologies can be applied to capture CO_2 emissions from lime production. ✓ Captured CO_2 can then be utilized in various ways, such as in the production of synthetic fuels, and chemicals, or as a component in building materials ✓ Improved thermal efficiency, improved electrical efficiency, raw material substitution and mineralizers can mitigate CO_2 emission

ISSUE CONCERN	POTENTIAL NEGATIVE IMPACT	PROPOSED MITIGATION MEASURES
	impacts, such as ground-level ozone, acid rain, global warming, water quality deterioration, and visual impairment. ✓ Sulfur dioxide (SO_2) in high concentrations can affect breathing and may aggravate existing respiratory and cardiovascular disease. ✓ SO_2 is also a primary contributor to acid deposition, or acid rain.	✓ SO_2 emission can be mitigated by inherent scrubbing, oxygen control (increase), fuel substitution (lower total sulfur), raw material substitution (lower sulfide sulfur) and raw material alkali/sulfur balance ✓ NOX emission can be mitigated by oxygen control (decrease), indirect firing, low-NOX burner, mid-kiln firing, process improvements, process control improvements, low-NOX calciner, staged combustion, semi-direct firing and mixing air fan. ✓ CO emission can be mitigated by good combustion practice, excess air (increase), raw material substitution, pyroprocessing system design and mixing air fan. ✓ Raw material substitution and tailpipe scrubber technologies can mitigate potential NH_3 emissions
Noise & vibration	✓ Noise induced hearing loss ✓ Damage to the worker's hearing mechanism ✓ Reduction of productivity and efficiency ✓ Upset the sense of balance and cause blood vessels to constrict ✓ Fatigue, headache, nervousness,	✓ The use of silencers ✓ Room enclosures for mill operators. ✓ Noise barriers/ attenuators. ✓ Installing suitable mufflers on compressor components. ✓ Installing acoustic barriers ✓ Installing vibration isolation for mechanical equipment ✓ Provision of personal hearing protection

ISSUE CONCERN	POTENTIAL NEGATIVE IMPACT	PROPOSED MITIGATION MEASURES
	irritability and high pretension ✓ Stress and reduced concentration.	such as ear plugs and ear mufflers ✓ Use of acoustic insulating materials, isolation of the noise source, and other engineering controls should be investigated and implemented, where feasible. ✓ Periodic medical hearing checks ✓ Record and respond to complaints
Waste generation	✓ Air pollution especially from lime dust ✓ Skin irritation when in contact dust ✓ Water pollution ✓ Production loss ✓ Irritation of eyes ✓ Chocking of plants ✓ Odor from decomposing food leftovers from the canteen ✓ Blockage of drainage system by scrap and other non-decomposing solid wastes. ✓ Some electronic office waste such as used toner cartridges and absolute office electronic equipment contain hazardous substances.	✓ Adoption of water conservation opportunities for facility cooling systems ✓ Use of heat recovery methods or other cooling methods to reduce the temperature of heated water prior to discharge ✓ Segregation of wastewater streams to ensure compatibility with selected treatment option ✓ Segregation and pretreatment of oil and grease containing effluents Segregation and pretreatment of oil and grease containing effluents ✓ Sewage from the industrial facility is to be discharged to an appropriate sewage treatment plant system ✓ Storm water should be separated from process and sanitary wastewater streams in order to reduce the volume of wastewater to be treated prior to discharge.
Safety & health hazards	✓ Dust exposure	✓ Good housekeeping

ISSUE CONCERN	POTENTIAL NEGATIVE IMPACT	PROPOSED MITIGATION MEASURES
	✓ Heat exposure ✓ Physical hazards ✓ Radiation exposure ✓ Chemical hazards ✓ Industrial hygiene issues ✓ Falling / impact with objects ✓ Hot surface burns ✓ Transportation ✓ Contact with allergic substances	✓ Use of air–conditioned, closed cabins ✓ Use of dust extraction and recycling systems ✓ Use of air ventilation (suction) in lime-bagging areas ✓ Use of PPE, as appropriate to address residual exposures ✓ Engineering controls ✓ Shielding surfaces where workers' proximity and close contact with hot equipment ✓ Minimizing the work time required in high temperature environments by implementing shorter shifts ✓ When working on equipment with moving parts, ensure the equipment is de-energized, isolated and locked/tagged out ✓ Use fall protection such as belts
DECOMMISSIONING PHASE		
Noise and vibration	✓ Interfere with conversation and communication at the workplace ✓ Negate general work performance, thought and concentration. ✓ Negate relaxation. ✓ Causes annoyance. ✓ Induces hearing loss if exposure is continuous for a long time	✓ Develop and implement a comprehensive noise conservation programme ✓ Ensure the decommissioning site is secured by appropriate noise attenuators. ✓ Provide all decommissioning staff with appropriate PPEs such as ear plugs and ear mufflers. ✓ Enforce proper use of the provided noise protective PPEs by all workers. ✓ Ensure equipment used is well maintained and serviceable

ISSUE CONCERN	POTENTIAL NEGATIVE IMPACT	PROPOSED MITIGATION MEASURES
Injuries & accidents	✓ Loss of life ✓ Loss of productive time ✓ Reduced productive ✓ Litigation	✓ Ensure all decommissioning workers are given appropriate PPEs. ✓ Ensure all decommissioning workers are trained on the appropriate use of the PPEs before use. ✓ Ensure each decommissioning worker and visitors to the decommissioning site also use the provided PPEs. ✓ Ensure that tools and equipment provided for use at the decommissioning site are well serviced and maintained. ✓ Ensure that the decommissioning site is free of hazards. ✓ Ensure that among the decommissioning workers at least one is a trained first aider. ✓ Ensure there is a fully equipped first aid station at the decommissioning site. ✓ Ensure appropriate measures are put in place to minimize fugitive dust by regularly sprinkling water on dusty ground
Dust pollution	✓ Lung infection resulting from inhaling of lime dust ✓ Skin irritation ✓ Itching of the skin	✓ Secure the entire site with appropriate dust screens ✓ Sprinkle water ✓ Provide all decommissioning staff with PPEs such as dust masks, overalls,

ISSUE CONCERN	POTENTIAL NEGATIVE IMPACT	PROPOSED MITIGATION MEASURES
	✓ Irritation of the eyes ✓ Chronic cough ✓ Reduced visibility ✓ Choking of plants	helmet, dust coats, safety boots and goggles. ✓ Ensure all workers make proper use of PPEs provided
Waste generation	✓ Blockage of drainage ✓ Poor housekeeping	✓ Minimize waste generation through re-use and recycling ✓ Provide appropriate receptacles for dropping waste ✓ Only NEMA licensed vehicles to collect waste from the site being decommissioned for disposal at licensed disposal site

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1. BACKGROUND

1.1 Introduction

This report presents findings of an Environmental Impact Assessment (EIA) Study for a proposed lime plant for the manufacture of lime. Lime processing plants are classified as high risk projects in the second schedule of the Environmental Management and Coordination Act (EMCA) 1999 Legal Notice number 31 of 2019 category 3 (9) (c). The Environmental Impact Assessment Study and report was prepared as provided for in Legal Notice No. 31 of 2019, section 58 (2) of the Environmental Management and Coordination Act, 1999 and the Environmental (Impact Assessment and Audit Regulations), 2003.

1.2 Project definition

The proposed project will be to construct and install a lime plant for the production of lime. The proposed lime plant will consist of limestone preparation & dosing unit, pet coke grinding, parallel flow regenerative (PFR) kiln for quicklime production, quick lime handling unit, hydrated lime production and handling unit, packing plant for hydrated lime and quality control unit. The plant will also have a power supply and water supply utilities and services facilities.

1.3 Location

Mombasa Cement Limited Vipingo factory is located in Kilifi County, Kilifi South Sub-County, Kikambala Division, Takaungu /Mavueni Location at Vipingo off Mombasa-Kilifi Road on two parcels of land namely MN/III/291/2 and MN/III/4391. The proposed lime plant will be constructed on sections of the said parcels of land which are side by side. The existing cement plants of MCL Vipino are on the two parcels of land. Appendix 1 is land documents for the proposed project site. The GPS Coordinates for the proposed lime plant site is latitude $3^0$44'9.6''S and longitude $39^0$50'43.81''E. Plate 1 is a view of a section of the proposed project site.

1.4 Project Proponent

Mombasa Cement Limited, a private company incorporated with limited liabilities in the Republic of Kenya is the project proponent. The company holds a certificate of incorporation number C. 106734 date eleventh November two thousand and three and personal identification number certificate P051159492Z dated second June 2004. .A copy of the proponent's PIN certificate and certificates of incorporation is attached in appendix 2.

Plate 1 *Cenchrus ciliaris & Azadirachta indica* growing in a section of the proposed project site

1.5 Project Objective and Scope

1.5.1 Objective

The objective of the proposed project is to construct a lime manufacturing plant to manufacture quicklime and hydrated lime.

1.5.2 Scope

The proposed project will cover the following; limestone preparation & dosing unit, pet coke grinding, parallel flow regenerative (PFR) kiln for quicklime production, quicklime handling unit, hydrated lime production and handling unit, packing plant for hydrated lime, quality control., a power supply and water supply utilities and services facilities.

1.6 Terms of Reference

Terms of reference (ToR) for the EIA study were prepared and submitted to the National Environment Management Authority (NEMA) for approval. The ToR was approved by NEMA appendix 3 is copy of the ToR approval from NEMA.

2. BACKGROUND TO ENVIRONMENTAL IMPACT ASSESSMENT

2.1 Definition of Environmental Impact Assessment

Broadly environmental impact assessment (EIA) refers to the need 'to identify and predict the impact on the environment and on man's health and wellbeing of legislative proposals, policies, programmes, projects and operational procedures, and to interpret and communicate information about the impacts'(Munn 1979). UNECE (1991) defines EIA as 'an assessment of the impacts of planned activity on the environment', IAIA (2009) on the other hand defines EIA as 'the process of identifying, predicting, evaluating and mitigating the biophysical, social and other relevant effects of proposed development proposals prior to major decision being taken and commitments made'. Glasson *et.al* (2012) defines EIA as 'a systematic process that examines the environmental consequences of development actions in advance'. EIA is thus a vital tool that aid formulation of development actions, decision making, an instrument for sustainable development and vehicle for stakeholder consultation and participation (Glasson *et.al* 2012).

2.2 The purposes of EIA

2.2.1 An aid to decision making

EIA is an aid to decision-making. For the decision maker, for example, a local authority, it provides a systematic examination of the environmental implications of a proposed action, and sometimes alternatives, before a decision is taken. The EIA can be considered by the decision-maker along with other documentation related to the planned activity. EIA is normally wider in scope and less quantitative than other techniques, such as cost-benefit analysis (CBA).It is not a substitute for decision making, but it does help to clarify some of the trade-offs associated with a proposed development action, which should lead to more informed and structured decision-making. The EIA process has a potential, not always taken up, to be a basis for negotiation between the developer, public interest groups and the planning regulator. This can lead to outcome that balances well the interests of the development action and the environment.

2.2.2 An aid to the formulation of development actions

Developers may see the EIA process as another set of hurdles to jump before they can proceed with their various activities; the process can be seen as yet another costly and time-consuming activity in the development consent process. However, EIA can be of great benefit to them, since it can provide a framework for considering location and design issues and environmental issues in parallel. It can be an aid to the formulation of development actions, indicating areas where a project can be modified to minimize or eliminate all together its adverse impacts on the environment. The consideration of environmental impacts early in the planning life of a development can lead to more environmentally sensitive development; to improved relations between the developer, the planning authority and the local communities; to a smoother development consent process, and sometimes to a worthwhile financial return on the extra expenditure incurred. O'Riordan and Sewell (1981) links such concepts of negotiation and redesign to the important environmental themes of 'green consumerism' and 'green capitalism'. The growing demand by consumers to goods that do no environmental damage, plus a growing market for clean technologies, is generating a response from developers. EIA can be the signal to the developer of potential conflict; wise developers may use the process to negotiate 'environmental gain' solutions, which may eliminate or offset negative environmental impacts, reduce local opposition and avoid costly public inquiries. This can be seen in the wider and contemporary context of corporate social responsibility (CSR) being increasingly practiced by major businesses (Crane et al.2008)

2.2.3 A vehicle for stakeholder consultation and participation

Development actions may have wide-ranging impacts on the environment, affecting many different groups in society. There is increasing emphasis by government at many levels on the importance of consultation and participation by key stakeholders in the planning and development of projects. EIA can be a very useful vehicle for engaging with communities and stakeholders, helping those potentially affected by a proposed development to be much better informed and to be more fully involved in the planning and development process.

2.2.4 An instrument for sustainable

Existing environmentally harmful developments have to be managed as best as they can. In extreme cases, they may be closed down, but they can still leave residual environmental problems for decades to come. It would be much better to mitigate the harmful effects in advance, at the planning stage, or in some cases avoid the particular development together. This of course leads on to the fundamental role of EIA as an instrument for sustainable development-a role some writers have drawn attention to as one often more hidden than it should be when EIA effectiveness is being assessed (Jay et al.2007)

2.3 Origins and development of EIA

The first EIA legislation was formerly established in the United States of America in 1969 (NEPA 1970), in Europe the 1985 European Community directive on EIA (Directive 85/337) introduced broadly uniform requirements for EIA for all member states (CEC, 1985). In Australia, the Commonwealth EIA system was established in 1974 under the Environmental Protection (Impact of Proposal) Act (Wood 2003, Ellott and Thomas, 2009). The United Kingdom enacted a formal legislation on EIA in 1988 (Glasson *et.al* 2012). China formerly enacted its first EIA legislation in 1979 (Moorman and Ge 2007). In Africa and the Middle East, Israel and Algeria pioneered in enactment and implementation of EIA legislations in 1982, 2003 and 1983, 1990 respectively (Economic Commission for Africa, (2005) Almagi *et.al* (2007). In East Africa Uganda pioneered in enacting EIA legislation in 1998, Kenya EIA legislation was enacted in 2000, and implemented in 2003 (Morara *et.al* 2011).

2.4 Key elements in the EIA process

The environmental impact assessment process comprises of various interactive steps such as screening, scoping, consideration of alternatives, action design, preparation of the EIA report, reviewing or evaluating the report, decision making, and post decision activities such as monitoring and auditing (Glasson *et al.*, 1994; Wood, 1995). According to UNEP (2002) key elements in the EIA process are screening, scoping, impact analysis, mitigation, reporting, review, decision-making, follow up and public involvement. Figure 2 is the schematic presentation of general EIA process adopted from UNEP' environmental impact assessment training manual.

2.4.1 Screening

Screening determines whether or not a proposal requires an EIA and, if so, what level of analysis is necessary. This process brings clarity and certainty to the implementation of EIA, ensuring that it neither entails excessive review nor overlooks proposals that warrant examination. Legal Notice No. 31 of 30th April 2019, that amended the second schedule of the Environmental Management and Coordination Act, 1999 categorizes Lime Mills under high risk projects in section 3 (9) (p) of the amended second schedule of the Act. Based on this, it is required that an environmental impact assessment study report be submitted for the proposed project. Regulation 11 (1) of the Environmental (Impact Assessment and Audit) Regulations, 2003 require that an environmental impact assessment study be conducted in accordance with the terms of reference developed during the scoping exercise by the proponent and approved by the Authority.

2.4.2 Scoping

Scoping identifies the important issues in readiness for preparation of terms of reference; it is a critical, early step in the preparation of an EIA (UNEP. 2002). The scoping process identified the issues that are likely to be of most importance during the EIA and eliminated those that are of little concern. In this way, the EIA study was focused on the significant effects and time and money are not wasted on unnecessary investigations (Glasson *et al.*, 2012). The following were the key issues identified to be focused on during the EIA study.

- ✓ Impacts on local air quality
- ✓ Noise and vibration impacts
- ✓ Traffic related impacts
- ✓ Waste related impacts
- ✓ Occupational injuries and accidents
- ✓ Increase demand and use of water

2.4.3 Impact analysis

Impact analysis is carried out in the detailed phase of the EIA; it involved identifying the impacts more specifically, predicting the characteristics of the main impacts and evaluating the significance of the residual impacts (UNEP, 2002).

2.4.4 Impact Mitigation

Mitigation is the stage of the EIA process when measures are identified to avoid, minimize or remedy impacts. These measures are implemented as part of the process of impact management, together with any necessary adjustments to respond to unforeseen impacts. Both elements are integral to ensuring that the EIA process leads to practical action to offset the adverse environmental impacts of proposed developments (UNEP, 2002). Mitigation recommends feasible and cost–effective measures to prevent or reduce significant negative impacts to acceptable levels.

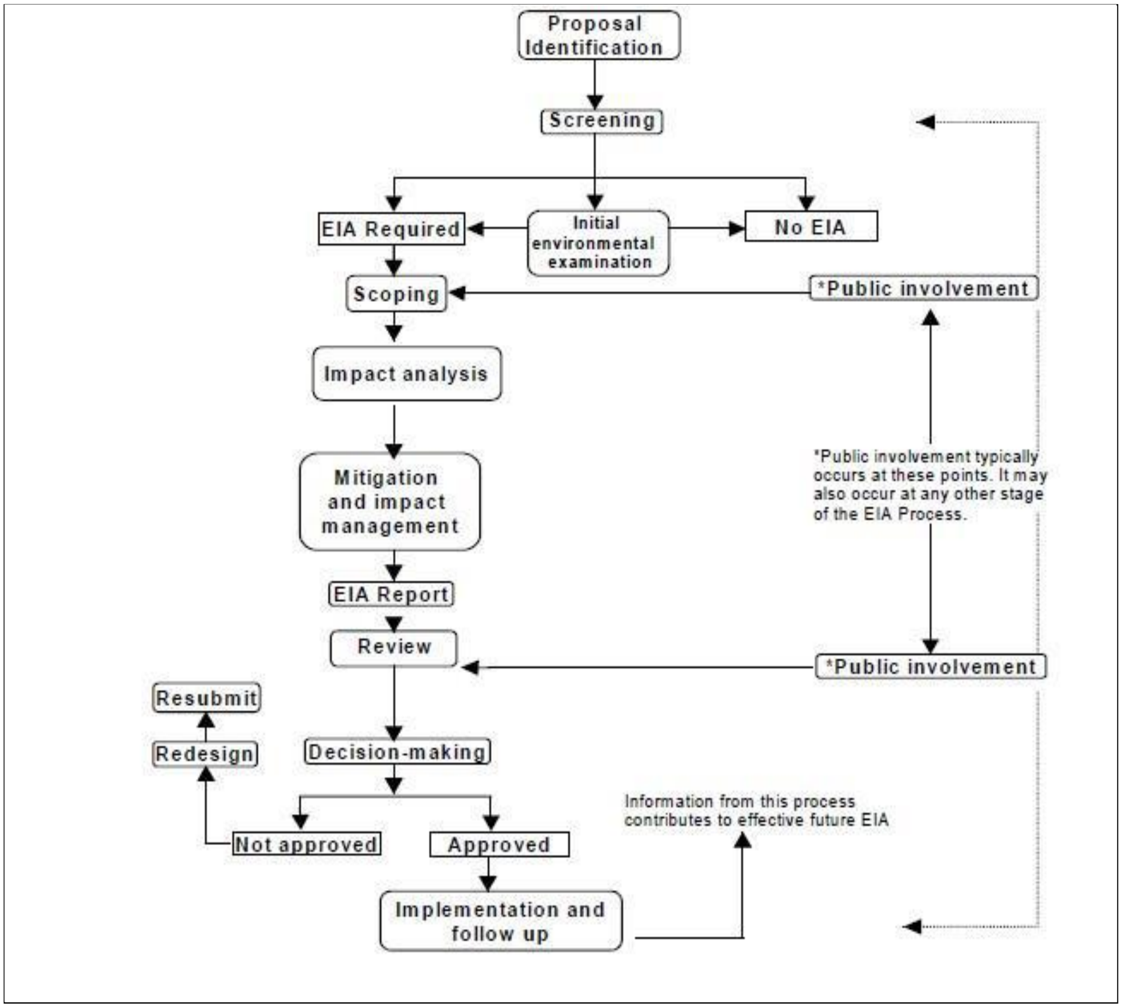


Figure 1: Generalized EIA process flowchart. Adapted from UNEP 2002

2.4.5 Reporting

Reporting involves compiling all the information obtained into an EIA report which is a keystone document. It assembles the information that assists the proponent in managing the impacts of the proposal, the responsible authority in decision-making and condition setting; and the public in understanding the likely impacts of the proposal (UNEP, 2002).

2.4.6 Report review

The review stage of the EIA report is one of the main ‘checks and balances’ built into the EIA process to establish the quality of an EIA. It helps to ensure the information submitted is credible and sufficient for decision-making purposes (UNEP, 2002) by verifying the accuracy and comprehensiveness of the report

(Glasson *et al.,* 2012). The decision-making element of the EIA process involves approving or rejecting the proposal and setting conditions. Decision making stage provides for incorporation of environmental considerations into proposed development (Glasson *et al.*, 2012). Once the proposed project is approved, implementation and follow up complete the EIA process (UNEP, 2002).

2.4.7 Monitoring and auditing

Monitoring, auditing and other tools are used to 'close the loop' of impact prediction and condition setting (Sadler, 1996). Monitoring and auditing is vital as it is used to identify the impacts that occur; to check that these are within the levels predicted and required by legislation; determine that mitigation measures are properly implemented and work effectively; ensure the environmental benefits expected are being achieved; and provide feedback to improve future applications of the EIA process (Arts, 1998).

3. APPROACH AND METHODOLOGY

3.1 Approach

At the beginning of the assignment inception meetings were held between the Proponent representative and the Consulting Team Leader in the proponent's office first and latter at the proposed project site. The meetings served as formal introduction for clarification of Terms of Reference (ToR) for the study team and physically show the team the proposed project site. A ToR for the EIA study was then developed and submitted to NEMA for approval.

3.2 Methodology

The following methodology was used in undertaking the Environmental Impact Assessment:

i) Scoping and development of Terms of Reference
ii) Desk review of relevant project documents including project design documents, relevant policy and legislative documents including relevant international conventions, agreements and protocols ratified by Kenya.
iii) Field visits for detailed documentation of site conditions and actual site assessment.
iv) Baseline studies
v) Public participation
vi) Impact prediction and mitigation measures determination
vii) Reporting.

3.2.1 Scoping

Scoping identified the important issues in readiness for preparation of terms of reference; it was a critical, early step in the preparation of an EIA study report. The scoping process identified the issues that are likely to be of most importance during the EIA and eliminated those that were of no concern.

3.2.2 Desk review

Desktop review included review of National Policies applicable to the proposed project including Kenya's Vision 2030, The Kenya Youth Development Policy 2019, National Energy Policy 2018, Sessional Paper no. 4 of 2013 on the Employment Policy and Strategy for Kenya, National Climate Change Framework Policy 2018, Climate Risk Management Framework (2017), National Climate Change Response Strategy 2010 among others**.** The review also include review of national laws including**,** Environmental Management and Co-ordination Act (EMCA) 1999**,** The Environmental Management and Coordination

(Water Quality) Regulations, 2006**,** The Environmental Management and Coordination (Noise and Excessive Vibration Pollution) (Control) Regulations 2009; Physical planning Act**,** The Public Health act**,** the Environmental Management and Coordination (Water Quality) Regulations, 2006;**,** The Environmental Management and Coordination (Waste Management) Regulations, 2006**,** The Employment Act 2007**,** The Labour Institutions Act 2007**,** The Work Injuries Benefits Act 2007**,** The Occupational Safety and Health Act 2007**,** The Environmental Management and Coordination (Noise and Excessive Vibration Pollution) (Control) Regulations 2009**,** The Lands Act 2012**,** The Energy Act 2006**,** Integrated Waste Management Act 2022**,** National Construction Authority Act No. 41 of 2011**,** The Environmental (Impact Assessment and Audit) Regulations 2003.

3.2.3 Field assessment

Field assessment involved visiting the proposed project site and documenting the current condition on the site. This involved documenting exiting structures onsite and neighboring facilities. Also the location where the proposed project will be constructed was assessed in relation to the existing structures. The assessment also included the existing access road to the proposed project site and available of vacant space to meet needs of the proposed project. The site was assessed for any flora and fauna and observations recorded. GPS coordinates for the site were taken by a handheld GPS and photographs of site observation were taken. Site office meetings were held between the Lead Consultant and team, the Project Engineers, the Company Environmental and Safety Officer who collectively responded to questions and clarified emerging issues during site assessment.

3.2.3 Public participation

Public participation involved conducting three public meetings (barazas) in three different locations adjacent to the proposed project site as was suggested by the local leadership. The meetings were also publicized locally through the Chief-Sub-Chief- Mzee wa Mtaa- Nymba Kumi channel to ensure the information reached each housed within every Nyumba Kumi cluster. To supplement the local meetings a detailed questionnaire survey was carried out, the questionnaire survey targeted various groups/ institutions including local leaders, civil society groups operating in the area, local learning institutions, and local faith based institutions and local health institutions.

3.2.4 Environmental baseline

Two critical environmental baselines covering greenhouses gases and ambient particulate matter were carried out to document the baseline conditions before implementation of the proposed project.

3.2.5 Reporting

All the information and data collected from scoping exercise, the desk top document review, field assessments, environmental baseline and stakeholder consultation and participation was compiled into two reports namely:-

- ✓ Terms of Reference Report; and
- ✓ Environmental Impact assessment (EIA) Study Report.

Terms of Reference Report was submitted to NEMA as specified in Regulation 11 (1) and 11(2) of the Environmental (Impact Assessment and Audit) Regulations, 2003. The Environmental Impact assessment (EIA) Study Report was prepared as specified in Regulation 18 of the Environmental (Impact Assessment and Audit) Regulations, 2003 and submitted to NEMA as specified in Regulation 19 of the Environmental (Impact Assessment and Audit) Regulations, 2003.

3.3 Study team

Sigtuna Consultancy Limited, a registered and licensed EIA/EA Firm of Experts registration number 9582, was contracted by Mombasa Cement Limited to carry out the environmental impact assessment study for the project and prepare an environmental impact assessment study report. Environmental baseline was carried out by Lahvens Limited Laboratory, a NEMA Designated Laboratory. Appendix 4 is copy of practicing licenses of the firm of experts and Lead Expert.

3. POLICY AND LEGAL FRAMEWORK

3.1 Relevant National Policies

3.1.1 National Environment Policy, 2013

The National Environment Policy document was prepared with the goal of bettering the quality of life for present and future generations through sustainable management and use of the environment and natural resources. The document underscores the importance and contribution of environment and natural resources to the local and national economy, people's livelihoods and the provision of environmental services such as watershed protection and carbon sequestration. It also reviews the status of environment in Kenya and highlights the key environmental issues and challenges. It identifies Kenya's critical ecosystems and natural resources and proposes measures to enhance conservation and management of ecosystems and sustainable use of natural resources. It addresses a wide range of issues relating to environmental quality and health. The areas covered include air quality, water and sanitation, waste management, radiation, toxic and hazardous substances, noise, HIV and AIDS and environmental diseases. It also outlines strategies and actions that will ensure effective implementation of the Policy and the Environmental Management and Coordination Act.

3.1.2 National Climate Change Framework Policy Sessional Paper No. 5 of 2016

This Policy was developed to facilitate a coordinated, coherent and effective response to the local, national and global challenges and opportunities presented by climate change. The policy adapts an overarching mainstreaming approach to ensure the integration of climate change considerations into development planning, budgeting and implementation in all sectors and at all levels of government. The Policy therefore aims to enhance adaptive capacity and build resilience to climate variability and change, while promoting a low carbon development pathway. The response to climate change in Kenya must adhere to the constitutional governance framework and commitment to sustainable development, while addressing the goal of attaining low carbon climate resilient development. To attain the latter, the policy focuses on appropriate mechanisms to enhance climate resilience and adaptive capacity, and the transition to low carbon growth.

3.1.3 Kenya's Vision 2030

The Country's development blueprint that aims to transform Kenya into a newly- industrializing, middle income country providing a high quality of life to all its citizens in a clean and secure environment by the year 2030.

3.1.4 The Kenya Youth Development Policy 2019

The Kenya youth development policy promotes holistic empowerment and participation of the youth in socio-economic and political development for themselves, the country and the future. Ensure adequate youth development and empowerment while harnessing their potential for productive engagement at local, County, National and International levels.

3.1.5 National Energy Policy 2018

The national energy policy's overall objective is to ensure sustainable, adequate, affordable, competitive, secure and reliable supply of energy at the least cost geared to meet national and county needs while protecting and conserving the environment.

3.1.6 Sessional Paper no. 4 of 2013 on the Employment Policy and Strategy for Kenya

This policy promotes full employment as a priority in national, economic and social policy and to enable the economically active population to attain and secure sustainable livelihood through productive and freely chosen employment by the year 2030.

3.1.7 Sessional Paper No. 01 of 2017 on National Land Use Policy

whose overall goal is to provide legal, administrative, institutional and technological framework for optimal utilization and productivity of land and land related resources in a sustainable and desirable manner at National, County and local level.

3.1.8 Sessional Paper 01 of 2021 on National Water Policy

The aim is to guide the achievement of sustainable management, development and use of water resources in Kenya. It provides a framework for sustainable management and financing of water resources; water harvesting and storage; and for equitable, efficient, and universal access to water supply and reasonable standards of sanitation, for domestic, economic use and ecosystem sustenance.

3.1.9 Sessional Paper No.13 of 2014 on Integrated Coastal Zone Management (ICZM) Policy The vision of the ICZM Policy is "A coastal zone with health ecosystem and resources that sustain the socio- economic development and well-being the current and future generations". It seeks to promote sustainable development in the coastal zone in line with the principles of the constitution and objectives of Vision 2030.

3.1.10 National Climate Change Framework Policy Sessional Paper No. 5 of 2016

The Policy aims to enhance adaptive capacity and build resilience to climate variability and change, while promoting a low carbon development pathway. The response to climate change in Kenya must adhere to the constitutional governance framework and commitment to sustainable development, while addressing the goal of attaining low carbon climate resilient development. To attain the latter, the policy focuses on appropriate mechanisms to enhance climate resilience and adaptive capacity, and the transition to low carbon growth.

3.2 National legislations

3.2.1 The Constitution of Kenya 2010

The Constitution of Kenya 2010 is the overarching legal framework for matters on environment. It recognizes the environment as part of the country's heritage, and which must be safeguarded for future generations. It provides for the right to a clean and healthy environment for every person in Article 42, obligating the state to enact legislation to protect that right as well as to establish systems of environmental impact assessment, environmental audit and monitoring of the environment in Article 69. Article 69 imposes on the State, other obligations including, to:

- Ensure sustainable exploitation, utilization, management and conservation of the environment and natural resources, and ensure the equitable sharing of the accruing benefits;
- Encourage public participation in the management, protection and conservation of the environment;
- Eliminate processes and activities that are likely to endanger the environment; and
- Utilize the environment and natural resources for the benefit of the people of Kenya.

Article 69 (2) similarly confers a conservation obligation on parties including the proponent of the proposed hot rolling lime mill. The proponent is thus obligated to cooperate with State organs and other persons to protect and conserve the environment.

3.2.2 The Environmental Management and Co-ordination Act, 1999

EMCA, 1999 (amended) 2015, provides a legal and institutional framework for the protection and conservation of the environment in line with Article 42 of the Constitution of Kenya, 2010. The ultimate objective is to provide a framework for integrating environmental considerations into the country's overall economic and social development. According to section 58 of the Act projects specified in the second schedule that are likely to have significant impact on the environment have to be subjected to an EIA study. Lime mills are categorized as high risk projects in the second schedule of the act and hence must be subjected to environmental impact assessment study prior to implementation.

3.2.3 The Occupational Safety and Health Act, 2007

This Act came into force in 2007 and replacing The Factories and Other Places of Work Act, Cap 514. It makes provisions for the health, safety and welfare to be observed by employers and persons employed in places of work. Part IV of the act covers health issues such as the state of cleanliness, refuse management, employee space requirement, ventilation and sanitary conveniences. Part V covers fire safety, operation and maintenance of machinery, fencing requirements, storage of dangerous substances, training and supervision of workers. Part VI deals with welfare issues; drinking water supply, washing facilities, sitting areas and first aid provision.

3.2.4 The Lands Act 2012

The Land Act 2012 is "an Act of Parliament to give effect to Article 68 of the Constitution, to revise, consolidate and rationalize land laws; to provide for the sustainable administration and management of land and land based resources, and for connected purposes". Part I of the act is preliminary provisions, part II of the act deals with management of public land, part III of the act deals with administration of public land (Leases, Licenses and Agreements), part IV of the act deals with community land, part V of the act deals with administration and management of private land, part VI of the act deals with general provisions of leases, part VII of the act deals with general provisions of charges, part VIII of the act deals with compulsory acquisition of interests in land, part IX of the act deals with settlement programmes, part X of the act deals with easements and analogous rights, part XI of the act deals with miscellaneous, the schedule lists repealed laws i.e. The Way leaves Act, Cap. 292 and The Land Acquisition Act, Cap. 295. The proposed project will fully comply with the provisions and requirements of the Lands Act 2012.

3.2.5 The Public Health Act Cap 242

Key relevant provisions of this Act are:

- Section 10, 11, 12, and 13 for regulating the maintenance, repair and inspection of drains, latrines, cesspool or septic tanks
- Section 28, 29, and 30 which give requirements for the construction of drains in connection with buildings and
- Section 115 prohibiting nuisances that may cause injury or health hazards.

The proposed project will comply with the provisions of the Public Health Act.

3.2.6 Work Injuries Benefits Act 2007

Section 7 of the Act stipulates that every employer shall obtain and maintain an insurance policy with an insurance company approved by the Minister in respect of any liability that the employer may incur under this Act to any of his employees. An employee who is involved in an accident resulting in the employees' disability or death is subject to the provisions of this Act, and entitled to benefits provided for under the Act. Section 3 of the Act however states that no employee shall be entitled to compensation if an accident, not resulting to serious disability or death, is caused by the deliberate and willful misconduct of the employee. The proposed project will comply with the provisions and requirements of this Act.

3.2.7 The Sustainable Waste Management Act 2022

The Sustainable Waste Management Act, 2022 provide for the sustainable management of waste. It provides for the creation of extended producer responsibility schemes as well as a circular economy for the reduction of waste. The Act provides for take back schemes and the labeling of products that may cause pollution. It provides for the creation of material recovery facilities in every County as well as the creation of incentives to encourage recycling. The purpose of the Act is thus to establish the legal and institutional framework for sustainable waste management and the realization of the constitutional provision on the right to a clean and healthy environment.

Section 19 of this Act outlines duties of private sector entities as follows:

(1) A private sector entity shall prepare a three-year waste management plan and submit an annual monitoring report to the Authority which shall specify—

(a) the actual quantities of waste generated by the entity;

(b) the waste management methods applied by the entity; and

(c) any other information that the Authority may require.

(2) Notwithstanding the generality of subsection (1), the Cabinet Secretary shall, within six months of the coming into force of this Act, *Gazette* the category of private sector entities that shall be required to prepare waste management plans which shall be based on the volume of production of waste.

(3) A private sector entity that fails to comply with the provisions of subsection (1) commits an offence and shall, on conviction, be liable to a fine of not more than two hundred thousand shillings and the person responsible for the private sector entity shall, in addition to the fine imposed on the entity, be liable to imprisonment for a term not exceeding three months.

(4) A private sector entity shall—

(a) adopt the following cleaner production principles including—

(i) improvement of production processes through conserving raw materials and energy;

(ii) Limit the use of toxic raw materials to safe laws within such times as may be prescribed by the authority;

(iii) reducing toxic emissions and wastes; and

(iv) monitoring the product cycle from beginning to end by;

(b) identify and eliminate potential negative impacts of the product;

(c) enable the recovery and reuse of the product where possible;

(d) reclaim and recycle;

(e) incorporate environmental concerns in the design, process and disposal of the product;

(f) collect, segregate and dispose of or cause to be disposed of the waste in accordance with this Act;

(g) shall segregate waste by separating hazardous waste from non-hazardous waste and dispose of the waste in a facility provided by the county government or the Authority;

(h) transfer the waste to a person who is licensed to transport and dispose of the waste in accordance with this Act;

(i) clean up and restore the site it was using to its natural state;

(j) prepare a waste management plan and integrate it in its corporate strategies and plans; and

(k) provide waste segregation receptacles at its premises for organic, plastic and general dry waste.

(5) A private entity that generates waste shall segregate the waste by separating hazardous waste and dispose of the hazardous waste in a facility provided by the county government or the Authority.

(6) A private entity or any its officers that fails to manage waste in accordance with this Act commits and offence and on conviction, shall be liable to a fine—

(a) of at least five per cent of the entity's net income registered in the previous tax year or five million shillings whichever is the higher; and

(b) of at least two hundred thousand shillings for the entity's officers.

(7) Where a private entity or any of its officers has been convicted of an offence under subsection (3), and the entity continues to fail to comply with the provisions of this Act, the entity or the officer commits a further offence and for each day the failure continues on conviction, shall be liable to a fine -

(a) not exceeding zero-point-five per cent of the entity's net income registered in the previous tax year, for the private entity; and

(b) not exceeding twenty thousand shillings for the entity's officers.

3.3 Regulatory Framework

3.3.1 The Environment (Impact Assessment and Audit) Regulations, 2003

These regulations provide guidelines for conducting an EIA study as well as environmental auditing and monitoring. The Regulations state in Regulation 3 that "the Regulations should apply to all policies, plans, programmes, projects and activities specified in Part III and V of the Regulations" basically lists the guidelines of undertaking, submission and approval of the EIA/SEA Report. The Regulations requires proponents to conduct annual environmental audits to identify the environmental impacts of their undertakings and propose mitigation measures to improve their environmental performance. Section 17 of the same regulation stipulates that during the process of conducting the audit the proponent shall seek the views of persons who may be affected by their operations. The proponent of the proposed project would be required to comply with the provisions of this legislation.

3.3.2 Building Operations and Works of Engineering Construction Rules, 1984

The provisions of the Factories Act relevant to building operations and engineering construction works are contained in the Abstract of the Act for Building Operations and Works of Engineering Construction Rules. These rules specify the minimum safety and health measures to be taken during construction works which include that the proponent should:

- Give notice of particular operations or works;
- Such notice should be sent in writing to the Occupational Health and Safety Officer, not later than seven days after commencement of construction;
- Post printed copies or prescribed abstracts of the Occupational Safety and Health Act at the site of operations or works (Section 61 of the Act);
- Provide sufficient and suitable sanitary conveniences for persons employed. These must be kept clean and well lit.

The contractor appointed by the proponent would be expected to adhere to these provisions.

3.3.3 Environmental Management and Coordination (Noise and Excessive Vibration) (Pollution Control) Regulations, 2009

The regulations apply to persons wishing to operate or repair any equipment or machinery, engage in any commercial or industrial activity that is likely to emit noise or excessive vibrations. The regulations specify the limits or levels within which these shall be undertaken. The Regulations also stipulate in the second schedule that construction activities undertaken during the night should not emit excessive noise beyond the permissible levels.

3.3.4 Environmental Management and Coordination (Water Quality) Regulations, 2006

These regulations provide protection to ground water or surface water from pollution by providing the limits and parameters of pollutants in treated waste water which can be discharged into the environment.

Relevant provisions of this regulation applicable to the proposed project include:-

- Every person shall refrain from any act which will directly or indirectly cause pollution and it shall be immaterial whether or not the water source was polluted before the enactment of these regulations;
- No person shall throw or cause to flow into or near a water source any liquid, solid or gaseous substance or deposit any such substance as to cause pollution;
- Discharge of effluent from sewer must be licensed according to the act;
- Water abstraction must only be done after approval of an Environmental Impact Assessment study.

3.3.5 Environmental Management and Coordination (Waste Management) Regulations, 2006

Part II of these regulations lists the responsibility of the waste generator and prescribes the proper mechanism of handling all waste through segregation and finally proposes environmental management programme through implementation of cleaner production mechanisms.

Relevant provisions of this regulation include:-

- Prohibition of any waste disposal on a public highway, street, road, recreational area or in any public place except in designated waste receptacle
- All waste generated to be collected, segregated and disposed in a manner provided for under these regulations
- All waste generators to minimize waste generated by adopting cleaner production methods
- All waste transporters to be licensed according to the Act
- Collection and transportation of the waste to be done in such a manner not to cause scattering of the waste
- The vehicle and equipment for waste transportation to be in such a manner not to cause scattering or escape of the waste

At the construction stage of construction debris would be generated. The proponent should ensure that the waste is managed in line with the provisions of these regulations.

3.3.6 Environmental Management and Coordination (Air Quality) Regulations, 2014

The objective of these Regulations is to provide for prevention, control and abatement of air pollution to ensure clean and healthy ambient air. The general prohibitions state that no person shall cause the emission of air pollutants listed under First Schedule (priority air pollutants) to exceed the ambient air quality levels as stipulated under the provisions of the Seventh Schedule (Emission limits for controlled and non-controlled facilities) and Second Schedule (Ambient air quality tolerance limits). The proponent will be guided by provisions of this act, during operation phase. Air quality monitoring will be guided by the standards stipulated thereof.

3.4 County Legislations

3.4.1 Kilifi County Environment (Regulation and Control) Act, 2016

This Act provides for the protection of the environment in Kilifi County. It seeks to ensure a clean and healthy environment. The provisions of this Act are additional to other requirements imposed by or under the Environmental Management and Coordination Act, 1999 (amended) 2015 or any other written law. The Act established in every Sub-County, a Committee known as the Sub-County Environment Committee. Such Committees are responsible for the proper management of the environment within the sub-county for which it is appointed. Specific provision is made regarding air pollution, noise pollution and public nuisances. Every owner or operator of a controlled facility shall ensure that emissions from the facility do not cause air pollution in any territory outside the facility, in excess of the prescribed relevant ambient air quality levels. The Department shall, in collaboration with other departments and agencies of the county government provide methods of abating and regulating air pollution.

3 BASELINE INFORMATION

5.1 **Baseline Green-House Gases**

Gases that trap heat in the atmosphere are called greenhouse gases. Six categories of pollutants were measured at the seventeen measurement locations within the proposed lime plant and the receiving neighborhoods. The monitored categories of pollutants were sulphur dioxide (SO_2); oxides of nitrogen (NO_x) (which includes nitric oxide (NO) and nitrogen dioxide (NO_2)); carbon monoxide (CO); carbon dioxide (CO_2); Total Volatile organic compounds, (TVOCs) and Ammonia (NH_3). The Environmental Management and Coordination (Air Quality) Regulations 2014 stipulates limit values of greenhouse gases. Part 65 and 66 details the requirements on monitoring and assessment of ambient air quality, part 85 shows the need for establishment of baseline levels of priority air pollutants listed in the first schedule of the guideline and included PM_{10}, $PM_{2.5}$, SO_2, NO_2, and CO. Statutory requirements relevant to the proposed project as captured in the first schedule of the Regulations are tabulated in Table 1.

Table 1: Ambient Air Quality Tolerance Limits (greenhouse gases)

	Pollutant	**Time weighted Average**	**Industrial area**	**Residential, Rural & Other area**	**Controlled areas*** **
1.	Sulphur dioxide	Instant Peak		500 µg/m^3	-
2.		Instant peak (10min)		0.191 ppm	-
3.	Non-methane hydrocarbons	instant Peak	700ppb	-	-
4.	Total VOC	24 hours**	600 µg/m^3	-	-
5.	Oxides of Nitrogen	24 hours	100 µg/m^3	0.1 PPM	-
6.		Instant peak		0.5 PPM	-
7.	Nitrogen dioxide	One hour		0.2 ppm	-
		Instant peak		0.5 ppm	-
8.	Carbon monoxide / carbon dioxide	One Hour	10 mg/m^3	4.0 mg/m^3	10 mg/m^3
9.	Ozone	1-Hour	200 µg/m3	0.12 PPM	-

Extract from the Ambient EMC Air Quality regulations, 2014 (Tolerance Limits)

5.1.1 Potential greenhouses gases receptors

The most immediate neighbors of Mombasa Cement Limited-Vipingo Unit are the Indian ocean to the East and the Rea Vipingo Sisal Plantation to the West. The most immediate learning institution is Vuma Primary school. Other learning institutions in the neighborhood include; Mkwajuni Youth Polytechnic (Vocational Training Centre), Takaungu Secondary School, Shariani Secondary School, Kilifi High Vision Secondary School, Mnarani Secondary School, Vutakaka Junior School, Takaungu Primary School, Mkwajuni Primary School, Shauri Moyo Primary School, Shariani Primary School, Kapecha Primary School, Mtwapa Elite Academy-Shariani, Timboni Primary School, Kadzinuni Primary School, Mkomani Primary School , Creek View School and the Zawadi Star Junior School. Health institutions within the vicinity of the plant include Kadzinuni Dispensary, Rayman Medical Clinic and Takaungu Dispensary. Religious institutions within the vicinity of the plant include Mwakujuni Mosque-Masjid Safina, Mkomani-Masjid Hudaa and Bethel Temple of Christ. There are various homesteads, subsistence farm lands and business developments within the neighborhood.

5.1.2 Greenhouse gases monitoring location

Seventeen number of monitoring locations were identified including several receivers either sensitive (residential locations and offices) or non-sensitive (production areas). The compartmentation of the survey locations was done to accommodate receivers to the East, West, North and South including the wind directions and speed. Table 2 gives the GPS coordinates of location were data was collected.

Table 2: Locations and dates of monitoring

Measurement Sites / Receivers	Dates of sampling
Westwards of Proposed Lime Plant **S** 3º 43' 54.818''**,** **E** 39º 50' 28.946	10th May 2023
Eastwards of Proposed Lime Plant **S** 3º 43' 51.971''**,** **E** 39º 50' 35.884''	10th May 2023
Philip Mason's Homestead S 3º40'59.8296'', E 39º51'30.5712''	11th May 2023
Homes Near Fazil and Sons Quarry S 3º41'00.708'', E 39º51'28.4256''	11th May 2023
Vuma Primary school boundary S 3º42'45.5688'', E 39º51'26.9712''	11th May 2023
Vuma Staff Quarters	11th May 2023

S 3º41'13.38", E 39º51'09.9"	
Homesteads Near Vuma Staff Quarters S 3º43'05.7576", E 39º50'51.2844"	11th May 2023
Coast Auto Section S 3º 44' 07.4076", E 39º50'35.502"	11th May 2023
Admin Office Area S 3º44'18.1968", E 39º50'32.4312"	11th May 2023
Takaungu Bmu Fish Point S 3º 41'00.708", E 39º 51'282.4256"	12th May 2023
Takaungu Villas Estates S 3º 40'59.8944", E 39º 51'29.5344"	12th May 2023
Takaungu Primary School S 3º 40'59.8296", E 39º 51'30.5712"	12th May 2023
Takaungu Bashraheil Police station 3º41'00.4812", E 39º51'28.6272"	12th May 2023
Takaungu Mosque S 3º40'58.2672", E 39º51'42.1992"	12th May 2023
Takaungu Secondary School S 3º40'57.7344", E 39º51'46.5984"	12th May 2023
Pentagon 5 & 6 Residences S 3º44'16.1268", E 39º50'43.2816"	12th May 2023
White House S 3º44'13.8696", E 39º50'09.5064"	12th May 2023

Table 3 gives the environmental parameters at each of the selected monitoring location as at the time of data collection.

Table 3: Environmental parameters at selected GHGs baseline monitoring locations

Monitoring Locations	**Environmental parameters**				***Remarks***
	Air temps °C	Pressure hPa	Humidity %	Wind Speed km/hr	
Westwards of Proposed Lime Plant	28	1010.9	74	25 km/hr South wind	Ambient conditions present
Eastwards of Proposed Lime Plant	28	1010.9	73	25 km/hr South wind	Ambient conditions present

Philip Mason's Homestead	26	1011.79	82	25 km/hr South West wind	Ambient conditions present
Homes Near Fazil and Sons Quarry	27	1011.79	75	29 km/hr South wind	Ambient conditions present
Vuma Primary Wall	28	1011.79	74	28 km/hr South wind	Ambient conditions present
Vuma Staff Quarters	29	1011.79	74	30 km/hr South wind	Ambient conditions present
Homesteads Near Vuma Staff Quarters	30	1011.79	68	30 km/hr South wind	Ambient conditions present
Coast Auto Section	30	1011.79	63	33 km/hr South wind	Ambient conditions present
Admin Office Area	30	1011.79	62	34 km/hr South wind	Ambient conditions present
Takaungu Bmu Fish Point	27	1012.01	78	34 km/hr South wind	Ambient conditions present
Takaungu Villas Estates	29	1012.01	73	35 km/hr South wind	Ambient conditions present
Takaungu Primary Sch.	29	1012.01	70	29 km/hr South wind	Ambient conditions present
Takaungu Bashraheil Police	29	1012.01	70	27 km/hr South wind	Ambient conditions present
Takaungu Mosque	30	1012.01	68	28 km/hr South wind	Ambient conditions present
Takaungu Secondary Sch.	30	1012.01	67	30 km/hr South wind	Ambient conditions present
Pentagon 5 & 6 Residential	30	1011.79	67	31 km/hr South wind	Ambient conditions present
White House	30	1011.79	67	32 km/hr South wind	Ambient conditions present

5.1.3 Greenhouse gases baseline results

Table 4: Greenhouse gases baseline

Monitoring Locations	**CO** **mg/m^3**	**SO_2** **ppm**	**NO_2** **ppm**	**NO** **ppm**	**NH_3** **ppm**	**TVOC** **µg/m^3**
Westwards of Proposed Lime Plant	0.18	0.028	0.028	<0.001	<0.001	16
Eastwards of Proposed Lime Plant	0.15	0.022	0.031	<0.001	<0.001	12
Philip Mason's Homestead	0.17	0.020	0.007	<0.001	<0.001	13
Homes Near Fazil And Sons Quarry	0.20	0.019	0.011	<0.001	<0.001	9
Vuma Primary Wall	0.14	0.015	0.015	<0.001	<0.001	8
Vuma Staff Quarters	0.11	0.021	0.009	<0.001	<0.001	5
Homesteads Near Vuma Staff Quarters	0.23	0.017	0.017	<0.001	<0.001	4
Coast Auto Section	0.19	0.010	<0.001	<0.001	<0.001	22
Admin Office Area	0.13	<0.001	<0.001	<0.001	<0.001	31
Takaungu Bmu Fish Point	0.21	<0.001	<0.001	<0.001	<0.001	11

Takaungu Villas Estates	0.25	<0.001	0.013	<0.001	<0.001	9
Takaungu Primary Sch.	0.16	<0.001	<0.001	<0.001	<0.001	8
Takaungu Bashraheil Police	0.22	0.012	0.007	<0.001	<0.001	8
Takaungu Mosque	0.25	<0.001	0.005	<0.001	<0.001	5
Takaungu Secondary Sch.	0.19	<0.001	<0.001	<0.001	<0.001	9
Pentagon 5 & 6 Residentials	0.17	<0.001	<0.001	<0.001	<0.001	19
White House	0.12	<0.001	<0.001	<0.001	<0.001	14

Table 5: Recorded greenhouse gases compared to air quality regulatory limits

Monitoring Locations	***NO_2***		***SO_2***		***CO***		***TVOC***		***REMARKS***
	Conc. (ppm)	EMC AQR guide 2014 (ppm)	Conc. (ppm)	EMC AQR guide 2014 (ppm)	Conc. (mg/ m^3)	EMC AQR guide 2014 (mg/m^3)	Conc. (µg/ m^3)	EMC AQR guide 2014 (ppm)	
Westwards of Proposed Lime Plant	0.028	0.2	0.028	0.191	0.18	4.0	16	-	Complies
Eastwards of Proposed Lime Plant	0.031	0.2	0.022	0.191	0.15	4.0	12	-	Complies
Philip Mason's Homestead	0.007	0.2	0.020	0.191	0.17	4.0	13	-	Complies
Homes Near Fazil And Sons Quarry	0.011	0.2	0.019	0.191	0.20	4.0	9	-	Complies
Vuma Primary Wall	0.015	0.2	0.015	0.191	0.14	4.0	8	-	Complies
Vuma Staff Quarters	0.009	0.2	0.021	0.191	0.11	4.0	5	-	Complies
Homesteads Near Vuma Staff Quarters	0.017	0.2	0.017	0.191	0.23	4.0	4	-	Complies
Coast Auto Section	<0.001	0.2	0.010	0.191	0.19	4.0	22	-	Complies
Admin Office Area	<0.001	0.2	<0.001	0.191	0.13	4.0	31	-	Complies
Takaungu Bmu Fish Point	<0.001	0.2	<0.001	0.191	0.21	4.0	11	-	Complies
Takaungu Villas Estates	0.013	0.2	<0.001	0.191	0.25	4.0	9	-	Complies
Takaungu Primary Sch.	<0.001	0.2	<0.001	0.191	0.16	4.0	8	-	Complies
Takaungu Bashraheil Police	0.007	0.2	0.012	0.191	0.22	4.0	8	-	Complies
Takaungu Mosque	0.005	0.2	<0.001	0.191	0.25	4.0	5	-	Complies
Takaungu Secondary Sch.	<0.001	0.2	<0.001	0.191	0.19	4.0	9	-	Complies

Pentagon 5 & 6 Residential	<0.001	0.2	<0.001	0.191	0.17	4.0	19	-	Complies
White House	<0.001	0.2	<0.001	0.191	0.12	4.0	14	-	Complies

Detailed report of environmental baseline for ambient green-house gases monitoring is in appendix 5.

5.1.4 Discussion of GHGs monitoring results

CO concentration was observed to be 0.25 mg/m^3 at Takaungu Villas estate and Takaungu Mosque while the minimum 1-hour CO concentration was observed to be 0.11 mg/m^3 at Vuma staff quarters. All CO concentrations recorded at all survey locations complied with the EMC (Air quality) regulations 2014 of 4.0 mg/m^3 before implementation of the proposed lime plant. The concentration levels of carbon monoxide recorded across the seventeen survey locations showed some form of consistency therefore, no signs of distinguished outliers influencing the CO concentration. The results for the sulfur dioxide (SO_2) concentrations were notably below the air quality guidelines. The maximum 1-hour SO_2 concentration of 0.028 ppm was recorded Westward of the proposed lime plant while the minimum SO_2 concentration of 0.010 ppm was recorded at Coast Auto section. Sulfur dioxide concentrations were below detection levels of the equipment used hence not recorded across eight survey locations. Sulfur dioxide concentrations record at Westwards of Proposed Lime Plant, Eastwards of Proposed Lime Plant, Philip Mason's Homestead, Homes Near Fazil and Sons Quarry, Vuma Primary boundary and Vuma Staff Quarters marginally surpassed the ambient concentrations (0.02 ppm). The concentration levels of sulfur dioxide recorded across all survey locations were somewhat consistent therefore, no signs of notable outliers influencing the concentration of SO_2. The consistency of the results could also symbolize similar sources of sulfur dioxide across the survey locations. The main source of sulfur dioxide pollutants was combustion of fuel during movement of motor vehicles and trucks on site and around the survey locations. There was no instant peak exceedance of the AAQTL of 0.191 ppm thus the frequency of exceedance was zero. This result is 100.00% in compliance of the EMC (Air quality) Regulations 2014 maximum limits before implementation of the proposed lime plant.

The maximum 1-hour NO_2 concentration (0.031 ppm) was recorded at Eastwards of Proposed Lime Plant while the minimum 1-hour NO_2 concentration (0.005 ppm) was recorded at Takaungu Mosque. Nitrogen dioxide concentrations recorded at all the seventeen survey locations were within the ambient levels (0.05ppm). There were no 1-hour exceedance of the AAQTL of 0.2 ppm thus the frequency of exceedance was zero. The concentrations of NOx at the survey locations were 100.00% in compliance of the EMC (Air quality) regulations 2014 maximum limits before implementation of the proposed lime plant. The concentration levels of nitrogen dioxide recorded across all survey locations could have resulted from combustion of fuel during movement of motor vehicles and trucks on site and around the survey locations. The maximum TVOC concentration (31 μg/m3) was recorded at the administration area while the minimum 1-hour TVOC concentration (4 μg/m3) was observed at homestead near Vuma staff quarters. TVOC concentrations recorded in the survey locations were not compared against the EMC (Air quality) regulations 2014 since there was no short term weighted averages given under the regulation for TVOC

5.2 Ambient Particulate Matter Monitoring

Particulate matter is the term for particles and aerosols found in the air, including dust, dirt, soot, smoke, and liquid droplets, and can be large and dark enough to be seen with the naked eye or so small that they can only be detected with an electron microscope. Many manmade and natural sources emit particulate matter directly while others emit gaseous pollutants that react in the atmosphere to form particulate matter. The size of the particulate has important health considerations. Particulate matter less than or equal to 10 microns in diameter (PM10) poses a health concern because it can be inhaled into and accumulate in the respiratory system. Particulate matter less than or equal to 2.5 microns in diameter (PM2.5) is believed to pose the greatest health risks as it can lodge deeply into the lungs; a PM2.5 particles is approximately 1/30th the average width of a human hair. Typically, these smaller particles are suspended in the air for long periods of time. Total Particulate Matter (TPM) is the term applied to any particle suspended in the atmosphere, but depending on the monitoring method, is typically limited to particulate matter less than 44 microns. Particulate larger than 10 microns is typically associated with a nuisance issue rather than a health issue. The Environmental Management and Coordination (Air Quality Regulations), 2014 whose objective is to prevention, control and abate air pollution to ensure clean and healthy environment. Part 65 and 66 details the requirements on monitoring and assessment of ambient air quality, part 85 shows the need for establishment of baseline levels of priority air pollutants listed in the first schedule of the guideline and included PM_{10}, $PM_{2.5}$, SO_2, NO_2, and CO. Statutory requirements relevant to the proposed project as captured in the first schedule of the Regulations are tabulated in Table 6.

Table 6: Ambient air quality tolerance limits

	Pollutant	Time weighted Average	Industrial area	Residential, Rural & Other area	Controlled areas***
	Respirable particulate matter (<10 $\mu g/m^3$) (RPM)	24 hours**	150$\mu g/Nm^3$	100$\mu g/Nm^3$	75$\mu g/Nm^3$
	$PM_{2.5}$	24 hours	75 $\mu g/m^3$	-	-
	Sulphur dioxide	Instant Peak		500 $\mu g/m^3$	-
		Instant peak (10min)		0.191 ppm	-
	Non-methane hydrocarbons	instant Peak	700ppb	-	-
	Total VOC	24 hours**	600 $\mu g/m^3$	-	-
	Oxides of Nitrogen	24 hours	100 $\mu g/m^3$	0.1 PPM	-
		Instant peak		0.5 PPM	-
	Nitrogen dioxide	One hour		0.2 ppm	-
		Instant peak		0.5 ppm	-
	Carbon monoxide / carbon dioxide	One Hour	10 mg/m^3	4.0 mg/m^3	10 mg/m^3
	Ozone	1-Hour	200 µg/m3	0.12 PPM	-

Source: Extract from the Ambient EMC Air Quality regulations, 2014 (Tolerance Limits)

5.2.1 Potential particulate matter receptors

The most immediate neighbors of Mombasa Cement Limited-Vipingo Unit are the Indian ocean to the East and the Rea Vipingo Sisal Plantation to the West. The most immediate learning institution is Vuma Primary school. Other learning institutions in the neighborhood include; Mkwajuni Youth Polytechnic (Vocational Training Centre), Takaungu Secondary School, Shariani Secondary School, Kilifi High Vision Secondary School, Mnarani Secondary School, Vutakaka Junior School, Takaungu Primary School, Mkwajuni Primary School, Shauri Moyo Primary School, Shariani Primary School, Kapecha Primary School, Mtwapa Elite Academy-Shariani, Timboni Primary School, Kadzinuni Primary School, Mkomani Primary School , Creek View School and the Zawadi Star Junior School. Health institutions within the vicinity of the plant include Kadzinuni Dispensary, Rayman Medical Clinic and Takaungu Dispensary. Religious institutions within the vicinity of the plant include Mwakujuni Mosque-Masjid Safina, Mkomani-Masjid Hudaa and Bethel Temple of Christ. There are various homesteads, subsistence farm lands and business developments within the neighborhood.

5.2.2 Particulate matter monitoring locations

Seventeen number of monitoring locations were identified including several receivers either sensitive (residential locations and offices) or non-sensitive (production areas). The categorization of the survey locations was done to accommodate receivers to the East, West, North and South including the wind directions and speed. Two categories of pollutants were measured at seventeen selected monitoring locations within the proposed lime plant and the receiving neighborhoods. The monitored categories of pollutants were particulate matter (PM) (which includes particles less or equal to than 2.5 microns ($PM_{2.5}$), particles less than or equal to 10 microns (PM_{10}). Table 7 gives the GPS coordinates of location were data was collected.

Table 7: Monitoring sites and dates of monitoring

Measurement Sites / Receivers	**Dates of sampling**
Westwards of Proposed Lime Plant **S** 3º 43' 54.818"**, E** 39º 50' 28.946	10th May 2023
Eastwards of Proposed Lime Plant **S** 3º 43' 51.971"**, E** 39º 50' 35.884"	10th May 2023
Philip Mason's Homestead S 3º40'59.8296", E 39º51'30.5712"	11th May 2023
Homes Near Fazil and Sons Quarry S 3º41'00.708", E 39º51'28.4256"	11th May 2023
Vuma Primary school boundary S 3º42'45.5688", E 39º51'26.9712"	11th May 2023
Vuma Staff Quarters S 3º41'13.38", E 39º51'09.9"	11th May 2023
Homesteads Near Vuma Staff Quarters S 3º43'05.7576", E 39º50'51.2844"	11th May 2023
Coast Auto Section S 3º 44' 07.4076", E 39º50'35.502"	11th May 2023
Admin Office Area S 3º44'18.1968", E 39º50'32.4312"	11th May 2023
Takaungu Bmu Fish Point S 3º 41'00.708", E 39º 51'282.4256"	12th May 2023
Takaungu Villas Estates S 3º 40'59.8944", E 39º 51'29.5344"	12th May 2023
Takaungu Primary School S 3º 40'59.8296", E 39º 51'30.5712"	12th May 2023

Takaungu Bashraheil Police station 3º41'00.4812", E 39º51'28.6272"	12th May 2023
Takaungu Mosque S 3º40'58.2672", E 39º51'42.1992"	12th May 2023
Takaungu Secondary School S 3º40'57.7344", E 39º51'46.5984"	12th May 2023
Pentagon 5 & 6 Residences S 3º44'16.1268", E 39º50'43.2816"	12th May 2023
White House S 3º44'13.8696", E 39º50'09.5064"	12th May 2023

Table 8 gives the environmental parameters at each of the selected monitoring location as at the time of data collection.

Table 8: Environmental parameters at selected baseline particulate matter monitoring locations

Monitoring Locations	**Environmental parameters**				***Remarks***
	Air temps °C	Pressure hPa	Humidity %	Wind Speed km/hr	
Westwards of Proposed Lime Plant	28	1010.9	74	25 km/hr South wind	Ambient conditions present
Eastwards of Proposed Lime Plant	28	1010.9	73	25 km/hr South wind	Ambient conditions present
Philip Mason's Homestead	26	1011.79	82	25 km/hr South West wind	Ambient conditions present
Homes Near Fazil and Sons Quarry	27	1011.79	75	29 km/hr South wind	Ambient conditions present

Vuma Primary Wall	28	1011.79	74	28 km/hr South wind	Ambient conditions present
Vuma Staff Quarters	29	1011.79	74	30 km/hr South wind	Ambient conditions present
Homesteads Near Vuma Staff Quarters	30	1011.79	68	30 km/hr South wind	Ambient conditions present
Coast Auto Section	30	1011.79	63	33 km/hr South wind	Ambient conditions present
Admin Office Area	30	1011.79	62	34 km/hr South wind	Ambient conditions present
Takaungu Bmu Fish Point	27	1012.01	78	34 km/hr South wind	Ambient conditions present
Takaungu Villas Estates	29	1012.01	73	35 km/hr South wind	Ambient conditions present
Takaungu Primary Sch.	29	1012.01	70	29 km/hr South wind	Ambient conditions present
Takaungu Bashraheil Police	29	1012.01	70	27 km/hr South wind	Ambient conditions present
Takaungu Mosque	30	1012.01	68	28 km/hr South wind	Ambient conditions present
Takaungu Secondary Sch.	30	1012.01	67	30 km/hr South wind	Ambient conditions present

Pentagon 5 & 6 Residential	30	1011.79	67	31 km/hr South wind	Ambient conditions present
White House	30	1011.79	67	32 km/hr South wind	Ambient conditions present

5.2.3 Particulate matter baseline results

Table 9: Particulate matter (<10 microns)

Monitoring Locations	**Particulate Matter ≤10 (PM_{10})**			
	Sampling time	Concentration (µg/m^3)	Guideline (µg/m^3)	Remarks
Westwards of Proposed Lime Plant	2 hours	68.50	-	No guideline for short term emissions
Eastwards of Proposed Lime Plant	2 hours	72.10	-	No guideline for short term emissions
Philip Mason's Homestead	2 hours	60.20	-	No guideline for short term emissions
Homes Near Fazil and Sons Quarry	2 hours	65.40	-	No guideline for short term emissions
Vuma Primary Wall	2 hours	69.44	-	No guideline for short term emissions
Vuma Staff Quarters	2 hours	55.15	-	No guideline for short term emissions
Homesteads Near Vuma Staff Quarters	2 hours	54.00	-	No guideline for short term emissions
Coast Auto Section	2 hours	50.70	-	No guideline for short term emissions
Admin Office Area	2 hours	49.25	-	No guideline for short term emissions
Takaungu Bmu Fish Point	2 hours	40.50	-	No guideline for short term emissions
Takaungu Villas Estates	2 hours	45.60	-	No guideline for short term emissions
Takaungu Primary Sch.	2 hours	42.80	-	No guideline for short term emissions
Takaungu Bashraheil Police	2 hours	47.00	-	No guideline for short term emissions
Takaungu Mosque	2 hours	44.50	-	No guideline for short term emissions
Takaungu Secondary Sch.	2 hours	45.15	-	No guideline for short term emissions
Pentagon 5 & 6 Residential	2 hours	40.95	-	No guideline for short term emissions

White House	2 hours	41.40	-	No guideline for short term emissions

Table 10: Particulate matter (<2.5 microns)

Monitoring Locations	Particulate Matter ≤2.5 ($PM_{2.5}$)			
	Sampling time	Concentration (µg/m^3)	Guideline (µg/m^3)	Remarks
Westwards of Proposed Lime Plant	2 hours	50.92	-	No guideline for short term emissions
Eastwards of Proposed Lime Plant	2 hours	53.65	-	No guideline for short term emissions
Philip Mason's Homestead	2 hours	43.28	-	No guideline for short term emissions
Homes Near Fazil and Sons Quarry	2 hours	44.50	-	No guideline for short term emissions
Vuma Primary Wall	2 hours	47.60	-	No guideline for short term emissions
Vuma Staff Quarters	2 hours	40.24	-	No guideline for short term emissions
Homesteads Near Vuma Staff Quarters	2 hours	42.30	-	No guideline for short term emissions
Coast Auto Section	2 hours	40.50	-	No guideline for short term emissions
Admin Office Area	2 hours	40.85	-	No guideline for short term emissions
Takaungu Bmu Fish Point	2 hours	30.75	-	No guideline for short term emissions
Takaungu Villas Estates	2 hours	38.55	-	No guideline for short term emissions
Takaungu Primary Sch.	2 hours	35.70	-	No guideline for short term emissions
Takaungu	2 hours	37.25	-	No guideline for short term

Bashraheil Police				emissions
Takaungu Mosque	2 hours	36.00	-	No guideline for short term emissions
Takaungu Secondary Sch.	2 hours	36.80	-	No guideline for short term emissions
Pentagon 5 & 6 Residential	2 hours	32.35	-	No guideline for short term emissions
White House	2 hours	31.88	-	No guideline for short term emissions

Detailed environmental baseline report for ambient particulate matter monitoring is in appendix 6

5.2.4 Discussion of ambient air quality monitoring results

Particulate matter concentrations recorded at all the survey locations were fugitive dust from the surrounding quarry activities, material storage piles, traffic pattern access areas surrounding storage piles and all traffic pattern roads and parking facilities, unloading and transporting operations of materials, crushers, grinding mills, conveyor transfer points and conveyor bagging operations.

A statistical analysis for the 2-hr monitoring of particulate matter PM_{10} was completed at seventeen survey locations. The maximum 2-hour PM_{10} concentration extended to levels of 72.1 µg/Nm^3 at the Eastwards side of the proposed lime plant. Similarly, the minimum 2-hour PM_{10} concentration extended to levels of 40.5 µg/Nm^3 at Takaungu BMU fish point. PM_{10} concentrations recorded in the survey locations were not compared against the EMC (Air quality) regulations 2014 since there was no short term weighted averages given under the Regulations. Looking at particulate matter $PM_{2.5,}$ the maximum 2-hour $PM_{2.5}$ concentration extended to levels of 53.7 µg/Nm^3 at the Eastwards side of the proposed lime plant. Similarly, the minimum 2-hour $PM_{2.5}$ concentration extended to levels of 30.8 µg/Nm^3 at Takaungu BMU fish point. Appendix 6 is the detailed Environmental baseline study report for ambient particulate matter monitoring.

5.3 Physiography

5.3.1 Topography

The site for MCL Vipingo plant forms part of the Coastal plain which, according to the first Kilifi County Integrated Development Plan 2013-2017, the county lies up to 30m above sea level, with very few prominent peaks exceeding, and forms a narrow belt varying in width from 3 to 20 km. Considered as a whole, the topography of MCL Vipingo site is of a north-south trending ridge. The western part of the ridge, with a smooth slope is mainly covered by coalesced ancient sand dunes, while the summit and eastern part are mainly covered by coral limestone. Whereas the western slope of the ridge is smooth from the Mombasa-Kilifi road through the sisal plantation to the vegetated top, the eastern slope is of step-like features of coral limestone from the top down to the sea. Sandy beach, that is characteristic of the coastline in Mombasa to the South, is lacking. Instead, the sharp and rugged limestone cliffs form a distinctive local feature. Due to the constant interaction with seawater, part of the cliff is considerably eroded forming a coral rug.

Plate 2 considerably eroded sharp and rugged limestone cliffs at the shoreline of MCL Vipingo site

5.3.2 Drainage

Surface drainage is poorly developed in the proposed project area. Consequently the area lacks in streams or rivers. The nearest river is the Kombeni flowing into the Takaungu creek, some 10 km NE of the area. However, the proposed project site area has underground water and borders with the Indian Ocean.

5.4 Climate

The average total annual rainfall at Vipingo is over 1100mm. The rain falls in two seasons: between late March and early June, with May as the month of maximum rainfall, and between October and November. The place is generally hot. The average daily temperatures increase as from the month of November, with the hottest Months being December to February. The maximum daily temperatures reach 34°C and the minimum 25°C during the hottest months. The coolest time of the year is between June and August, when maximum and minimum temperatures recorded average 29°C and 21°C, respectively. Vipingo experiences winds of average speed. The windiest time of the year is during the South-East Monsoon from May to September, while the calmest months are November to March. The strongest winds are experienced during the month of August. On average, the temperatures are always high at Vipingo, most rainfall (rainy season) is seen in April, May, October and

November the warmest month is March., the coolest month is July. May is the wettest month while February is the driest month.

5.4.1 Temperature

On average, the temperatures at Vipingo area are always high, .the warmest month is March, and the coolest month is July the average annual temperature is: 31.0° Celsius (87.8° Fahrenheit). Figure 1 is a graph of average minimum and maximum temperature of Vipingo area over the year.

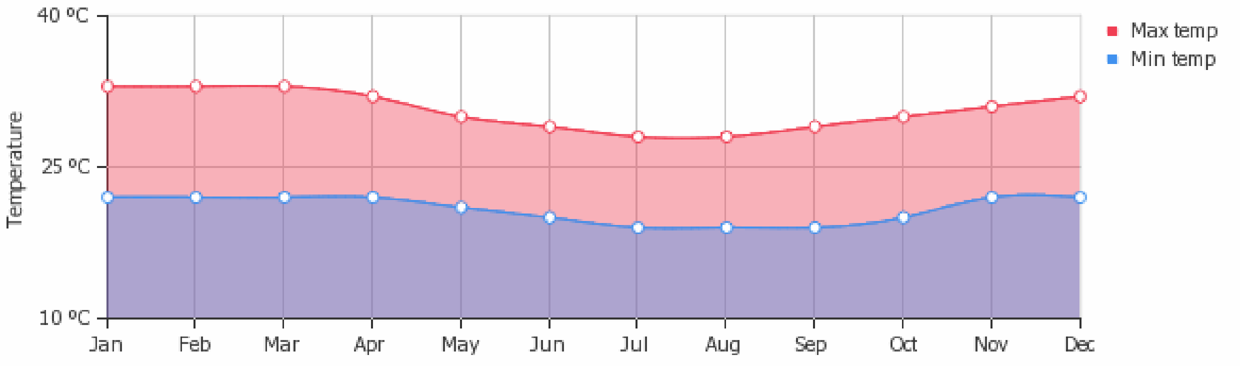


Figure 1: Average minimum and maximum temperature of Vipingo area over the year

Source: www. Weather and climate.com data from *nearest weather station: Mombasa, Kenya (31.1 KM).*

5.4.2 Water temperature

On average, March has the hottest water temperature while September has the coldest water temperature. Figure2 is the average mean water temperature at Vipingo over the year.

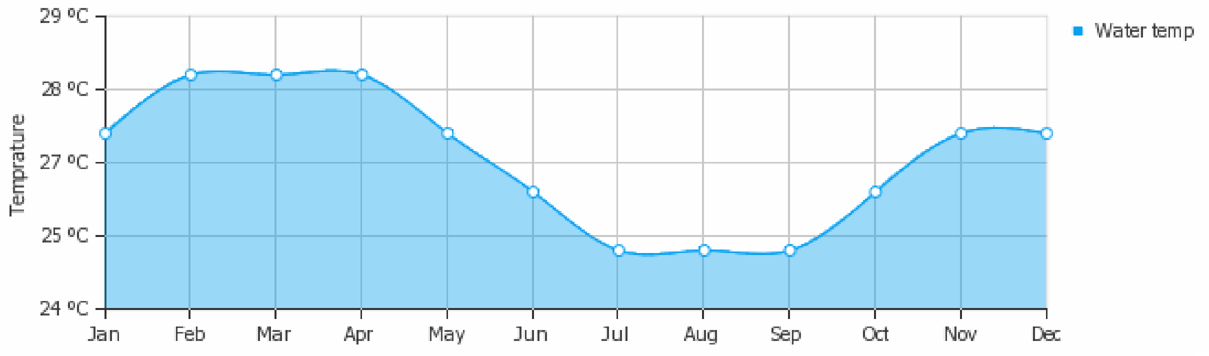


Figure 2: Average mean water temperature at Vipingo area over the year

Source: www. Weather and climate.com data from *nearest weather station: Mombasa, Kenya (31.1 KM).*

5.4.3 Precipitation

The rainy season at Vipingo area is in the months of April, May, October and November. On average, May is the wettest month while February is the driest month. The average amount of annual precipitation is: 39.37 in (999.9 mm) as shown in figure 3.

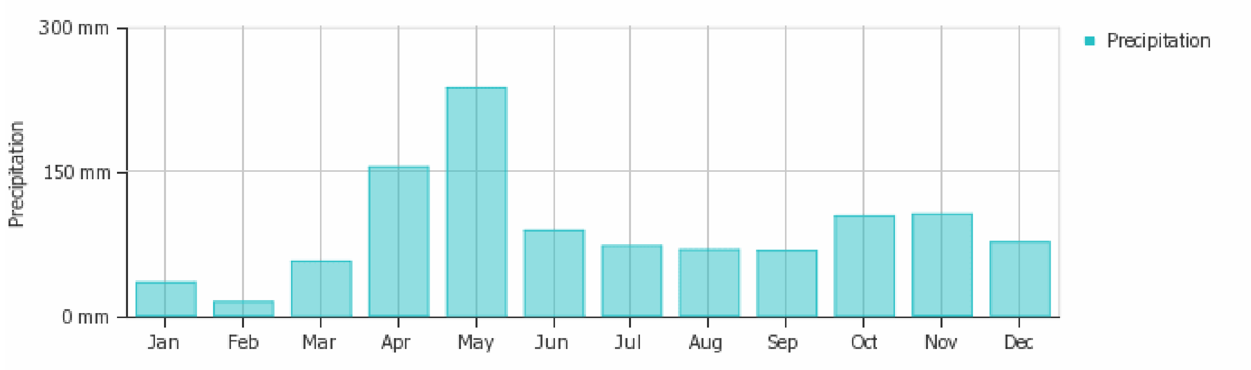


Figure 3: Average precipitation in Vipingo area over the year

Source: www. Weather and climate.com data from *nearest weather station: Mombasa, Kenya (31.1 KM).*

5.4.4 Monthly rainy days

Most rainy days are in April, May and August, on average, May has the most rainy days while February has the least rainy days. The average annual amount of rainy days is: 132.0 days as shown in figure 4.

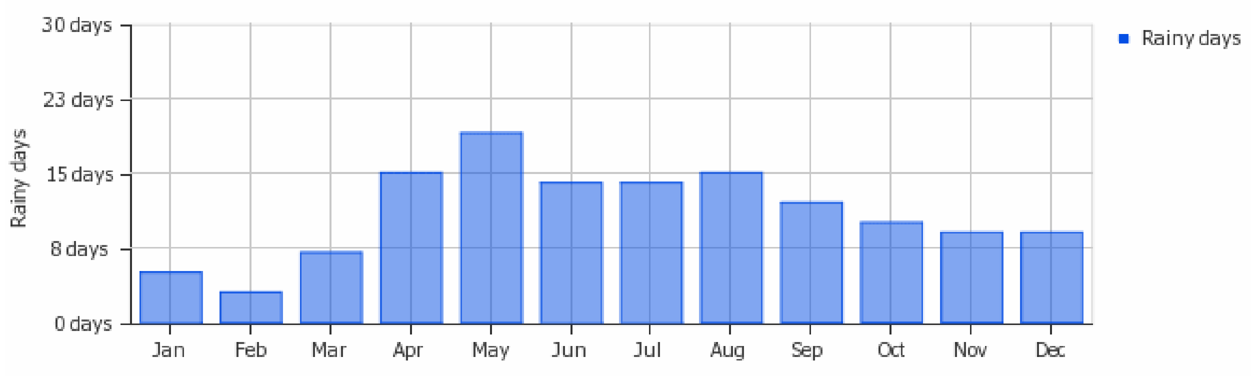


Figure 4: Average rainy days in Vipingo area over the year

Source: www. Weather and climate.com data from *nearest weather station: Mombasa, Kenya (31.1 KM).*

5.4.5 Humidity

On average, May is the most humid while February is the least humid month. The average annual percentage of humidity is: 74.0%. Figure 5 is the mean monthly relative humidity over the year in Vipingo area.

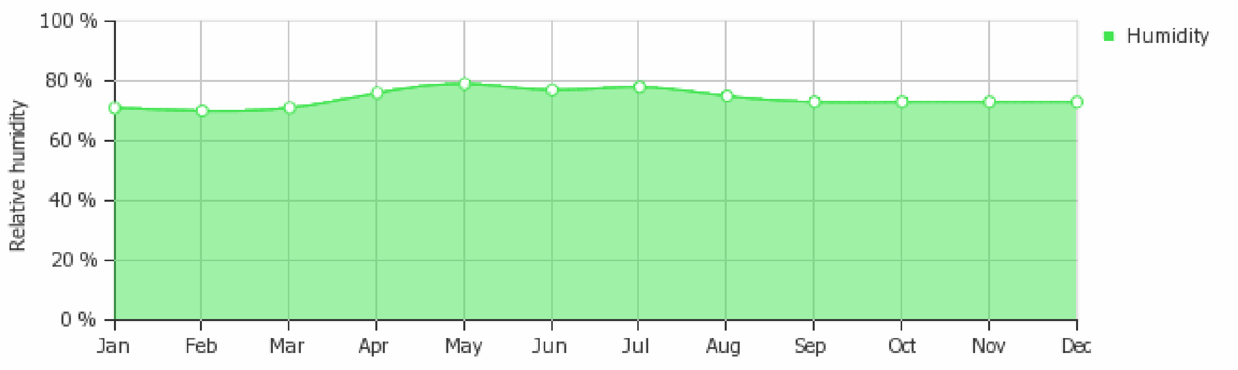


Figure 5: Mean monthly relative humidity over the year in Vipingo area

5.4.6 Wind

On average, the most wind is seen in May while the least wind is seen in November. Figure 6 is the mean monthly wind speed over the year in Vipingo in meters per second.

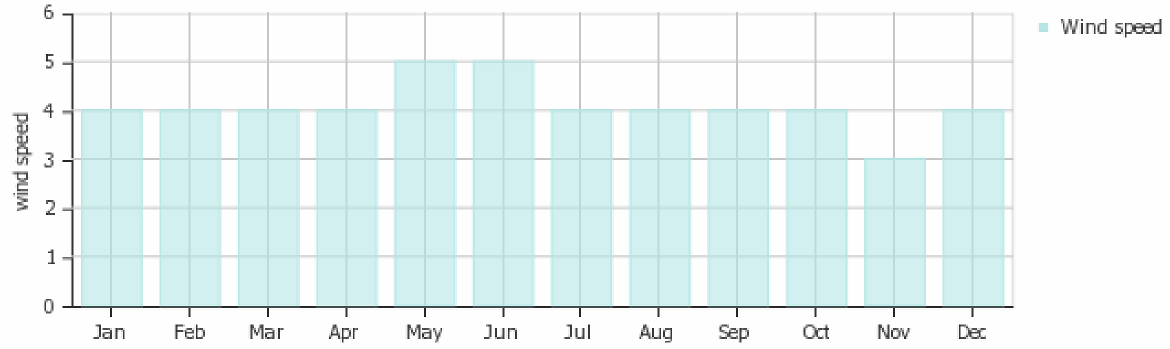


Figure 6: Mean monthly wind speed over the year in Vipingo in meters per second

Source: www. Weather and climate.com data from *nearest weather station: Mombasa, Kenya (31.1 KM).*

5.4.7 Sunshine

On average, October is the sunniest month while May has the lowest amount of sunshine. Figure 7 is the monthly total of sun hours over the year in Vipingo.

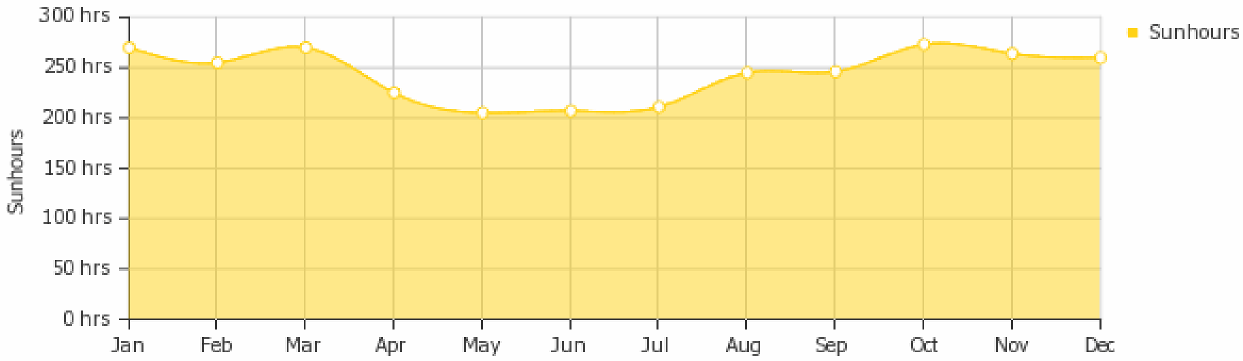


Figure 7: Monthly total of sun hours over the year in Vipingo

Source: www. Weather and climate.com data from *nearest weather station: Mombasa, Kenya (31.1 KM).*

5.5 Vegetation

Within the MCL Vipingo Limestone deposits site, the vegetation community can be described to be of three distinct habitats namely secondary vegetation habitat that develops as a result of periodic clearing of site vegetation, shoreline rocky outcrop habitat that has developed as a result of shoreline wave interactions with the adjacent coral limestone and indigenous plants habitat that is of indigenous vegetation (Plate 3). The secondary vegetation habitat is dominated by *Ricinus communis* and *Phyllanthus reticulatus*, the rocky outcrop habitat near the shoreline is dominated by *Mimusops obtusifolia* while the indigenous vegetation habitat is further into the quarry sites where there are small patches of indigenous plants such as Adansonia *digitata*, *Cassytha filiformis* and Azidiracta *indica*. There are about 77 species of plants within the coral limestone deposits area. The grass family Gramineae is the most dominant with species like *Cenchrus cilliaris*, *Dactyloctenium aegyptium*, *Urochloa trichopus* and *Digitaria nuda* The Bean family or Leguminosae is second with species like *Senna didymobotrya*, *Indigofera tinctoria* and *Canavalia rosea*. The most dominant vegetation life form at the site is the herbaceous plants followed by shrubs, sedges and grasses, trees at the site are very few. Table 11 is a list of plant species at the limestone deposit site.


Secondary vegetation habitat developing as a result of periodic clearing

Rocky outcrop habitat

Parasite(Cassytha filifomis **)growing on** ***Azidiracta indica***

Plate 3: Vegetation communities at the coral limestone deposits area of MCL Vipingo site

Table 11: List of plant species at the coral limestone deposit site at MCL Vipingo

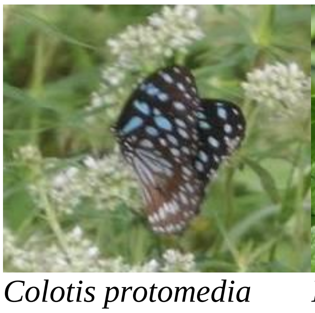
Family	Genus	Species	Life form
Acanthaceae	*Hygrophila*	auriculata	Herb
Acanthaceae	*Justicia*	gangetica	Herb
Acanthaceae	*Thunbergia*	alata	Herb
Amaranthaceae	*Achyranthes*	aspera	Herb
Amaranthaceae	*Psilotrichum*	sericeum	Herb

Family	Genus	Species	Life form
Amaranthaceae	*Aerva*	lanata	Herb
Amaryllidaceae	*Scadoxus*	sp	Herb
Araceae	*Gonatopus*	boivinii	Herb
Asparagaceae	*Asparagus*	racemosus	Herb
Balanitaceae	*Balanites*	sp	Shrub
Bombacaceae	*Adansonia*	digitata	Tree
Burseraceae	*Commiphora*	edulis	Shrub
Capparaceae	*Capparis*	cartilaginea	Shrub
Commelinaceae	*Commelina*	mascsrenica	Herb
Commelinaceae	*Commelina*	africana	Herb
Compositae	*Conyza*	sp	Herb
Compositae	*Launaea*	cornuta	Herb
Compositae	*Vernonia*	sp	Herb
Convolvulaceae	*Hewittia*	sublobata	Herb
Convolvulaceae	*Merremia*	ampelophylla	Herb
Cucurbitaceae	*Coccinia*	grandiflora	Herb
Cucurbitaceae	*Momordica*	trifoliotata	Herb
Cyperaceae	*Cyperus*	rotundus	sedge
Cyperaceae	*Cyperus*	cyperoides	sedge
Cyperaceae	*Fimbristylis*	cymosa	sedge
Euphorbiaceae	*Ricinus*	communis	Shrub
Euphorbiaceae	*Euphorbia*	hirta	Herb
Euphorbiaceae	*Dalechampia*	scandens	Herb
Gramineae	*Cenchrus*	ciliaris	Grass
Gramineae	*Dactyloctenium*	aegyptium	Grass
Gramineae	*Enteropogon*	macrostachyus	Grass
Gramineae	*Chloris*	gayana	Grass
Gramineae	*Urochloa*	trichopus	Grass
Gramineae	*Digitaria*	nuda	Grass
Gramineae	*Bothriochloa*	insculpta	Grass
Gramineae	*Sporobolus*	vaginicus	Grass
Juncaceae	*Juncus*	sp	sedge
Lauraceae	*Cassytha*	filiformis	Herb
Labiatae	*Plectranthus*	flaccidus	Herb
Labiatae	*Ocimum*	sp	Herb
Labiatae	*Hyptis*	suaveolens	Herb
Leguminosae	*Indigofera*	tinctoria	Herb
Leguminosae	*Senna*	didymobotrya	Shrub
Leguminosae	*Acacia*	sp	Shrub
Leguminosae	*Tephrosia*	villosa	Herb
Leguminosae	*Teramnus*	labialis	Herb
Leguminosae	*Canavalia*	rosea	Herb
Leguminosae	*Tephrosia*	pumila	Herb
Malvaceae	*Hibiscus*	vitifolius	Herb
Malvaceae	*Thespesia*	danis	Shrub

Family	Genus	Species	Life form
Malvaceae	*Sida*	ovata	Herb
Meliaceae	*Azidiracta*	indica	Tree
Moraceae	*Ficus*	sp	Tree
Pedaliaceae	*Pedalium*	murex	Herb
Plumbaginaceae	*Plumbago*	zeylanica	Herb
Rhamnaceae	*Ziziphus*	mucronata	Tree
Rubiaceae	*Psychotria*	punctata	Shrub
Rubiaceae	*Diodia*	aulacosperma	Herb
Rubiaceae	*Spermacoce*	laevis	Herb
Rutaceae	*Zanthoxylum*	sp	Tree
Sapindaceae	*Allophylus*	pervillei	Tree
Sapotaceae	*Sideroxylon*	inerme	Tree
Sapotaceae	*Mimusops*	obtusifolia	Tree
Scrophulariaceae	*Striga*	gesnerioides	Herb
Simaroubaceae	*Harrisonia*	abyssinica	Shrub
Solanaceae	*Solanum*	incanum	Shrub
Solanaceae	*Withania*	somnifera	Shrub
Solanaceae	*Physalis*	peruviana	Herb
Sterculiaceae	*Melhania*	ovata	Herb
Sterculiaceae	*Melhania*	ovata	Herb
Ulmaceae	*Trema*	orientalis	Shrub
Verbenaceae	*Lantana*	camara	Herb
Verbenaceae	*Clerodendrum*	glabrum	Shrub
Verbenaceae	*Premna*	resinosa	Shrub
Vitaceae	*Cyphostemma*	sp	Herb

5.6 Fauna

The vegetation habitats at the coral limestone deposit at MCL Vipingo site are a habitat to different fauna species. These fauna at the site include insect, mammals, herpetiles (reptiles and amphibians) and avifauna (birds). The area has significant number of butterfly species and bees, there are about of 34 butterfly species and 4 bee species. Three species of butterflies common in the area are *Papilio demodocus*, *Junonia oenone* and. *Euphaedra neophron* (Plate 4). The common bee species within the habitats at the limestone deposits are *Apis mellifera, Melliponula* species *and Proxylocopa* species. Table 12 is a list of butterfly species.



Colotis protomedia

Eurema floricola

Junonia oenone

Pardopsis

punctatissima

Leptotis pirithous *Acraea eponina* *Colotis regina* *Euphaedra neophron*

Plate 4: Common butterfly species within the coral limestone deposits habitats at MCL Vipingo site

Table 12: List of butterfly species at the MCL Vipingo limestone deposit site

Genus	**Species**
Acraea	*eponina*
Acraea	*insignis*
Amauris	*niavius*
Axiocerses	*harpax*
Azanus	*jesous*
Baliochila	*hildegarda*
Belenois	*aurota*
Belenois	*creona*
Byblia	*anvatara*
Byblia	*ilithyia*
Catopsilia	*florella*
Colitis	*daira*
Colitis	*euippe*
Colotis	*antevippe*
Colotis	*danae*
Colotis	*protomedia*
Colotis	*vesta*
Euphaedra	*neophron*
Eurema	*brigitta*
Eurema	*floricola*
Eurema	*regularis*
Eurytela	*dryope*
Freyeria	*trochylus*

Genus	Species
Graphium	*angolanus*
Hypolycaena	*philippus*
Junonia	*hierta*
Junonia	*natalica*
Junonia	*oenone*
Junonia	*orithya*
Melanitis	*leda*
Papilio	*demodocus*
Pardopsis	*punctatissima*
Phalanta	*phalantha*
Zizula	*hylax*

The vegetation habitats within the limestone deposits are also a home to some mammals such as African Savanna Hare (*Lepus microtis*), Four-toed elephant-shrew (*Petrodromus tetradactylus*), Red-legged sun squirrel (*Heliosciurus rufobrachium*) and Four-toed hedgehog (*Eraniceus albiventris*). The vegetation habitats are also home to herpetofauna (reptiles, snakes, lizards, geckos, and amphibians). Herpetofauna at the site include Puff Udder (*Bitis arietans*), speckled sand snake (*Psammophis punctulatus*), Black mamba (*Dendroaspis polylepis),* Variable ground skink (*Mabuya varia),* Long-tailed sand lizard (*Latastia longicaudata),* Day gecko (*Lygodactylus pictu) and* Black-lined plated lizard (*Gerrhosaurus nigrolineatus). The area is also rich in avifauna; there are about 27 species of birds in the area* comprising of different assemblages and from various feeding guilds and families (table 7). The birds include grassland birds, wetlands birds, water birds, woodland birds and birds associated with human dominated landscapes.

Table 13: Species of birds at the vast limestone deposit habitats at MCL Vipingo site

Bird species	Common Name
Cisticola galactotes	Winding Cisticola
Corvus splendens	House Crow
Hirundo aethiopica	Ethiopian Swallow
Apus affinis	Little Swift
Pycnonotus barbatus	Common Bulbul
Anthus cinnamomeus	Grassland Pipit
Vidua macroura	Pin-tailed Whydah
Cypsiurus parvus	African Palm-swift

Bird species	Common Name
Tchagra senegalus	Black-crowned Tchagra
Hirundo smithii	Wire-tailed Swallow
Centropus superciliosus	White-browed Coucal
Milvus migrans	Black Kite
Ardea melanocephala	Black-headed Heron
Nicator gularis	Eastern Nicator
Hirundo daurica	Red-rumped Swallow
Charadrius tricollaris	African Three-banded Plover
Caprimulgus pectoralis	Fiery-necked Nightjar
Chrysococcyx caprius	Diederik Cuckoo
Ploceus cucullatus	Village Weaver
Serinus gularis	Streaky-headed Seedeater
Passer domesticus	House sparrow
Laniurius leucorhynchus	Tropical boubou
Euplectes nigroventris	Zanzibar Red Bishop
Onychognathus morio	Red-winged Starling
Motacilla aguimp	African Pied Wagtail
Burhinus vermiculatus	Water Thick-knee
Ploceus subaureus	African Golden Weaver

5.7 Geology

5.7.1 Introduction

The regional geological setting of Kilifi County is dominated by the rifting and break-up of the Palaeozoic Gondwana continent and the development of the Indian Ocean (Embleton and Valencio, 1977). Upper Proterozoic gneisses of the Mozambique belt form the basement of an intra-cratonic basin, filled with continental Permo-Triassic clastics (Pohl and Horkel, 1980). Rifting during the early to middle Jurassic, presumably preceded partly by up-doming along the incipient rift, transformed it into a marine marginal basin at the trailing edge of the African plate (Horkel et.al., 1984). Most of the area is underlain by the continental Permo-Triassic sediments assigned to the Duruma Group (Caswell, 1953), which is generally considered as the Kenyan equivalent of the Karroo system of southern Africa (Horkel et.al., 1984). The Duruma group includes the Taru Formation, Maji ya Chumvi formation, Mariakani Formation and Mazeras Formation (Onyancha and Nyamai, 2014). The Duruma sediments essentially comprise grits, arkosic sandstones, and additives s accumulated under lacustrine, sub-aerial conditions (Onyancha and Nyamai, 2014). They also include minor marine ingressions in a broad, roughly NNE-SSW trending intra-cratonic trough, which formed towards the end of the Paleozoic within the Proterozoic gneisses of this part of the Gondwana (Embleton and Valencio, 1977). This fault trend controlled the deposition of all the other formations (Onyancha and Nyamai, 2014) including the Magarini formation and Mtomkuu (Kambe) formation.

After the termination of the Duruma sedimentation, major faulting and rifting led to the breakup of Gondwanaland; it caused a fundamental facies change from a continental cratonic trough to a marginal marine basin with sediments, located at the trailing edge of the continent (Horkel et.al., 1984). This transition is marked by a middle Jurassic marine ingression. The basal sediments of the Mtomkuu (Kambe) formation were deposited under near-shore neritic and estuarine conditions (Onyancha and Nyamai, 2014). Basal transgression conglomerates, largely composed of Duruma detritus, are overlain by impure micritic limestones, occasionally with small bioherms, and near-shore oolithic limestones, which were deposited in a shallow shelf environment with only moderate terrigeneous contamination (Braithwaite, 1984).

Erosion prevailed during the Tertiary until the Upper Pliocene, when tectonic reactivation resulted in increased erosion (Embleton and Valencio, 1977). Fluviatile pebble beds, gravels and sands of the Magarini formation were deposited on down-faulted and eroded Jurassic and Duruma sediments. After a regression during the Late Pleistocene, dunes which form the bulk of the Magarini formation were blown-up. This led to the formation of Pleistocene sands. At the same time, corals accumulated to form the Reef Complex along the Coast. The oldest rocks are the Gneisses of Neo Proterozoic Era while the youngest is the Reef Complex of Recent Age. The location of MCL Vipingo site consists of three geological units namely the Coral Reef Complex, Magarini Formation and Quaternary Sands. The units are readily identifiable and their field relationships clearly indicate the depositional history of the area.

5.7.2 Coral Reef Complex

Most of the MCL Vipingo site is founded on the Coral Reef Complex. In the wider context, the unit covers a long stretch of the Kenyan Coast from Vanga in the south to Lamu in the north. The Coral Reef Complex is considered to be Pleistocene age. Coral limestone, which is dead remains of sea corals, is the main rock type of the reef complex. However, depending on the conditions that prevailed at the time of deposition, within a locality, other sedimentary rocks may be found alongside the limestone. Often such rocks would include additives and marl. From cement manufacturing point of view, additives and marl are raw materials enriching and would therefore not be problematic if found at the MCL Vipingo site. Over most of the unit, a thin layer of either wash down sand or brown soil covers the coral limestone. The brown soil (terra rosa), formed from weathering of part of the limestone, supports pockets of vegetation.

5.7.3 Magarini Formation

Part of the MCL Vipingo site, especially the south-western and north-western sectors, consists of sandy reddish brown soils. The soils are part of the Magarini Formation that is Pliocene age. Magarini sands comprise of fluviatile pebble beds of gravels and sands deposited in fresh water environment. In the regional context, the Magarini Formation, known to consist of yellowish to brownish sandy soils with layers of clays, occupies a considerable part of the Coastal Belt inland of the Coral Reef Complex. The Magarini Formation resulted from back reef depositional environment.

5.7.4 Quaternary Sands

Thick alluvial sand deposits considered as Quaternary in age cover some parts of MCL Vipingo site. The sands are regarded to be derivatives of the Magarini Formation. Vegetative cover on the alluvial sands is mainly grass, indicating relatively low amount of soil and recent age of the unit. The alluvial sands are very difficult to drive through.

5.8 Groundwater

MCL Vipingo site has groundwater resources; groundwater in the area occurs in confined and unconfined aquifers in sedimentary formations of fluvial and lacustrine origin. Groundwater flow direction is generally eastward with recharge rate decreasing westward. The geology of the area plays an important role in determining occurrence of the groundwater. Whereas coral limestone is permeable, the Magarini Formation and Quaternary alluvial sands have layers of clay that help trap water. Therefore over the entire Coastal Belt, occurrence of groundwater is characteristic of the dune sands lying behind the coral limestone. Given that MCL Vipingo site is within the Reef Complex which was formed from accumulation of corals along the coast, limestone cavens allow sea-water intrusion inland where there are no faults causing little drawdown in boreholes even with continuous large-scale abstraction. As there are no sandy beaches on the coastline adjacent to MCL Vipingo site, there is constant interaction of seawater and the rugged coral limestone cliffs (Plate 5). The interaction increases and reduces during high and low tide, respectively. Therefore the coral limestone forms an important medium for interface of the fresh groundwater and seawater at the site.

Plate 5: Constant interaction of seawater and the rugged coral limestone cliff at MCL Vipingo site

During drilling of boreholes and digging of wells at the site, subsurface formations are encountered into Pleistocene and Magarini sands. Magarini sands comprise of fluviatile pebble beds of gravels and sands deposited in fresh water environment while Pleistocene sands were formed from blowing up of Magarini sands during the Pleistocene times. Water suitable for domestic purposes is encountered in unconfined aquifers at depths between 22 and 32 m. Caving of the sands during borehole drilling through these aquifers is possible. At depths of 41 m to 50 m, the borehole water is mainly saline in coral and clay bands. The presence of displaced faults in parts of the site restricts lateral influx of saline water; further the presence of faults with throws to the coast restricts the inland movement of sea water. MCL recognizes the important natural role of the coral limestone in the provision of groundwater to the company and local community living in the vicinity of the site. There are two boreholes and two hand dug wells at MCL Vipingo site. The boreholes provide water that is first treated in a reverse osmosis plant prior to its use in cooling of the clinkerisation plant. The wells on the other hand provide water for domestic use. Further there are shallow water wells in the neighborhood of the company used by the local community.

5.9 Climate Change and Vulnerability Risk Assessment

Raw materials used in agriculture and the industrial sector such as calcium phosphates, fluoride, bromide, ferrocyanide, and nitrate, calcium acetate, stearate, oleate, tartrate, lactate, citrate, benzoate, and gluconate are manufactured from lime. Lime is produced from the calcination of limestone mainly calcium carbonate ($CaCO_3$) at high temperature (900–1200 °C). The calcination reaction is highly endothermic; thus, a heat input is required, e.g., from the combustion of fuels such as coal, coke, and secondary fuels. One of the major greenhouses that are produced from lime production process is Carbon dioxide (CO_2). Lime manufacturing has a significant impact on air pollution and greenhouse gas emissions. During supply and shipping of raw materials, the lime manufacturing process generates dust, nitrogen sulfur oxide, carbon dioxide, and carbon monoxide. The generated CO_2 together with other greenhouse gases are observed into the atmosphere. Increased carbon dioxide absorption in the atmosphere contributes to climate change. According to the Intergovernmental Panel on Climate Change (IPCC), Greenhouse gas emissions, particularly CO_2, must be decreased by 50-80% by 2050 if climate change threat has to be addressed. CO_2 emitted from lime production process is depended on the raw material used, fuel and production process.

Limestone is a typical raw material in lime production, during the direct heating of the limestone; carbon dioxide is emitted as a result of the combustion. During kiln's heating, additional CO_2 is produced due to the chemical conversion of $CaCO_3$ into calcium oxide (CaO). Also, nitrogen oxide, and sulfur oxide are emitted from the burning of fossil fuels. Sulfur oxide is generated during the unexpected sulfur corrosion process in limestone. Overall, the total CO_2 emissions per ton of burnt lime vary between 1 to 2 t_{CO2}/t lime. Use of coal in firing kiln during calcination of limestone in kilns produces 50-70% of the total CO_2 generated from lime plants. 50% of the total CO_2 produced from a lime plant is produced during limestone calcination process, 40% is produced during the kiln fuel combustion, and 5% is produced during the transportation balancing while the remaining 5% is accounted for from electricity consumed in the manufacturing operations.

5.9.1 Greenhouse gases and climate change

Greenhouse gases absorb heat radiating from the Earth's surface and re-release it in all directions including back toward earth's surface. Carbon dioxide is earth's most important greenhouse gas, a gas that absorbs and radiates heat. Whereas carbon dioxide in the atmosphere is critical in achieving a balanced natural greenhouse effect on earth, adding large quantities of carbon dioxide to the atmosphere through constant realises from manufacturing concerns such as lime plants, contributes in supercharging the natural greenhouse effect, causing global temperature to rise. Carbon dioxide and other greenhouse gases act like a blanket or a cap, trapping some of the heat that earth might have otherwise radiated out into space resulting in global warming. Consequently, increased carbon dioxide release from anthropogenic activities and its absorption in the atmosphere contributes to climate change.

5.9.2 Potential impact of increased Carbon dioxide emissions

The more CO_2 is trapped in the atmosphere, the more heat will be trapped in the environment. That contributes to the rise in global temperatures and influences climate change. That results in extreme weather events like wildfires, tropical storms, heat waves, and severe drought, negatively affecting crop production and disrupting the animals' natural habits.

5.9.3 Proposed mitigations measures

The mitigate the negative impacts of climate change and vulnerability as a result of lime production, the following measures are proposed;-

- ✓ Deployment and use of carbon dioxide removal technologies that will ensure carbon capture and storage. Two groups of carbon capture technologies can be deployed, namely, post-combustion and oxyfuel combustion directly in the lime rotary Kiln. Carbonate looping is a post-combustion carbon capture technology whereby the CO_2 capture is achieved by utilizing limestone as a sorbent, i.e., the raw material of the lime production facility. The sorbent binds CO_2 from the kiln flue gases in a carbonator and is regenerated through a temperature increase in a calciner. Carbon looping technology has the potential to efficiently capture CO_2 from lime plants by exploiting the synergies of the calcination.
- ✓ Reducing the carbon that is to be generated during lime production in the first place through energy efficiency technologies and use of energy from renewable sources.
- ✓ Reusing carbon as an input to create feed stocks and fuels including mobile carbon capture technology that captures and stores carbon.
- ✓ Recycling carbon through the natural carbon cycle with bioenergy, and, unique to circular carbon economy (through natural sinks such as forests and oceans and the use of hydrogen-based synthetic fuels to recycle CO_2
- ✓ Supporting increase in tree cover within project catchment through budget support for large scale tree planting initiatives such as those currently spearheaded by the National Government through designated tree planting efforts during National Tree Planting days.

5.9.4 Recommendations

Carbon Pricing

Lookout for and take advantage of any existing or proposed carbon pricing mechanism, such as a carbon tax or cap-and-trade system will incentivize lime manufacturers to reduce their greenhouse gas emissions. This would create a financial incentive for companies to adopt cleaner production methods and invest in low-carbon technologies.

Circular Economy

Implement a circular economy where waste materials, including lime based are recycled and reused in new construction projects. Provide support and incentives for the establishment of recycling facilities and the development of innovative technologies for lime recycling

Public Awareness and Education

Carryout public awareness campaigns to educate individuals, businesses, and the construction industry about the environmental impact of lime production and the benefits of sustainable alternatives. Promote consumer demand for low-carbon construction materials and environmentally friendly practices.

Building Codes and Green Certifications

Introduce and enhance building codes that promote energy-efficient and sustainable construction practices. Encourage the adoption of green certifications, such as LEED (Leadership in Energy and Environmental Design), for construction projects, which would prioritize the use of sustainable materials like low-carbon lime.

Low-Carbon Alternatives

Encourage the use of low-carbon lime alternatives, such as supplementary cementitious materials like fly ash, slag, or pozzolanic materials. Lookout for opportunities for incentives, subsidies, or tax breaks for construction projects that use these environmentally friendly alternatives.

6. PROJECT DESIGN

The proposed project will involve the manufacturing and production of lime by heating crushed limestone to around 1,100 degrees Celsius in a shaft furnace or rotary kiln. The heating of limestone will release carbon dioxide; leaving calcium oxide ($CaCO_3$ produces $CaO + CO_2$). After heating, the quicklime will be crushed and then milled to the appropriate fraction. The capacity of the proposed lime plant will be 250TPD (Tons per Day). The Lime Plant is designed to produce Quick Lime and Hydrated Lime (for Chemical industries) Grade A, B & C as per EAS 73:2000. The main plant and equipment of the lime plant, excluding utility services will be as follows:

- ✓ Limestone preparation & dosing unit
- ✓ Pet coke grinding
- ✓ Parallel flow regenerative (PFR) kiln for QL production
- ✓ Quick lime handling unit
- ✓ Hydrated lime production and handling unit
- ✓ Packing plant for hydrated lime
- ✓ Quality control
- ✓ Utilities & services

Appendix 7 is the site layout plan of the proposed lime plant.

6.1 Limestone Preparation & Dosing Unit

Limestone from mines, after the crusher, is normally having a top size of 80-100 mm. After the crusher there is a diverter gate; while the main stream is going to the existing LS stacker, the other side of the diverter provide the feed to a BE. The discharge from the BE is fed to a single deck Vibratory screen with a cut size of 40 mm. The under size (-40 mm) is fed back to the LS stacker belt. The coarse fraction (+40 mm) is transported to the Lime Plant through Dumpers and stored as stockpile. At the Lime Plant, One no. of stockpile of capacity 3,000 T is considered (size 20 X 40 m). From the stock pile (size +40-80 mm) the limestone is fed to a dump hopper, which feeds to a BE through a feeder and a BC. The discharge of the BE is fed to two nos of LS silos of capacity 250 T each, through a reversible BC. At the bottom of both to LS silos, there is a vibratory screen with a cut size of 40 mm. The under size (-40 mm) LS is collected in a reject hopper of 25 T capacity. The coarser fraction (+45-80 mm) is discharged into a BC which in turn, feeds to the skip conveyor (which is input point for controlled feeding to the Maertz PFR Lime Kiln).

6.2 PET Coke Grinding

Raw pet-coke (size: 95% under 20 mm) from sources, is received at Lime Plant, unloaded by tipper trucks and stored as stockpile. One no. of stockpile of capacity 1,000 T is considered for the pet-coke. The pet-coke grinding mill (Capacity 8 TPH Closed Circuit Ball Mill) is designed to also cater to future requirement of another 250 TPF PFR Kiln for QL production. Raw PC is reclaimed from storage yard and fed to dump hopper through a pay-loader. The raw PC is fed to a feed hopper (50 T) through dump hopper, vibro-feeder, magnetic separator & metal detector. A reject hopper of 5 T capacities is provided for collection & disposal of the reject material. From the fed hopper, PC is fed into Air Swept Grinding Mill (8 TPH) for generation of fine pet-coke for dosing into the system. The mill is fitted with dynamic air classifier (for control of product size) and a hot air generator (HAG) for drying. Moisture in raw PC is max 10%. The ground pet-coke (size <15% retained on 90 microns) is stored into fine fuel silo (50 T) for feeding to PFR Kiln. CO_2 inertisation system is also provided as a safety measure. The PC grinding plant is designed to cater to current & future requirement for 250 TPD PFR Kiln each.

6.3 Parallel Flow Regenerative (PFR) Kiln for Quicklime Production

For the defined project, one no. of PFR kiln of capacity 250 TPD with all accessories, fuel firing system and control equipment is considered. The PFR Kiln order has been placed to M/s Maertz, Germany. The sized limestone (+40 to - 80 mm) from the crushed limestone storage bin is fed into the PFR Kiln with the help of weigh hopper & skip bucket. After calcination, quick lime produced in PFR kiln, is transported to the vibrating screen (via a vibro-feeder, BC and a BE). The Vibrating screen is designed for separation of manufactured quick lime into a fine fraction (0-50 mm), and lumps (50-100 mm) sizes. Each size is stored in respective silos of 300 T capacity each. .

6.4 Quicklime Handling Unit

Quicklime (Calcined limestone), of two different sizes (Grades) are kept in the two nos. of 300 T silos, wherefrom they are extracted through vibro feeders. Out of these, one line goes to a 25 T Hopper which is fitted with bulk loading spout for bulk loading. The other line goes to the input section of the Hydration Plant.

6.4.1 Hydrated Lime Production and Handling Unit

The quicklime from the storage silos is extracted with help of vibrating feeder and is fed to the weigh feeder which conveys the quicklime through bucket elevator to the Hydrator. From the hopper the QL is extracted and fed to Hydrator through weigh feeder. The material after hydration goes to separator, the coarse will go to mill and then again to separator for products of different grades. The HL from storage silos is extracted and fed to packing machine for packing & dispatch.

6.4.2 Hydration Plant

The hydrator is a three-stage machine of the latest design; the stages contain horizontal rotating shafts with specially designed hi-efficiency paddles to mix continuously the reacting lime and the water. Paddles have different design in the various hydrator stages for the optimum matching of their specific operational performances. The hydrator consists of a first stage with single shaft, equipped with an advanced multi-point water injection system for the most accurate control of the initial phase of the slaking process. The specially designed water sprayers assure the best coverage and water distribution over the first stage thus improving the reaction efficiency. The second stage comes with double counter rotating shafts, strongly mix the material, favoring the completion of reaction in the large volume of this second chamber which is approximately the double of the first one. The second stage should have special design paddle shape to improve the mixing efficiency. The paddles allow a better mixing / shearing action on the material in the section where the hydration reaction is completed. The third stage features improve the homogenization of the material. Furthermore, the third stage paddles have the mixing / shearing action to enhance the hydrated lime homogenization and reduction of light agglomerates. The design and the sizing of each single component is specially thought for high reactivity quicklime, however, the variable speed of the first stage and the new overflows weirs permit to adapt the premixing strength and retention time to a range of different lime qualities. The produced hydrated lime is conveyed to six nos. of the storage silos (two each for three different grades, A, B & C) as per EAS 73:2000.

6.5 Packing Plant for Hydrated Lime

For hydrated lime, packing products are stored in 6 hoppers of 3 grades. One no. of fines bag valve type packer of capacity 15TPH is considered for fine hydrated lime packing and one no. of Jumbo packer machine of capacity 30 TPH, common for grades A, B & C, is considered for big bag loading &dispatch. Additionally, a ware house of 25 X 15 M is also provided near the packing plant, for intermediate storage of HL bags.

6.6 Quality Control

Facilities and equipment for the qualitative control of the raw materials, fuel and final products as envisaged for the project is elaborated as under.

6.6.1Analysis and Sampling

6.6.1.1 Limestone

A manual bulk material analyzer system shall be used for real time process control provided on the transport from the crusher to the limestone stockpile.

6.6.1.2 Quicklime

Manual sampling facilities shall be provided for the material leaving the lowest hopper(s) of the PFR Kiln.

6.6.1.3 Hydrated Lime

Manual sampling facilities shall be provided for the hydrated lime

6.6.1.4 Fuel

Manual / Automatic screw sampling system shall be provided on the transport from the fuel mill to fine fuel bin.

6.6.1.5 Conventional Chemical analysis equipment

In addition to all above, conventional chemical analysis will also be used if required by the system. Further, lab equipment like microscope, Fuel, ash analyzer, etc. have also been considered.

6.6.1.6 Samples Transport

Manual transport of samples from various sampling points will be considered.

6.6.1.7 Quality Control Plan

To produce good quality Lime, sampling & testing of various grades of limestone, fuels, in-process materials and the final product will be carried out regularly at the required intervals for taking timely corrective action.

6.6.1.8 Laboratory

The laboratory shall be accommodated in Central Control Room building. The quality control concept includes all sampling stations and a fully equipped chemical and physical laboratory (main laboratory for analytical and shift laboratory). The laboratory shall be equipped all the quality control equipment including the apparatus, instruments, glassware and the required chemicals.

6.7 Utilities & Services

6.7.1 Power Distribution

Approximate power demand for the 250 TPD Lime plant plus future 250TPD lime plant is envisaged as 5MVA. Power for the Lime plant is supplied from existing 6.6kV Line-I MRSS Switchgear located at Line-I Main Receiving Substation (MRSS) Building. Two (2) nos. 6.6kV outgoing feeders are made available at MRSS Switchboard to supply the power (at 6.6kV) to the load center of lime plant. One load centre is designated for the present lime plant. The Load Centre is a three storied building with ground floor serving as Cable Cellar, first floor serving as switchgear floor housing electrical panels and second floor serving as CCR/Admin office. From the load center, power is distributed to motors and other loads through 6.6kV switchgear, distribution transformers of suitable rating, 415V PMCC, Motor control centers, Distribution boards etc. Overhead cable laying method is adopted for routing cables in the plant and underground cable laying is avoided as far as possible.

Air condition system is considered in the load centre building with the aim to keep the building temperature less than 25^{o}C. Central Air Conditioning system is provided on equipment floor and CCR/Admin office. Pressurized ventilation system is employed in cable cellars with the aim to keep the cable cellar under slightly positive pressure. Load centers are equipped with complete safety equipment set. LED lighting fixtures are used for plant lighting. Lighting circuits are isolated from main power circuit through 1:1 lighting transformer of suitable size. Suitable earthing system is installed for safety to personnel, safety to equipment, protection against lightning, computer and other electronic data processing system, neutral of different voltage system. One 110V SMF Battery and Battery Changer cum DC Distribution Board of required capacity are located in the load centre to give control power supply to various equipment viz. 6.6 kV switchgear, 415V ACBs in the load centre.

6.7.2 Water Supply

Water will be required for preparation of hydrated lime, as a coolant for machineries, hot gases, drinking, sanitation etc. The integrated Lime Plant is estimated to require about 500 m3 of water per day (excluding firefighting water). Out of which, the 330 TPD Hydration Plant is estimated to consume about 350 m3 of water per day. Water demand is met from the underground water.
Appendix 8 is the process flow chart for lime production.

6.8 Project cost

The cost of implementation of the proposed project as presented by the Project Proponent is KSH 937,500,000.00. The proponent will be required to pay to the National Environment Management Authority 0.1% of the total project cost being the applicable EIA processing and monitoring fees. Appendix 9 is the Bills of Quantity of the proposed project.

7. ANALYSIS OF ALTERNATIVES

A Project Alternative is another combination of the project's costs, schedules, resources, and risks that allow achieving the same results as compared to the project baseline. It is one or more ways to produce the project and address its need while using the same resource base yet operating in a new way and facing new working conditions. Project alternatives considered for the proposed project are the Yes-project alternative, the No-project alternative, alternative project site and alternative technology. Evaluation of each of the projection options is as follows.

7.1 The Yes-project alternative

The Yes-project alternative means that the proposed project be implemented as currently proposed without alterations. This implies that the proposed project location, proposed project design to be implemented as currently proposed. The proposed project is a lime plant for the production of quicklime and hydrated lime. The proposed project location is at Vipingo area of Kilifi County off Mombasa-Kilifi Highway within the premises of Mombasa Cement Limited Vipingo Unit. The proposed project site is adjacent to the two existing Mombasa Cement Limited clinkerlization plants and cement mills. Limestone that will be the raw material to be used in the manufacture of quicklime and hydrated lime will be sourced from existing Mombasa Cement Vipingo limestone quarries. These limestone queries are in close proximity to the proposed site for the lime plant. The availability of limestone in existing licensed and operational queries that are at close proximity to the proposed site of the lime plant will mean that it will be less costly in terms of time, financial resources, manpower and transportation requirement when sourcing limestone for lime production. In view of this the proposed project site is ideal owing to its close proximity to the raw material sources and existing clinker and cement mills.

7.2 The No-project alternative

The no project alternative means that the project be rejected in its entirety as currently proposed. This means that implementation of the proposed project as currently proposed will not be realized. This implies that the current design of the project be rejected, the proposed location and the proposed technology all be rejected. This project alternative will deny the project proponent the opportunity to diversify products manufactured at Mombasa Cement Limited Vipingo.

7.3 Alternative project site

Within Vipingo area there are other parcels of land that are owned by Mombasa Cement Limited that can be potential sites for locating the proposed lime plant. Further at Roka there are parcels of land owned by Mombasa Cement limited that can be an alternative site were the lime plant can be constructed. However, the proposed project site remains the ideal site since the company has active licensed limestone quarries that are supplying limestone to the existing, silenced and operational clinker and cement plants. The same quarries will supply required limestone to the lime plant.

7.4 Alternative technology

To manufacture lime products, limestone and fuel are loaded into the lime kiln, after preheating, it begins to decompose at 850°C, and completes calcination at 1200°C; after cooling, it is discharged out of the kiln to complete the production of quicklime products. Different kiln types have different ways of preheating, calcining, cooling and discharging ash, but several process principles are the same: high quality of raw materials, good quality of lime; high calorific value of fuel, low quantity consumption; limestone particle size and calcining time are proportional; the activity of quicklime is inversely proportional to the calcination time and the calcination temperature. Alternative technologies analysis covers the different lime kiln technologies that can be used in the production of lime. These include rotary kiln, twin shift vertical lime kiln and annular lime kiln.

7.4.1 Lime Rotary Kiln

Lime rotary kiln is also called roller rotary kiln. To make sure it's air leakage coefficient is less than 10 percent, lime rotary kiln adopts advanced structure and reliable combined scale-like seal in both ends. It also uses composite refractory to reduce the loss of heat radiation. Lime rotary kiln's vertical preheater effectively magnifies the warm-up effect; the decomposition rate of preheated lime can be from 20% to 25%. The kiln has a reliable combined scale-like seal in both ends to guarantees its air leakage coefficient is less than 10 percent. It also uses composite refractory to reduce the loss of heat radiation. Lime rotary kiln has **a vertical cooler** which has dividable ventilation that cools down the lime into 80℃ making it easier to be transported and stored. The kiln can preheat the secondary kiln air up to more than 700℃, which reduces the need for moving parts and special materials. The main advantages of a lime rotary kiln include the following:-

- ✓ Lime rotary kiln's main drive system uses Ac frequency conversion control technology. It has superiority in all energy-saving and environmental protection, efficiency and steady operation.
- ✓ Lime rotary kiln's optimized the overall structure of the kiln head and kiln tail according to the characteristics and calcination requirements of lime. It successfully solves the pervasive problem such as dusk leak so makes a smother deliver.
- ✓ Lime rotary kiln leaves the specific length of gap between wheel belts and kiln according to the

thermodynamic calculation analysis system to make sure they closely fit in the work state.

This method effectively raises kiln's rigidity meanwhile prevents the necking phenomenon.

- ✓ Lime rotary kiln's quality of production is guaranteed because of even heat and low over-burn rate.
- ✓ Lime rotary kiln sets up a temperature-measurement interface, which is convenient to plug in temperature measuring devices to reach fully automated inspection.
- ✓ Lime rotary kiln's process of preparation is flexible. The high-temperature smoke in vertical preheater can be fully used to turn lime into an initial decomposition state.
- ✓ The vertical cooler an be put in kiln heat to instantaneously cool down lime, so product activity is raised and transportation is more convenient.

7.4.2 Twin shaft vertical lime kiln

The Twin Shaft Regenerative (TSR) kiln family consists of two main groups namely the Direct Crossover featuring a single channel placed between the shafts, and Radial Crossover featuring circular channels around the shafts which are then connected in the central part. The TSR-Kilns series utilizes the regenerative process for lime calcination. There are two distinguishing characteristics for the TSR-Kilns namely:

- ✓ The parallel flow of hot gases and stone in the burning zone, which allows a mild burning of the limestone without over-burning, and
- ✓ The regenerative preheating of all combustion air, using the limestone contained in the preheating zone of the kiln (in the non-burning shaft) as a heat accumulator.

- ✓ The TSR kilns represent the best option for high- and medium-reactivity lime production in terms of lower fuel consumption, lower maintenance costs, lower emission rates and higher quality lime.

7.4.3 Annular Lime Kiln

Annular shaft kilns were developed to produce lime from limestone in a single shaft kiln with direct-fired fluid fuel burners in combustion chambers. Limestone ($CaCO_3$) is fed into the shaft kiln on the top of the kiln and is evenly distributed using a rotary apparatus. The entire process inside a kiln can be divided into three zones namely preheating, calcinating and cooling zone. In preheating zone the limestone is heated with combustion gasses which escape around ‘’bridges” in the burning chamber towards the chimney in the opposite direction of the material flow. The calcinating zone is where chemical reactions happen and is the hottest zone. In lower section chambers, combustion gasses flow in direction of material towards the openings in the inner cylinder. The inner cylinder is under negative pressure generated by the injectors. The hot gas is rerouted back to the burners' chambers in the calcination zone through recirculation pipes. Negative pressure in preheating zone is ensured with the use of an ID fan which inlet is connected to the kiln chimney outlet. An outlet of the ID fan is connected to the particulate filter to separate the ash from the air on the chimney output. The ratio of the recirculating combustion gas through the inner standing cylinder and the gas which is being pulled through the preheat zone to the chimney is roughly 1:1 and is one of the most important parameters of the annular shaft kiln operational settings.

8 OCCUPATIONAL SAFETY AND HEALTH

Quicklime or calcium oxide (CaO), also known as burnt lime, is a white, caustic, alkaline, crystalline solid at room temperature. Calcium oxide is usually made by the thermal decomposition of limestone that contains calcium carbonate ($CaCO_3$; mineral calcite) in a lime kiln. This is accomplished by heating the material to above 825 °C a process called calcination or lime-burning, to liberate a molecule of carbon dioxide (CO_2), leaving quicklime behind. Calcium oxide is not considered acutely toxic via the oral, dermal, or inhalation route. The substance is classified as irritating to skin and the respiratory tract, with a potential risk of serious damage to the eye. Adverse systemic effects are not anticipated with local effects (due to alkaline pH). Quicklime reacts vigorously with water, releasing heat which may ignite combustible materials in specific instances. Contact with eyes can cause severe irritation or burning of eyes, including permanent damage. Contact with skin can cause severe irritation or burning of skin, especially in the presence of moisture.

8.1 Worker Safety

Lime, particularly quicklime, is an alkaline material that is reactive in the presence of moisture. Workers handling lime must be trained and wear proper protective equipment

8.1.1 Eye Hazards

Lime can cause severe eye irritation or burning, including permanent damage. Eye protection (chemical goggles, safety glasses and/or face shield) should be worn where there is a risk of lime exposure. Contact lenses should not be worn when working with lime products.

8.1.2 Skin Hazards

Lime can cause irritation and burns to unprotected skin, especially in the presence of moisture. Prolonged contact with unprotected skin should be avoided. Protective gloves and clothing that fully covers arms and legs are recommended. Particular care should be exercised with quicklime because its reaction with moisture generates heat capable of causing thermal burns.

8.1.3 Inhalation Hazards

Lime dust is irritating if inhaled. In most cases, nuisance dusts masks provide adequate protection. In high exposure situations, further respiratory protection may be appropriate, depending on the concentration and length of exposure (consult MSDS for applicable exposure limits).

8.2 Product Safety

Care should be taken to avoid accidental mixing of quicklime and water (in any form, including chemicals containing water of hydration) to avoid creating excessive heat. Heat released by this reaction can ignite combustible materials or cause thermal damage to property or persons. Lime dust can be removed from vehicles using rags dampened with dilute vinegar. After applying dilute vinegar, vehicles (especially chrome surfaces) must be washed with water.

8.3 First Aid

The Material Safety Data Sheet (MSDS) for the specific lime product should always be consulted for detailed first aid information. The following guidelines are general in nature. If skin contact occurs, brush off dry lime and then wash exposed skin with large amounts of water. If skin burns occur, administer first aid and seek medical attention, if necessary. If lime comes in contact with the eyes, they should first be flushed with large amounts of water. Seek medical attention immediately after administering first aid. For inhalation, remove exposed person to fresh air. Seek medical attention immediately after administering first aid. For further steps, consult the MSDS and follow the instructions of medical personnel.

9. STAKEHOLDER CONSULTATION

Consultation with stakeholders that are likely to be affected and those that are likely to have an interest in the proposed project was conducted as provided for in Regulation 17 of the Environmental (Impact Assessment and Audit) Regulations, 2003. The consultation was vital and served to:-

- Inform stakeholders especially those drawn from the proposed project site of the proposed development within their locality.
- Explain to the stakeholders the nature of the proposed project, its objectives and scope.
- Give stakeholders especially those drawn from the proposed project site an opportunity to present their views, concerns and issues regarding the proposed project.
- Obtain suggestions from the local community and other stakeholders on possible ways potential negative impacts can be effectively mitigated and how the local community can be part of the proposed project.

The consultation was two-fold, namely;

- Questionnaire survey
- Public meetings /*Barazas*

9.1 Questionnaire survey

A detailed questionnaire survey was carried out that targeted to reach out to primary stakeholders at the grassroots level. This included local learning institutions, local faith based institutions, among others. Appendix 10 is detailed questionnaire responses.

9.1.1 Questionnaire survey respondents

The following stakeholders' respondent to the questionnaire survey:-

- ✓ Curriculum Support Officer –Shariani Zone
- ✓ Mkwajuni Vocational Training Centre
- ✓ Tewa Training Centre
- ✓ Takaungu Secondary School
- ✓ Mkwajuni Secondary School
- ✓ Shariani Secondary School
- ✓ Timboni Primary School
- ✓ Shauri Moyo Primary School
- ✓ Vuma Primary School
- ✓ Takaungu Primary School
- ✓ Shariani Primary School
- ✓ Mtwapa Elite Academy -Shariani

- ✓ Vutakaka Junior School
- ✓ The Zawadi Junior School
- ✓ Takaungu Dispensary (Donata Lewa)
- ✓ Al-Amin Stores
- ✓ Kitsao Kahindi
- ✓ Wahda Muhammed
- ✓ Abdallah Omar Mahfudi
- ✓ Joseph C. Yaa
- ✓ Siti Mbwana Boga
- ✓ Isaac Menza
- ✓ Abdalla Moh'd Ali
- ✓ Bakari Mohamed c/o Takaungu Village

9.1.1 Summary of Issues, views and concerns presented by questionnaire respondents

The following is a summary of how various stakeholders consulted through questionnaire survey responded to how the proposed project may potentially affect them.

- ✓ The proposed project will create job opportunities for people.
- ✓ It will spur the economic development of the region.
- ✓ It will lead to social integration as well population increase.
- ✓ The project will improve the living standards of people.
- ✓ The proposed project will lead to improvement in infrastructural/communication facilities.
- ✓ Easy sourcing of building material (lime) from the hood.
- ✓ The corporate social responsibilities will enhance people's lives.
- ✓ It will lead to air pollution and thus related health condition.
- ✓ The proposed project is a potential source to noise pollution.
- ✓ Wastes if not properly treated and disposed will be hazardous to our environment.
- ✓ Project may result in injuries and accidents.
- ✓ The project may lead to increased school dropout rates in the region

9.1.2 Measures proposed by stakeholders to address issues and concerns raised

The following is a summary of measures that need to be put in place as proposed by stakeholders consulted through questionnaire survey:-

- ✓ Use modern technology to mitigate noise and air pollution.
- ✓ Proper waste products treatment and disposal mechanism to be in place.
- ✓ Civic education for awareness especially the impact of lime plant on the community.

- ✓ Improve health facilities around to handle the impact of the company's activities.
- ✓ Safety measures like availing protective gears/clothing to worker and safe driving on our roads should be enforced in the entire life of the project.
- ✓ Encourage environmental conservation programs e.g. tree planting initiatives that will limit the impact of dust in cement production.
- ✓ Adhere to all the laws and regulations as well as advice from NEMA.

9.2 Public Barazas

Stakeholder consultations and public consultation through public meetings involved carrying out three public meetings within the neighborhood of the proposed project site.

9.2.1 First Public Baraza

The first stakeholder consultation & public participation public baraza was held at Takaungu Assistant Chief's Office Grounds in the morning of 25th April 2023. The following were the main issues that emanated from the first public meeting.

- ✓ Dust pollution from lime production and use ad associated negative effects to not only the physical environment but also to the safety and health of workers and local community.
- ✓ MCL should increase scholarship support to learners in secondary and tertiary institutions within the project catchment area.
- ✓ Low wages and remunerations for workers an issue that MCL management should look into and address as the company expand and diversify to lime production.
- ✓ There is need to streamline corporate social responsibility (CSR) projects supported by the company to ensure they meet needs of the local community.

Appendix 11 is the attendance list and Minutes of the First Baraza while Plate 6 capture attendees during the first public baraza.

Plate 6: Snapshots of proceedings of the first public baraza held at Takaungu Assistant Chief's Office Grounds

9.1.2 Second Public Baraza

The second stakeholder consultation & public participation public baraza was held at at Mkuajuni area, Takaungu Chief's Office Grounds on 26th April 2023. The following were the main issues that emanated from the first public meeting.

- ✓ Dust pollution from MCL has resulted in drying of coconuts and cashew nuts trees in the locality.
- ✓ Dust pollution is contributing to coughing and signs of TB in the area.
- ✓ Residents of Mukuajuni are not benefiting from MCL presence in the area yet when MCL first came to the site, it was Kibaoni / Mkuajuni people who were consulted and welcomed the Mombasa Cement to the site.
- ✓ MCL has not fulfilled its promise of scholarships made to the community when they first begin investing in the area.
- ✓ MCL had not fulfilled its promise of ensuring 75% of employees of the company are sourced from the local community.
- ✓ The developer to consider developing an ECD and a primary school for Vijiweni residents to assist local learners and prevent them from walking long distance to the nearest ECD and primary school.

Appendix 12 is the attendance list and Minutes of the Second Baraza while Plate 7 capture attendees during the first public baraza

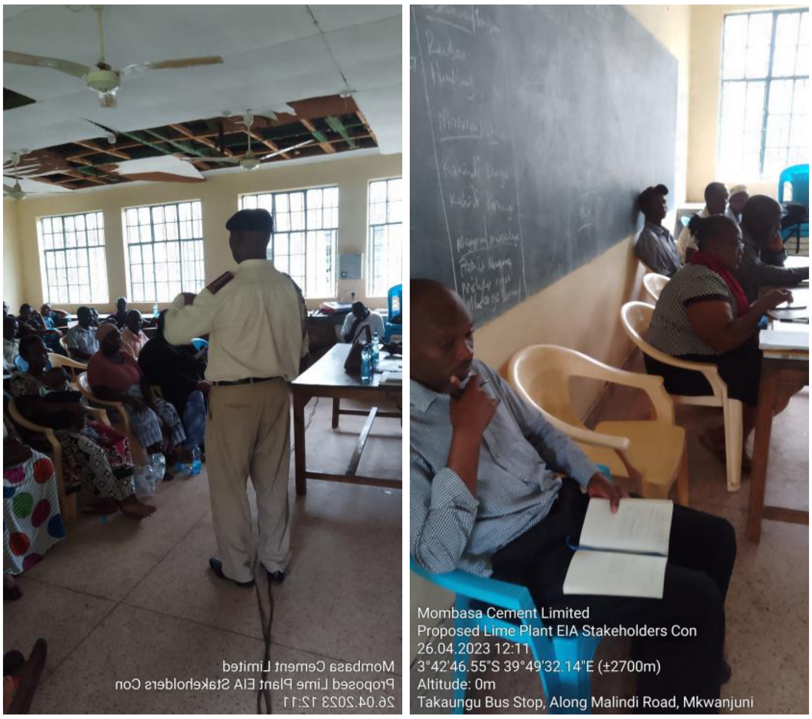


Plate 7 Snapshot of proceedings of the second public baraza

9.2.3 Third Public Baraza

The third stakeholder consultation & public participation public baraza was held at at Timboni Grounds on the afternoon of 26th April 2023. The following were the main issues that emanated from the first public meeting.

- ✓ Dust related ailments in the locality and that MCL should provide medical support on the local community.
- ✓ Boundary wall for MCL which has changed local aesthetics.
- ✓ MCL should also provide employment opportunities for women in the plant and not youths only.
- ✓ MCL to provide seedlings to the women groups and other conservation groups in the area.

Appendix 13 is the attendance list and Minutes of the Third Baraza while Plate 8 captures attendees during the first public baraza.

Plate 8 Snapshots from third public consultations baraza for the proposed project

10. POTENTIAL ENVIRONMENTAL IMPACTS AND PROPOSED MITIGATION MEASURES

10.1 Construction phase

The construction phase of the proposed project will involve the following:

- ✓ Construction of a and installation of the lime plant
- ✓ Construction of support facilities such as sanitary facilities, offices, weighbridge & weighbridge house.

The construction phase of the proposed project will potentially result in both positive and negative impacts.

10.1.1 Potential positive impacts during construction phase

- ✓ Employment opportunities for the local community
- ✓ Support to existing local businesses
- ✓ On job training opportunities for local people

10.1.1.1 Employment opportunities for the local community

Construction phase of the proposed project will likely create direct employment opportunities. Direct labour force will be required in all site construction activities. Other direct employment opportunities will include in the area of equipment operators such employees who will be hired to operate equipment used on site. This and other construction activities will create employment to the local community. The project also will provide indirect employment opportunities, in terms of service providers such as food outlets who will benefit from clientele drawn from workers at the proposed project site, other service providers such as transporters who will be hired to ferry construction materials into the site and construction waste out of the site.

10.1.1.2 Support to existing local businesses

Once the implementation of the proposed project begins and local people and others get hired at the construction phase, they will be remunerated for their work. This will translate to more money available in the pocket hence improved purchasing power. Local businesses are likely to benefit from improved purchasing power of people in the area as a result of their remuneration. There is likelihood that there will be more money in the pockets of people who will be directly or indirectly employed in the project and that part of the money will be spent in the local economy hence benefits local businesses.

10.1.1.3 On-job training opportunities for local people

Implementation of the proposed project will present an opportunity for non-skilled local people to be involved in the project and acquire skills through on-job training. Limestone and fuel are loaded into the lime kiln, after preheating, it begins to decompose at 850°C, and completes calcination at 1200°C; after cooling, it is discharged out of the kiln to complete the production of quicklime products.

10.1.2 Potential negative impacts during construction phase

Construction activities of the proposed lime plant are likely to result in the following:-

- ✓ Loss of vegetation
- ✓ Noise disturbance
- ✓ Fugitive dust
- ✓ Injuries and accidents
- ✓ Waste generation

10.1.2.1 Loss of vegetation

The proposed project site where the lime plant is to be construct has some vegetation growing on site. Observed vegetation on site includes bushes of Neem tree (*Azadirachta indica*) and grasses such as Buffel grass (*Cenchrus ciliaris*). Neem tree has remarkable ability to withstand air and water pollution as well as heat. The tree species is vital in restoring and maintaining soil fertility which makes it highly suitable in agro-forestry. Environmental benefits of Neem tree include reduced erosion and salination, and rehabilitation of degraded land. The *Cenchrus ciliaris* grass species is highly valued as a pastoral species due to its high nutritional value for sheep and cattle. The grass species is drought tolerant capabilities and ability to withstand heavy grazing. The species is important in mine site rehabilitation and erosion control. This species is thus important as fodder for livestock from adjacent communities who access the limestone deposit areas and other undeveloped parts of parcels of land owned by MCL such as the proposed project site. It is an important species which can be used in restoration of mined and decommissioned borrow pits of MCL. During construction phase, vegetation at the proposed site will be cleared to pave way for construction works. This will result in overall reduction of vegetation on site which will translate to reduced local carbon sink and overall reduction in local greenery. Potential negative environmental impacts likely to result from vegetation clearing from the proposed project site will include:-

- ✓ Direct loss of local vegetation
- ✓ Diminishing of local carbon sink resulting in reduced area capacity of carbon sequestration.
- ✓ Overall reduction of flora in the area and overall loss and/or reduction of ecological and economic services derived from the lost floral species.
- ✓ Loss and or reduced foliage for local fauna species

10.1.2.1.1 Proposed mitigation measure of potential vegetation loss

Mitigation measures proposed to mitigate potential vegetation loss include the following:-

- ✓ Limit vegetation removal to actual proposed project site only.
- ✓ Plant trees especially Casuaina around the periphery of the lime plant and in open spaces in the compound of the plant.
- ✓ MCL to support planting of trees in public areas such as schools, Chief Camp, local dispensaries within the project catchment to offset overall vegetation loss in the area.

10.1.2.2 Noise disturbance

The construction phase of the proposed lime plant will involve undertaking various activities that can be a potential source of noise. Noise and vibration is likely to be generated during site preparation, site excavation and construction of the lime plant and associated facilities. Heavy equipment activity on site will significantly contribute to noise and vibration on site during construction phase. Potential noise receptors during the construction phase may include construction workers and staff of Mombasa Cement Vipingo who will be at the vicinity of the proposed project site. Noise generation during the construction phase however will be limited to the duration of project construction. Potential negative impacts of such noise may include:-

- ✓ Impaired oral communication among the staff involved in the construction activities resulting in shouting and laud talking among themselves when communicating.
- ✓ Reduced concentration for workers.
- ✓ Annoyance to neighbours.
- ✓ Noise induced hearing loss.

10.1.2.2.1 Proposed mitigation measures of noise disturbance

The following measures are proposed to mitigate potential negative impacts of noise:-

- ✓ Ensure equipment like heavy duty cranes being used are appropriately serviced and maintained.
- ✓ Put in place a comprehensive noise and vibration conservation programme which will include noise and vibration level monitoring, use of noise attenuators, training and use of appropriate personal protective equipment
- ✓ Ensure the provisions of Environmental Management and Coordination (Noise and excessive vibration control) Regulation, 2009 are adhered to.

10.1.2.3 Fugitive dust

Excavation and removal of overburden will potentially result in fugitive dust generation. Such fugitive dust will potentially negatively affect potential receptors such as workers, adjacent homesteads and other neighboring facilities. The fugitive dust can negatively affect workers on site and those adjacent MCL facilities in terms of throat irritation, skin irritation, coughing and sneezing.

10.1.2.3.1 Proposed mitigation measures for fugitive dust

The following measures are proposed to mitigate potential negative impacts of fugitive dust-

- ✓ Regular sprinkle water on opened up dusty areas.
- ✓ Secure construction site with dust screens.
- ✓ Provide construction workers with appropriate personal protective equipment.
- ✓ Monitor fugitive dust levels.
- ✓ Ensure the provisions of the Environmental Management and Coordination (Air Quality) Regulations 2014 are strictly adhered to.

10.1.2.4 Injuries and accidents

During the construction phase of the proposed lime plant and associate facilities various activities will be undertaken such as site clearance, ground excavation, trenching, and construction of concrete bases. Considering that undertaking of these activities will involve the use of heavy equipment such as excavators, loaders, and cranes among others; and that some of the work will involve working at height and working in confined areas such as in trenches. Such a working environment coupled with the use of such working equipment may potential be a source of occupational accidents, injuries, misses and near misses at the workplace. Negative impacts that may arise from the said potential sources of occupational accidents, injuries, misses and near misses at the workplace may include:-

- ✓ Injuries to workers at the workplace.
- ✓ Loss of productive workforce.
- ✓ Loss of man-hours.
- ✓ Reduced productivity.
- ✓ Delays in project implementation and litigations.

10.1.2.4.1 Proposed mitigation measures to potential injuries and accidents

The following measures are proposed to mitigate injuries and accidents-

- ✓ Ensure only skilled and experienced workers are involved in the construction of the lime plant.
- ✓ Ensure suitable, appropriate, well serviced and maintained equipment are availed to the workers.
- ✓ Workers working at height and in confined areas must be provided with appropriate safety equipment.
- ✓ An equipped first aid station to be on site with trained and experienced first aiders, stand by ambulance and referral hospital.
- ✓ Ensure that the provisions of the Occupational Safety and Health Act, 2007 are adhered to.

10.1.2.5 Waste generation

During the construction phase waste will be generated from ground preparation in readiness for construction of lime plant and associated facilities. This waste will include vegetation/ plant matter that will be cut and removed and excavated overburden rock/ soil material. Other wastes may include waste paper from use of cement (empty cement bags), fastening, wrapping and packaging material (wooden pallets, carton boxes, polythene materials, nylon). Waste likely to be generated from servicing of construction equipment may include waste oil, empty containers of lubricants and absorbent material.

10.1.2.5.1 Proposed measures to mitigate against waste generation and associate impacts

The following measures are proposed to mitigate against potential negative impacts of waste generated:-

- ✓ Reduce generation of waste from cement bags by using bulk cement delivered in bulk tankers as opposed to bagged cement.
- ✓ Collect and recycle all empty cement bags by sending used cement bags to recyclers.
- ✓ The proponent will segregate non-hazardous waste into organic and non-organic fractions.
- ✓ The proponent will provide facilities that are properly labeled and colour coded receptacles, bins, containers and bags for the placement of the segregated waste.
- ✓ The proponent will hire the services of a licensed waste collector to collect, handle and transport the waste.

10.2 Production phase

The main component of limestone is calcium carbonate, while the main component of lime is calcium oxide. The basic principle of burning lime is to use the high temperature to decompose calcium carbonate in limestone into quicklime of calcium oxide and carbon dioxide.

10.2.1. Potential negative impacts during production phase

Potential negative environmental impacts likely from the production phase of the proposed lime plant will include the following:

- ✓ Increase in dust emissions
- ✓ Increase in gaseous emission
- ✓ Noise and vibration
- ✓ Waste related impacts
- ✓ Occupational safety and health concerns

10.2.1.1 Increase in dust emissions

There are two operational clinker and cement production plants at MCL Vipingo unit. The current clinker and cement production factories are a source of dust emissions in the area. The proposed lime plant will potentially be an additional source of dust emission in the area. Emissions of air pollutants can occur from a wide variety of activities during the construction, operation, and decommissioning phases of the proposed lime plant. These activities can be categorized based on the spatial characteristic of the source including point sources, fugitive sources, and mobile sources and, further, by process, such as combustion, materials storage, or other industry sector specific processes. Dust emissions may have adverse impacts to human health, safety, and the environment. Where it is not possible to eliminate dust emissions, the generation and release of dust should be managed through a combination of the following:

- ✓ Energy use efficiency.
- ✓ Process modification ·
- ✓ Selection of fuels or other materials, the processing of which may result in less polluting emissions.
- ✓ Application of emissions control techniques

The selected prevention and control techniques may include one or more methods of treatment depending on:

- ✓ Regulatory requirements.
- ✓ Significance of the source.
- ✓ Location of the emitting facility relative to other sources.
- ✓ Location of sensitive receptors.
- ✓ Existing ambient air quality and potential for degradation of the air-shed from the proposed project.
- ✓ Technical feasibility and cost effectiveness of the available options for prevention, control, and release of emissions.

10.2.1.2 Potential sources of lime dust

Dust emissions from the proposed lime plant will be from point sources which are discrete, stationary, identifiable sources of emissions that release pollutants to the atmosphere and fugitive sources that are distributed spatially and not confined to a specific discharge point. The major air contaminant from lime operations is dust. Sources of dust will include:

- ✓ Limestone dust from limestone preparation and dozing unit.
- ✓ Quicklime dust from kiln discharge, handling, shipping, and milling operations.
- ✓ Hydrate lime dust from hydrator operations, milling, and packing.

10.2.1.3 Potential negative impacts of lime dust

Potential negative impacts of exposure to lime dust would include the following:

- ✓ Lung infection resulting from inhaling of lime dust
- ✓ Skin irritation
- ✓ Itching of the skin

- ✓ Irritation of the eyes
- ✓ Chronic cough
- ✓ Reduced visibility
- ✓ Choking of plants

10.2.2 Proposed measures to mitigate exposure to lime dust

Exposure to lime dust can be mitigated by removing the dust being generated. Three dust removal technologies that can used to remove dust from lime production line are:

- ✓ Water sprinkling
- ✓ Use of bag filters
- ✓ Deployment of electrostatic precipitators

Water sprinkling to remove dust can be done in three areas namely limestone handling, crushing, and screening operations. The bag filter technology can be used in the lime plant to suck out dust generated. Bag filter system can be used in the following sections of the lime plant i.e. limestone preparation and dozing unit, PET coke grinding unit, lime kiln exhaust, quicklime handling unit, hydrated lime handling unit and hydrated lime packaging plant. Electrostatic precipitator technology can employed at the hydrated lime injection unit. High efficiency fabric filters are used for controlling dust emissions from lime production material handling and product bagging systems. At the lime kiln exhaust fiber glass bag filter systems are deployed. The bag filters system range in number depending on the size and production capacity of the lime` plant. Separate fabric filter control systems ranging in size from 30 actual cubic meters per minute capacity to more than 100,000 actual cubic meters per minute capacity. Fabric filter operation can be described in three sequential steps:

- ✓ Filtration of particles from the gas stream
- ✓ Gravity settling of the dust cake
- ✓ Removal from the hopper

Each of these steps must be performed properly to ensure high efficiency particulate collection. In fabric filter systems, particles are removed by 1) inertial impaction, 2) Brownian displacement, 3) electrostatic attraction, and 4) sieving. All four of these mechanisms are active in essentially all fabric filters simultaneously; however, the relative importance of each mechanism differs among fabric filter systems due primarily to the characteristics of the filtration media, the particulate matter size distribution, and the chemical composition of the particulate matter. The ability of fabric filters systems to remove particles over the entire size range of industrial concern of 0.1 to 100 micrometers is achieved due to the complementary characteristics of these removal mechanisms. Inertial impaction is highly efficient for large particles and Brownian displacement is efficient for small particles. Electrostatic attraction and sieving can be effective over the entire particle size range. Proper design, operation, and maintenance are needed to achieve high removal efficiency.

- ✓ One of the main design requirements is to provide sufficient filter media in the fabric filter system. The quantity of filtration media is expressed in terms of the air-to-cloth ratio (gross) defined below: A/C=Gas flow rate, m^3/min (actual)/Total filtration media area, m^2n As the air-to-cloth ratio increases, the localized gas velocities through the dust cake and fabric increase. At high air-to-cloth values, some small particles can gradually migrate through the dust layer and fabric. This is possible because dust particles within the cake are retained relatively weakly. After passing through the dust cake and fabric, these particles are re-entrained in the clean gas stream leaving the bag. To minimize emission problems related to excessively high air-to-cloth ratios, the design levels are limited. As an example, typical air-to-cloth ratios for plenum pulse fabric filters usually range from 0.6 to 2.4 (m^3/min per m^2).

- ✓ A second important design requirement is to provide sufficient filtration media cleaning capability. Routine cleaning of the filtration media is needed to ensure that a portion of the dust is removed from the filtration media surfaces to prevent excessively high gas flow resistance. In most types of fabric filters, agglomerated clumps or flakes of particulate matter are removed from the filter media surface. By allowing the material to agglomerate on the particle surface, the gravity settling of material from the vertical filter media to the hoppers below is facilitated. As indicated earlier, gravity settling of the collected material is an essential second step in the filtration process. Optimal cleaning of fabric filters also requires cleaning on the frequency and intensity most appropriate for the specific characteristics of the dust cake. Plant personnel operating and maintaining the fabric filters have an important role in ensuring proper cleaning. Bags that are allowed to collect dust have critical impacts on the entire system. Fugitive emissions increase, pressure drop across the bag house increases due to higher system resistance, the flow rate along with the fan current decreases for the same reason, the fan static pressure increases, and the hood static pressure decreases along with the decrease in flow rate.

- ✓ The third general design area of importance in all fabric filtration systems is the solids collection and handling systems. Lime plant dust sources generate relatively large quantities of material that must be collected and transported. Continuous removal of the solids from the fabric filter system is needed to ensure proper operation.

10.2.3 Increase in gaseous emission

There are three main sources of gaseous emissions from a lime production system namely raw materials, the fuel, and the process itself. A brief elaboration of each source as follows.

10.2.3.1 Raw Materials

The predominant constituent of the raw material mix for lime is calcium carbonate, the calcareous component is limestone. Since the raw mix constitutes over 75% calcium carbonate the degree of purity of the calcareous component determines the amount that is contained in the raw material mix. About 48% of the weight of the calcium carbonate is carbon and oxygen, the calcareous component of the raw material mix is a significant source of CO_2 emissions through calcination (de-carbonization). During the calcination of limestone, moisture, and volatile organic matter are first driven off. At higher temperatures, the partial pressure of CO_2 increases and decomposition of the carbonate begins. Decomposition does not progress at a rapid rate, however, until a temperature range of 700 - 800° C is reached for dolomite and 830 - 930° C for high-calcium stone. The loss of carbon dioxide during calcination leaves the residue in a porous, highly reactive state. Quicklime (CaO or mixtures of CaO and MgO) is produced by heating limestone to decompose the carbonate releasing CO_2 and leaving the oxide behind. Hydrated lime is produced by reacting the oxide with water to produce the corresponding hydroxide. Coral limestone the source of calcium carbonate to be used in lime production originated in an ocean, chlorine is present as a trace element, and this chlorine is available in the flue gas stream for the generation of hydrogen chloride. Limestone also contain sulfur in the form of sulfates, sulfides (metallic and organic), and, rarely, elemental sulfur. Sulfates pass through the kiln system without transformation into SO_2, but sulfides and elemental sulfur can result in the generation of SO_2 through the oxidation of sulfur in kiln systems. If localized reducing conditions exist in the pyroprocessing system, sulfates can be converted to SO_2. Limestone also can contain petroleum and/or kerogens that can be partially volatilized or pyrolyzed at temperatures present at the feed end of the pyroprocesses to result in organic emissions. These organic constituents or their nonvolatile residues can result in CO emissions when burned in an oxygen-deficient section of the pyroprocessing system.

10.2.3.2 Fuel

Petroleum coke (Petcoke) will be the main fuel used in the lime kiln system. Pet coke, prepared for the lime kiln, is a fine powder with both cohesive and flushing tendencies.

10.2.3.3 Process

The formation of gaseous pollutants primarily occurs in the kiln as the consequence of oxidation at a relatively high temperature. Process gas is vented through three points i.e., the discharge of the kiln, the alkali bypass, and the pet-coke mill, these points are equipped with a particulate matter control device (PMCD). Mombasa Cement proposes to use the precalciner kiln system in this process, there will be a special vessel called a calciner located between the kiln system and the preheater into which fuel is introduced. It is in this vessel that the bulk of the calcinations of the calcareous component of the limestone take place. The calcination reaction requires the most thermal energy of any reaction in the lime-making process. Typically, hot tertiary air is taken from the kiln firing hood and ducted outside the kiln to the precalciner vessel for combustion support. Gases produced from lime production process include carbon dioxide, carbon monoxide, nitrogen oxides, sulfur dioxide, and ammonia.

10.2.3.3.1 Carbon dioxide

Carbon dioxide results from the combustion of pet-coke fuel and the calcination of the limestone. Of the total amount of CO_2 emitted from lime kiln, about half of the CO_2 originates from the raw material while the other half originates from the combustion process.

10.2.3.3.2 Carbon monoxide

CO is a product of incomplete combustion of carbonaceous fuel resulting from insufficient oxygen at the combustion site, insufficient mixing of oxygen and fuel at the combustion site, and/or rapid cooling of the combustion products to below the ignition temperature of CO prior to its complete oxidation. CO can be formed unintentionally at any of the combustion sites in the pyroprocessing system. The emission of CO usually represents partially burned and underutilized fuel. However, as a result of using oxygen-deficient combustion in the riser duct or calciner as a NOX control strategy, CO sometimes is generated in the pyroprocess and may appear in the flue gas discharge if it is not somehow oxidized following its formation.

10.2.3.3.3 Nitrogen oxides

There are four mechanisms of NOX formation in lime kilns of which thermal and fuel NOX formation is the most important. Thermal NOX results from the oxidation of molecular nitrogen in air at high temperature. This phenomenon occurs in and around the flame in the burning zone of a lime kiln at a temperature greater than 1200ºC. Fuel NOX results from the oxidation of nitrogen in the fuel at any combustion temperature found in the lime production process. Because of the lower combustion temperature in the calciner and some sites of supplemental fuel combustion, the formation of fuel NOX often exceeds that of thermal NOX at these locations.

10.2.3.3.5 Ammonia

Trace quantities of NH3 in the exhaust gas from the kiln gas result from the pyrolysis of nitrogenous compounds in pet-coke and limestone. In addition, atmospheric reactions occur just outside of the stack between NH3 and the oxides of sulfur or HCl that produce ammonium sulfate, ammonium bisulfate, or ammonium chloride as very fine particulate matter (PM).

10.2.3.3.4 Sulfur dioxide

Sulfur dioxide results from the oxidation of sulfide or elemental sulfur contained in the fuel during combustion. In addition, sulfide or elemental sulfur contained in raw materials may be “roasted” or oxidized to SO_2 in areas of the pyroprocessing system where sufficient oxygen is present and the material temperature is in the range of 300-600°C. In addition, sulfates in the raw mix can be converted to SO_2 through localized reducing conditions in the kiln system.

10.2.3.3.6 Potential negative impacts of greenhouse gasses emission

- ✓ Carbon monoxide (CO) can cause harmful health effects by reducing oxygen delivery to the body's organs and tissues, as well as adverse effects on the cardiovascular and central nervous systems.
- ✓ CO contributes to the formation of smog (ground-level ozone), which can cause respiratory problems.
- ✓ Nitrogen oxide (NOx) can cause or contribute to a variety of health problems and adverse environmental impacts, such as ground-level ozone, acid rain, global warming, water quality deterioration, and visual impairment. Potentially affected populations include children, people with lung diseases such as asthma, and exposure to these conditions can cause damage to lung tissue for people who work or exercise outside
- ✓ Sulfur dioxide (SO_2) in high concentrations can affect breathing and may aggravate existing respiratory and cardiovascular disease. Sensitive populations include asthmatics, individuals with bronchitis or emphysema, children, and the elderly.
- ✓ SO_2 is also a primary contributor to acid deposition, or acid rain.

10.2.4 Proposed mitigation measures of gaseous emissions

10.2.4.1 Mitigation of Sulfur Dioxide Emissions

Emission of sulfur dioxide from lime production process can be mitigated by using the following technologies; inherent scrubbing, oxygen control (increase), fuel substitution (lower total sulfur), raw material substitution (lower sulfide sulfur) and raw material alkali/sulfur balance,. A brief explanation of each of the technology is as follows.

10.2.4.1.1 Inherent scrubbing

Inherent scrubbing is a combination of design characteristics of the lime pyroprocessing system which aid in removing some SO_2 from the flue gas stream. These include oxidizing atmospheres, long residence times, appropriate process temperature windows, intimate mixing of gases and reactive solids, and the ability to remove from the process an intermediate material.

10.2.4.1.2 Oxygen control (increase)

Control of SO_2 originating in fuel can be improved by an increase in oxygen (excess air) in the kiln system. Oxygen increase will result in oxidizing of sulfur to a solid sulfate that is retained in the lime or expelled from the system.

10.2.4.1.3 Fuel substitution (lower total sulfur)

In precalciner kiln systems, the emission of SO_2 that originates in the fuel is often nil because of the inherent ability of the calciner and an alkalibypass equipped kiln to absorb and/or remove sulfur. In the other systems and under certain process conditions, e.g., a deficiency of alkali metals, sulfur in the fuel can result in emissions of SO_2. It is intuitive that a reduction in the sulfur content of a solid fuel or the change to a sulfur free fuel, e.g., natural gas, has the potential to reduce SO_2 emissions.

10.2.4.1.4 Raw material substitution (lower sulfide sulfur)

Replacement of a raw material that contains sulfide sulfur with one of lower sulfide sulfur concentration reduces the potential for generation of SO_2. Sulfide sulfur in lime raw materials is most often in the form of iron pyrite but other sulfide compounds, including those of organic origin, may contribute to the potential for SO_2 generation. Selective purchasing, selective quarrying or judicious blending of available raw materials is used to accomplish the replacement.

10.2.4.1.5 Raw material alkali/sulfur balance

Raw material alkali/sulfur balance involves stoichiometrically balancing of the sulfur in the kiln system with the alkali metals, sodium and potassium. Under oxidizing conditions in the kiln, the sulfur preferentially forms alkali sulfates. If there is a deficiency in alkali metals, SO_2 can pass through the system even though there is an apparent abundance of calcium oxide with which the SO_2. Balancing the input of alkali metals to the input of sulfur can reduce SO_2 emissions.

10.2.4.2 Mitigation of Nitrogen Oxides Emission

Emission of Nitrogen Oxides from lime production process can be mitigated by using the following technologies; oxygen control (decrease), indirect firing, low-NOX burner, mid-kiln firing, process improvements, process control improvements, low-NOX calciner, staged combustion, semi-direct firing and mixing air fan. A brief explanation of each of the technology is as follows.

10.2.4.2.1 Oxygen control (decrease)

For control of NOX originating at the high temperature combustion site in a rotary kiln, a decrease in oxygen (excess air) in the burning zone tends to minimize the generation of thermal and fuel NOX. Both of these mechanisms of NOX formation are oxygen dependent. The reduction in excess air reduces the strength of the oxidizing conditions in the rotary kiln and usually causes an increase in SO_2 generated from the fuel used in the main flame.

10.2.4.2.2 Indirect firing

In the indirect-fired system, the powdered coal is separated from the drying and transport air by cyclones and/or fabric filters, and is stored in a bin or silo prior to being metered and pneumatically transported by ambient air to the combustion site. In an indirect-fired system, the primary air can be reduced to about 10-15% of the total combustion air. Since the generation of both thermal and fuel NOX is oxygen dependent, the reduction in available oxygen in the flame envelope in an indirect-fired coal system results in a reduction in NOX generation. Indirect coal firing systems generally result in improved thermal efficiency for the kiln system and a reduction in CO_2 emissions.

10. 2.4.2.3 Low-NOX burner

Adjustable burners with proprietary designs reduce NOX generation through the mixing scheme for fuel and primary air by reducing flame temperature, altering turbulence in the flame, and establishing oxygen-deficient recirculation zones in the flame.

10.2.4.2.4 Mid-kiln firing

Mid-kiln firing primarily provides for staged combustion once per revolution of the kiln, a single charge of fuel is introduced into the calcining zone through the kiln shell using a gated feed device. As the carbonaceous fuel charge burns in the low oxygen environment of the calcining zone, free radicals are generated that in turn chemically reduce the NOX that was generated in the burning zone to molecular nitrogen.

10.2.4.2.5 Process improvements

Improvement in an existing kiln system that improves the thermal efficiency of the process will be accompanied by a reduction in long-term NOX emissions per ton of clinker this is primarily because of the reduced consumption of fuel per unit of production.

10.2.4.2.6 Process control improvements

Process control improvements are characterized by the installation of new or better instrumentation and/or process control systems. In older kiln systems, the improvement might mean replacing an analog process control system with a digital computer. In newer kiln systems with an adequate digital computer, the use of one of the expert or fuzzy logic control systems and the necessary process instrumentation could represent a significant process control improvement. In essence, the expert systems are satellite computers that guide the process computer in controlling the kiln system. They are able to detect subtle changes in the process and to take corrective action more rapidly than the central control room operator. The common purposes of most process control improvements on kiln systems are to improve thermal efficiency and the clinker production rate. However, if a process control improvement project simply results in a more stable pyroprocessing system, lower NOX emissions over the short term, the long term, and per ton of lime will result.

10.2.4.2.7 Low-NOX calciner

Pyroprocessing systems offer proprietary calciner designs that carefully control the mixing sequence of fuel, air, and raw materials in the calciner vessel. The common feature of all these systems is an oxygen-deficient initial combustion zone in which free radicals are generated that subsequently react with NOX to form molecular nitrogen and other reaction products.

10.2.4.2.8 Staged combustion

Staged combustion (sometimes called secondary firing) involves developing a reducing zone in the flue gas flow path after the burning zone in which free radicals produced during staged combustion of hydrocarbon fuels react with NOX from the burning zone to form molecular nitrogen and other reaction products. The most prevalent location for staged combustion is in the riser duct between the discharge of the rotary kiln and the calciner vessel.

10.2.4.2.9 Semi-direct firing

Semi-direct firing systems for solid fossil fuels have the benefit of potentially reducing NOX generation through a reduction in primary air for the main kiln burner while avoiding the source of particulate matter emissions from the coal mill particulate matter combustion device found in an indirect-fired system. When compared to a direct-fired system, the reductions in NOX generation attributed to a semi-direct system can be as great as those that would be experienced with an indirect-fired system. Semi-direct firing systems mechanically separate the powdered coal in the coal mill exhaust from the coal drying and transport air to provide for better combustion control through independent metering of the coal being fed to the kiln and to sometimes reduce the quantity of primary air used in the main burner pipe.

10.2.4.2.10 Mixing air fan

Mixing air fan involves operating the flame at the discharge end of a rotary kiln with reduced oxygen at the combustion site, the generation rate of thermal and fuel NOX becomes less than if a large excess of oxygen were present. In addition, free radicals are formed in the flame that could react with NOX to form molecular nitrogen in the appropriate temperature window located downstream of the burning zone in the flue gas flow path.

10.2.4.2.11 Lime kiln dust insufflation

Lime kiln insufflations involves recycling usable Kiln Dust (KD) to the pyroprocess, KD sometimes is injected or insufflated into the burning zone in or near the main flame. The presence of these cold solids within or in close proximity to the flame has the effect of cooling the flame and/or the burning zone thereby reducing the formation of thermal NOX.

10.2.4.3 Proposed mitigation of Carbon Monoxide Emission

Emission of carbon monoxide from lime production process may be mitigated using the following technologies; good combustion practice, excess air (increase), raw material substitution, pyroprocessing system design and mixing air fan. A brief explanation of each this technology is as follows.

10.2.4.3.1 Good combustion practice

The most prevalent technology used for control of CO generation in cement kiln systems is good combustion practice. At each combustion site, adequate time, temperature, and turbulence are provided to make certain that the carbon component of the fuel is fully oxidized to CO_2. Good combustion practice contributes to maximum thermal efficiency, reduced operating cost, and the minimization of the emissions of NOX, CO_2, SO_2, and organic PICs.

10.2.4.3.2 Excess air (increase)

To provide for maximum thermal efficiency, the volumetric concentration of oxygen in the flue gas at the feed end of a rotary kiln and/or the exit of the preheater tower normally are held as close as possible to 1%. Because of site-specific conditions, this oxygen concentration may be insufficient to allow for complete combustion, and CO may be generated at the combustion site. A slight increase in the amount of air passing through the kiln system is often sufficient to reduce the excess CO emissions.

10.2.4.3.3 Raw material substitution

Some cement raw materials contain carbonaceous components that are only partially oxidized to CO in the low-temperature regions of the pyroprocess. These situations also may present excessive emissions of organic pollutants. Depending on local availability and costs, replacement of the offending raw material by selective purchasing, selective quarrying or judicious blending may be an effective technology to reduce emissions of CO and/or organic material.

10.2.4.3.4 Pyroprocessing system design

Emission of CO from unburned fuel represents an economic loss, to avoid this; the design of the clinker production plant should ensure complete combustion of fuels. In those situations where CO generation occurs simultaneously with the deliberate generation of free radicals used as reducing agents to minimize NOX emissions, the process normally is designed to oxidize residual CO to CO_2 once the NOX reduction has been accomplished.

10.2.4.3.5 Mixing air fan

Mixing air fun technology involves introducing high-pressure air in the range of a 2-10% replacement of the primary combustion air which is injected through the shell of the rotary kiln into the calcining zone to provide additional oxygen to the post-combustion flue gas to meet stoichiometric requirements and the kinetic energy necessary for the adequate mixing of flue gas within the kiln. To reduce CO emissions, this technology has an effective synergy with mid-kiln firing of solid fuel.

10.2.4.3.6 Mitigation measures of Carbon Dioxide Emission

Emission of carbon dioxide from lime production process can be controlled using the following technologies; improved thermal efficiency, improved electrical efficiency, raw material substitution and mineralizers. A brief explanation of each of the technology is as follows.

10.2.4.3.7 Improved thermal efficiency

The reduction in the amount of carbonaceous fuel burned in a kiln system through improved thermal efficiency has a direct relationship to the reduction in emissions of CO_2. Improvements in thermal efficiency are accomplished primarily through process and process control improvements. Maintenance of components of a kiln system that affect thermal efficiency, e.g., chains and seals, contribute to the maximization of the thermal efficiency of a given kiln system. Complete replacement of a kiln system with a more thermally efficient kiln system achieves a measurable reduction in CO_2 emissions per ton of lime.

10.2.4.3.8 Improved electrical efficiency

A reduction in the amount of electricity used to produce a ton of lime indirectly results in lower emissions of CO_2 from fossil fuel fired power plants. Many of the pollution abatement technologies decrease the electrical efficiency of a lime plant, e.g., larger fans using more electrical power are required to overcome pressure drop across equipment or to move a larger volume of flue gas.

10.2.4.3.9 Raw material substitution

Raw material substitution can be marginally effective in reducing CO2 emissions from pyroprocesses. Through control of the chemistry of the raw material, the kiln temperature can be lowered slightly thereby requiring marginally less carbonaceous fuel to complete the desired reactions.

10.2.4.3.10 Mineralizers

When added to the raw material, certain chemicals, e.g., calcium fluoride, are known to reduce significantly the kiln temperature and the carbonaceous fuel required to sustain the pyroprocess.

10.2.4.4 Proposed Mitigation of Ammonia Emission

Emission of ammonia from the production process can be controlled through raw material substitution and tailpipe scrubber technologies; A brief explanation of each of the technology is as follows.

10.2.4.4.1 Raw material substitution

The involvement of NH_3 in the formation of detached plumes and as a precursor to haze formation can be a concern. If a component of the raw material contains nitrogenous components that are converted to or liberated as NH_3 in the pyroprocess, the raw material could be replaced if a suitable, economically-viable substitute is locally available through selective purchasing, selective quarrying or judicious blending.

10.2.4.4.2 Tailpipe wet scrubber

NH_3 is highly soluble in water so a water spray tower should suffice to scrub NH_3 from the flue gas. The spray tower also would remove some soluble SO_2 and residual organic compounds from the flue gas.

10.2.5 Noise and Vibrations exposure

Exhaust fans and grinding mills are the main sources of noise and vibrations in lime plants.

Noise prevention and mitigation measures will be applied where predicted or measured noise impacts from the lime plant operations exceed the applicable noise level guideline at the most sensitive point of reception as specified in the Environmental Management and Coordination (Excessive Noise and Vibration) (Control) Regulations, 2009. The preferred method for controlling noise from the lime plant is to implement noise control measures at source. Methods for prevention and control of sources of noise emissions depend on the source and proximity of receptors.

10.2.5.1 Potential negative impacts of noise

- ✓ Continuous exposure of workers at the work place to high noise levels for a long time may result in noise induced hearing loss.
- ✓ Extremely laud noise at the work place can result in immediate lasting damage to the worker’s hearing mechanism.
- ✓ Exposure of workers to laud noise will result in reduction of productivity and efficiency of the workers at the work place, this will ultimately translate to overall reduction of productivity in the workplace and hence reduced output.
- ✓ Exposure of a worker to laud noise can upset the sense of balance and cause blood vessels to constrict, this will result in a rise in blood pressure hence reduction in the volume of blood flow.
- ✓ High noise levels at the work place can result in fatigue, headache, nervousness, irritability and high pretension; this will increase the likelihood of accidents at the workplace.
- ✓ Exposure of a worker to high noise levels will result in stressing the worker and thus result in reduced concentration.

10.2.5.2 Proposed mitigation measures of Noise and vibrations

Control of noise emissions may include:

- ✓ The use of silencers
- ✓ Room enclosures for mill operators.
- ✓ Noise barriers/ attenuators.

- ✓ Installing suitable mufflers on compressor components.
- ✓ Installing acoustic barriers without gaps and with a continuous minimum surface density of 10 kg/m^2 in order to minimize the transmission of sound through the barrier. Barriers should be located as close to the source or to the receptor location to be effective.
- ✓ Installing vibration isolation for mechanical equipment.
- ✓ If noise cannot be reduced to acceptable levels, personal hearing protection to be provided.
- ✓ No employee should be exposed to a noise level greater than 85 dB(A) for a duration of more than 8 hours per day without hearing protection. In addition, no unprotected ear should be exposed to a peak sound pressure level (instantaneous) of more than 140 dB(C).
- ✓ The use of hearing protection should be enforced actively when the equivalent sound level over 8 hours reaches 85 dB(A), the peak sound levels reach 140 dB(C), or the average maximum sound level reaches 110dB(A). Hearing protective devices provided should be capable of reducing sound levels at the ear to at least 85 dB(A).
- ✓ Although hearing protection is preferred for any period of noise exposure in excess of 85 dB(A), an equivalent level of protection can be obtained, but less easily managed, by limiting the duration of noise exposure. For every 3 dB(A) increase in sound levels, the 'allowed' exposure period or duration should be reduced by 50%.
- ✓ Prior to the issuance of hearing protective devices as the final control mechanism, use of acoustic insulating materials, isolation of the noise source, and other engineering controls should be investigated and implemented, where feasible.
- ✓ Periodic medical hearing checks should be performed on workers exposed to high noise levels.
- ✓ Developing a mechanism to record and respond to complaints.

10.2.6 Potential occupational safety and health impacts

The most significant negative occupational safety and health impacts that are likely to occur during the operational phase of lime plant include the following:

- ✓ Dust exposure
- ✓ Heat exposure
- ✓ Physical hazards
- ✓ Radiation exposure
- ✓ Chemical hazards
- ✓ Industrial hygiene issues

10.2.6.1 Dust exposure

Exposure to fine particulates is associated with work in most of the dust-generating stages of lime manufacturing, but most notably from quarry operation, raw material handling. Exposure to active (crystalline) silica dust (SiO_2), when present in the raw materials, is a relevant potential hazard in the lime manufacturing plant.

10.2.6.1.1 Dust exposure proposed mitigation measures

Methods to prevent and control exposure to dust include the following

- ✓ Control of dust through implementation of good housekeeping and maintenance.
- ✓ Use of air–conditioned, closed cabins.
- ✓ Use of dust extraction and recycling systems to remove dust from work areas, especially in grinding mills.
- ✓ Use of air ventilation (suction) in lime-bagging areas.
- ✓ Use of PPE, as appropriate to address residual exposures.
- ✓ Engineering controls.
- ✓ Use of mobile vacuum cleaning systems to prevent dust buildup on paved areas.

10.2.6.2 Heat exposure

The principal exposures to heat in lime processing plants occur during operation and maintenance of kilns or other hot equipment, and through exothermic reactions in the lime-hydrating process.

10.2.6.2.1 Heat exposure proposed mitigation measures

Recommended prevention and control techniques of exposure to heat include the following:

- ✓ Shielding surfaces where workers' proximity and close contact with hot equipment should be done, using personal protective equipment (PPE), as needed (e.g. insulated gloves and shoes).
- ✓ Minimizing the work time required in high temperature environments by implementing shorter shifts at these locations.
- ✓ Making available and using, as needed, air- or oxygen supplied respirators.
- ✓ Implementing specific personal protection safety procedures in the lime-hydrating process to avoid potential exposure to exothermic reactions.

10.2.6.3 Physical hazards

Injuries during lime manufacturing operations are typically related to slips, trips, and falls; contact with falling /moving objects; and lifting / over-exertion. Other injuries may occur due to contact with, or capture in, moving machinery (e.g. dump trucks, front loaders, forklifts). Activities related to maintenance of equipment, including crushers, mills, mill separators, fans, coolers, and belt conveyors, represent a significant source of exposure to physical hazards. Potential physical hazards in a lime production plant may include the following:

- ✓ Falling / impact with objects
- ✓ Hot surface burns
- ✓ Transportation

- ✓ Contact with allergic substances

10.2.6.3.1 Proposed mitigation measures for potential physical hazards

- ✓ When working on equipment with moving parts, ensure the equipment is de-energized, isolated and locked/tagged out.
- ✓ When working from a position with the potential risk for a fall from height, use fall protection such as belts.
- ✓ When flame welding, cutting or brazing in the proximity of any flammable material, use appropriate PPEs.
- ✓ Safety helmets to be used to protect workers below against falling material.
- ✓ Barriers like a toe boards or mesh guards to be provided to prevent items from slipping or being knocked off the edge of a structure.
- ✓ Danger areas to be clearly marked with suitable safety signs indicating that access is restricted to essential personnel wearing appropriate PPEs while the work is in progress.
- ✓ In case of any accident immediate and proper first aid to be administered prior to medical care at the plant site.

10.2.6.4 Radiation exposure

An X-ray station is sometimes used to continuously monitor the raw material mix on the belt conveyor feeding the raw mill. Operators of this equipment should be protected through the implementation of ionizing radiation protection measures. Radiation exposure can lead to potential discomfort, injury or serious illness to workers.

10.2.6.4.1 Proposed mitigation measures of exposure to radiations

Prevention and control strategies include:

- ✓ Places of work involving occupational exposure to ionizing radiation should be established and operated in accordance with recognized international safety standards and guidelines.
- ✓ Exposure to non-ionizing radiation (including static magnetic fields; sub-radio frequency magnetic fields; static electric fields; radio frequency and microwave radiation; light and near-infrared radiation; and ultraviolet radiation) should be controlled to internationally recommended limits.
- ✓ In the case of both ionizing and non-ionizing radiation, the preferred method for controlling exposure is shielding and limiting the radiation source. Personal protective equipment is supplemental only or for emergency use. Personal protective equipment for near-infrared, visible and ultraviolet range radiation can include appropriate sun block creams, with or without appropriate screening clothing.

10.2.6.5 Chemical Hazards and other Industrial Hygiene Issues

Chemical hazards represent potential for illness or injury due to single acute exposure or chronic repetitive exposure to toxic, corrosive, sensitizing or oxidative substances. Also chemical hazards represent a risk of uncontrolled reaction, including the risk of fire and explosion, if incompatible chemicals are inadvertently mixed. The potential accidental contact with CaO / CaOH on skin / eyes / mucous membranes is a specific hazard in lime production plants that needs to be assessed, prevented, and mitigated through emergency procedures and equipment. The presence of moisture may result in burns.

10.2.6.5.1 Chemical hazards proposed mitigation measures

- ✓ Facilities for immediate washing of the affected body surface should be available, including eyewash facilities where quicklime is handled.
- ✓ The handling areas should be covered and enclosed, if possible, to avoid generation of a dust hazard.
- ✓ Implementation of engineering and administrative control measures to avoid or minimize the release of hazardous substances into the work environment keeping the level of exposure below internationally established or recognized limits.
- ✓ Eliminate or keep the number of employees exposed, or likely to become exposed, to a minimum.
- ✓ Communicating chemical hazards to workers through labeling and marking according to national and internationally recognized requirements and standards, including the International Chemical Safety Cards (ICSC), Materials Safety Data Cement (MSDS), or equivalent. Any means of written communication should be in an easily understood language and be readily available to exposed workers and first-aid personnel.
- ✓ Training workers in the use of the available information (such as MSDSs), safe work practices, and appropriate use of PPE.

10. 2.7 Waste related pollution

10.2.7.1 Solid waste

Sources of solid waste in lime manufacturing can be of three categories namely process waste, domestic waste and office waste. Process waste includes lime production waste, mainly composed of spoil rocks, which are removed from the raw materials during lime preparation. Another potential waste stream involves the lime dust removed from the bypass flow and the stack, if it is not recycled in the process. Limited waste is generated from lime plant maintenance (e.g. used oil and scrap metal). Other waste materials may include alkali or chloride / fluoride containing dust buildup from the kiln. Domestic waste include waste from canteen and other eating places within the plant and waste from dwelling houses of staff such waste include food left offers, wastepaper. Office waste includes wastepaper, electronic waste and sweepings.

10.2.7.1.1 Potential negative impacts of solid waste

- ✓ Odor from decomposing food leftovers from the canteen
- ✓ Blockage of drainage system by scrap and other non-decomposing solid wastes.
- ✓ Some electronic office waste such as used toner cartridges and absolute office electronic equipment contain hazardous substances.

10. 2.7.2 Liquid waste

Liquid waste generated from lime manufacturing process includes industrial process wastewater, sanitary wastewater, storm water and waste oil. Wastewater is generated mainly from utility operations for cooling purposes in different phases of the process (e.g. bearings, kiln rings). Wastewater is also generated from sanitary facilities from the plant, from cleaning of floors and other surfaces and from tools and equipment cleaning such as motor vehicles. Process wastewater with high pH and suspended solids may be generated in some operations. Techniques for treating industrial process wastewater in this sector include flow and load equalization with pH adjustment; sedimentation for suspended solids reduction using settling basins or clarifiers; multimedia filtration for reduction in non settleable suspended solids. Waste oil is generated from servicing of machines and equipment. Handling of the waste oil includes water separation for reuse, selling to recyclers and burning in incinerators.

10.2.7.2.1 Potential negative impacts of wastewater generation

- ✓ Water shortage due to high use.
- ✓ Water contamination due to high dissolved solids and other contaminants
- ✓ Contamination of ground water if untreated contaminated wastewater is discharged into the environment
- ✓ Odor from untreated contaminated wastewater
- ✓ Degradation of the quality of water of the receiving water body if contaminated wastewater is discharged into aquatic environment prior to treatment.
- ✓ Contamination of soils if contaminated wastewater is discharged into the ground prior to treatment

10.2.7.3 Proposed measures to mitigate against solid waste generation

Measures that can be put in place to mitigate solid waste generation may include appropriate management practices and deliberate prevention of waste generation.

Management practices

Some of the management practices that can be put in pace to mitigate waste generation include:-

⇒ Establishing waste management priorities at the outset of activities based on an understanding of potential Environmental, Health, and Safety (EHS) risks and impacts and considering waste generation and its consequences.

⇒ Establishing a waste management hierarchy that considers prevention, reduction, reuse, recovery, recycling, removal and finally disposal of wastes.

⇒ Avoiding or minimizing the generation waste materials, as far as practicable.

⇒ Where waste generation cannot be avoided but has been minimized, recovering and reusing waste.

⇒ Where waste cannot be recovered or reused, treating, destroying, and disposing of it in an environmentally sound manner.

⇒ Collection of data and information about the process and waste streams in existing facilities, including characterization of waste streams by type, quantities, and potential use/disposition.

⇒ Establishment of priorities based on a risk analysis that takes into account the potential EHS risks during the waste cycle and the availability of infrastructure to manage the waste in an environmentally sound manner.

⇒ Definition of opportunities for source reduction, as well as reuse and recycling.

⇒ Definition of procedures and operational controls for onsite storage.

⇒ Definition of options / procedures / operational controls for treatment and final disposal.

Waste generation prevention

The lime production processes should be designed and operated to prevent, or minimize, the quantities of wastes generated and hazards associated with the wastes generated in accordance with the following strategy:

✓ Substituting raw materials or inputs with less hazardous or toxic materials, or with those where processing generates lower waste volumes.

✓ Applying manufacturing process that convert materials efficiently, providing higher product output yields, including modification of design of the production process, operating conditions, and process controls.

✓ Instituting good housekeeping and operating practices, including inventory control to reduce the amount of waste resulting from materials that are out-of-date, off specification, contaminated, damaged, or excess to plant needs.

10.2.7.4 Proposed measures to mitigate wastewater generation

Utilities operations wastewater management

Utility operations such as cooling tower and demineralization systems may result in high rates of water consumption, as well as the potential release of high temperature water containing high dissolved solids, residues of biocides, residues of other cooling system and anti-fouling agents. Recommended water management strategies for utility operations include:

⇒ Adoption of water conservation opportunities for facility cooling systems.

⇒ Use of heat recovery methods (also energy efficiency improvements) or other cooling methods to reduce the temperature of heated water prior to discharge to ensure the discharge water temperature does not result in an increase greater than 3°C of ambient temperature at the edge of a scientifically established mixing zone which takes into account ambient water quality, receiving water use, potential receptors and assimilative capacity among other considerations.

⇒ Minimizing use of antifouling and corrosion inhibiting chemicals by ensuring appropriate depth of water intake and use of screens. Least hazardous alternatives should be used with regards to toxicity, biodegradability, bioavailability, and bioaccumulation potential. Dose applied should accord with local regulatory requirements and manufacturer recommendations.

⇒ Testing for residual biocides and other pollutants of concern should be conducted to determine the need for dose adjustments or treatment of cooling water prior to discharge.

Sanitary Wastewater management

Sanitary wastewater includes effluents from domestic sewage, food service, and laundry facilities serving site employees. Miscellaneous wastewater from laboratories, water softening plant. Recommended sanitary wastewater management strategies include:

⇒ Segregation of wastewater streams to ensure compatibility with selected treatment option (e.g. septic system which can only accept domestic sewage).

⇒ Segregation and pretreatment of oil and grease containing effluents (e.g. use of a grease trap) prior to discharge into the environment.

⇒ Treatment to meet national standards for sanitary wastewater discharges.

⇒ Sewage from the industrial facility is to be discharged to an appropriate sewage treatment plant system, treatment to meet Environmental Management and Coordination (Water Quality) Regulations, 2006, standards for sanitary wastewater discharges.

⇒ Sludge from sanitary wastewater treatment systems should be disposed in compliance with Environmental Management and Coordination (Water Quality) Regulations, 2006.

Storm water management

Storm water includes any surface runoff and flows resulting from precipitation, drainage or other sources. Typically storm water runoff contains suspended sediments, metals, petroleum hydrocarbons, Polycyclic Aromatic Hydrocarbons (PAHs), coliform, etc. Rapid runoff, even of uncontaminated storm water, also degrades the quality of the receiving water by eroding stream beds and banks. In order to reduce the need for storm water treatment, the following principles should be applied.

- ✓ Storm water should be separated from process and sanitary wastewater streams in order to reduce the volume of wastewater to be treated prior to discharge.
- ✓ Surface runoff from process areas or potential sources of contamination should be prevented.
- ✓ Where this approach is not practical, runoff from process and storage areas should be segregated from potentially less contaminated runoff;
- ✓ Runoff from areas without potential sources of contamination should be minimized (e.g. by minimizing the area of impermeable surfaces) and the peak discharge rate should be reduced (e.g. by using vegetated and retention ponds).
- ✓ Where storm water treatment is deemed necessary to protect the quality of receiving water bodies, priority should be given to managing and treating the first flush of storm water runoff where the majority of potential contaminants tend to be present.
- ✓ When water quality criteria allow, storm water should be managed as a resource, either for groundwater recharge or for meeting water needs at the facility.
- ✓ Oil water separators and grease traps should be installed and maintained as appropriate at refueling facilities, workshops, parking areas, fuel storage and containment areas.

10.3 Decommissioning phase potential negative impacts

Potential negative impacts during decommissioning phase of the proposed lime plant will include the following:

- ✓ Noise and vibration
- ✓ Injuries and accidents
- ✓ Dust pollution
- ✓ Waste generation

10.3.1 Noise and vibration

Decommissioning of the lime plant will involve dismantling of all components of the lime plant and other support facilities. During demolition and dismantling noise and vibration is likely to be generated. Potential receptors of the noise and vibration will include the workers involved in the demolition and dismantling process, neighbors and visitors to the site. Potential impacts of noise and vibration during decommissioning phase will include the following:-

- ✓ Interfere with conversation and communication at the workplace
- ✓ Negate general work performance, thought and concentration.

- ✓ Negate relaxation.
- ✓ Causes annoyance.
- ✓ Induces hearing loss if exposure is continuous for a long time.

10.3.1.1 Proposed mitigation measures of noise and vibration

- ✓ Develop and implement a comprehensive noise conservation programme that includes training, equipment maintenance, engineering controls, use of PPEs, noise measurements among others.
- ✓ Ensure the decommissioning site is secured by appropriate noise attenuators.
- ✓ Provide all decommissioning staff with appropriate PPEs such as ear plugs and ear mufflers.
- ✓ Enforce proper use of the provided noise protective PPEs by all workers.
- ✓ Ensure equipment used is well maintained and serviceable.

10.3.2 Injuries and accidents

Decommissioning of the components of the lime plant will involve use of heavy equipment and machinery. Further the decommissioning will involve working at height and in confined areas. This will potentially expose workers involved in the decommissioning to injuries and accidents. Factors that will contribute to employee exposure to injuries and accidents will include:

- ✓ Use of poorly serviced equipment
- ✓ Equipment operation by inexperience operators
- ✓ Fatigue due to long working hours without breaks and or rest
- ✓ Destructions and poor concentration while working
- ✓ Lack of use of appropriate personal protective equipment
- ✓ Inappropriate use of personal protective equipment.
- ✓ Lack of or poor site supervision
- ✓ Poor site housekeeping.

10.3.2.1 Proposed mitigation measures for injuries and accidents

- ✓ Ensure all decommissioning workers are given appropriate PPEs.
- ✓ Ensure all decommissioning workers are trained on the appropriate use of the PPEs before use.
- ✓ Ensure each decommissioning worker and visitors to the decommissioning site also use the provided PPEs.
- ✓ Ensure that tools and equipment provided for use at the decommissioning site are well serviced and maintained.
- ✓ Ensure that the decommissioning site is free of hazards.
- ✓ Ensure that among the decommissioning workers at least one is a trained first aider.
- ✓ Ensure there is a fully equipped first aid station at the decommissioning site.

- ✓ Ensure appropriate measures are put in place to minimize fugitive dust by regularly sprinkling water on dusty ground.

10.3.3 Dust pollution

Fugitive dust will likely be generated during demolition of the lime plant and its associated components. The fugitive dust will potentially affect workers on site, visitors to the site and neighbours. Factors that will likely contribute to fugitive dust emission will include:-

- ✓ Lack of or poor site enclosure with appropriate dust screens.
- ✓ Lack of or poor water sprinkling on dusty surfaces before and during demolitions to arrest fine particles.
- ✓ Lack of use of appropriate personal protective equipment
- ✓ Inappropriate use of personal protective equipment
- ✓ Lack of or poor site supervision

10.3.3.1 Proposed mitigation measures of dust pollution

- ✓ Secure the entire decommissioning site with appropriate dust screens to trap fine dust particles.
- ✓ Sprinkle water to arrest fugitive dust.
- ✓ Provide all decommissioning staff with appropriate PPEs such as dust masks, overalls, helmet, dust coats, safety boots and goggles.
- ✓ Ensure all decommissioning workers make proper use of the PPEs provided.

10.3.4 Waste generation

Waste will be generated from the decommissioning of the lime plant. The waste will include concrete rubbles, scrap metal, and lime dust, among others. Depending on how the waste will be handled and disposed, it can impact the environment negatively. Poor handling of scrap metal will potential cause injuries and or accidents on site.

10.3.4. 1 proposed mitigation measures of waste generation

- ✓ Ensure all waste generated at the site being decommissioned is managed and disposed as provided for in the Sustainable Waste Management Act 2022 and the Environmental Management and Coordination (Waste Management) Regulations, 2006.
- ✓ Provide appropriate receptacles for dropping waste.
- ✓ Ensure only NEMA licensed vehicles collect waste from the site being decommissioned for disposal at licensed disposal site.

11. ENVIRONMENTAL MANAGEMENT PLAN

11.1 Working policies to be developed and documented by the proponent to guide project implementation

Implementation of the proposed project will require careful and sound environmental planning to ensure that all issues and concerns raised by all stakeholders are fully addressed and that all potential negative impacts are appropriately mitigated to ensure environmental sustainability. To achieve this; Mombasa Cement Limited who is the project proponent will upgrade existing policies and develop new ones where there is no existing policy to guide the implementation of the proposed project. The policies once upgraded and or developed will be vital in the following ways among others:

- ✓ The policies will enable management to develop and maintain sound relations with project staff and the neighboring community.
- ✓ The policies will enable management put in place measures and structures that will care for the safety, health and welfare of all project staff on site and the neighbouring community residents.
- ✓ The policies will provide a framework for management to plan for, and put in place, monitoring programmes that will ensure conservation and protection of the environment, appropriate waste management and disposal.
- ✓ The policies will provide a framework for Mombasa Cement Limited to scale up its corporate social responsibility, conservation of the environment as well as for the well-being of the local community.

The following policies will need to be either developed and documented or if they are in place upgraded by the project proponent to include the proposed project:-

- ❑ Environmental and sustainability policy
- ❑ Occupational Health and safety policy
- ❑ Stakeholder engagement and involvement policy
- ❑ Training and development policy
- ❑ Risk Management policy

11.1.1 Environmental and sustainability policy

Mombasa Cement Limited has an existing environmental policy. Management will be required to updated and enhance this policy to an environmental and sustainability policy. The enhanced policy will guide the project proponent to carry out the proposed project activities with the highest regard to the natural environment, social environment and sustainable utilization of natural resources. The policy will be in line with applicable national legislations, international guidelines, standards and best practices. The environmental and sustainability policy will therefore cover the following, among other issues: -

- ✓ All Kilifi County relevant legislations that the proponent will have to comply with before commencement of project implementation.
- ✓ All national statutory requirements that the pr63oponent will have to comply with before commencement of project implementation.
- ✓ Systems to be put in place to ensure continuous environmental improvement and performance throughout the project lifecycle.
- ✓ Comprehensive measures to be adopted by the proponent to ensure that utilization of natural resources are optimal with sustainability measures in place to ensure resource availability for future generation.
- ✓ Awareness creation to the surrounding community regarding sustainable utilization of natural resources, protection of sensitive ecosystems and bio-diversity maintenance for communal livelihood.
- ✓ Measures that provide for and ensure balancing between natural resource use, environmental conservation and economic development.

11.1.2 Occupational Health and safety policy

The project proponent has an existing Occupational Health and Safety Policy in place. However, management will be required to update this policy to meet the expanded requirement of the proposed project. This will ensure that the project proponent put in place appropriate measures that will ensure that the health, safety and welfare of all employees are cared for. Further the policy will also ensure and safeguard the health and safety of the local community within the project catchment. In addition to this the policy will safeguards the health and safety of visitors to the project site and all other stakeholders. The policy will highlight the following, among others: -

- ✓ Identity health and safety requirements of employees that need to be safeguarded in line with requirements and provisions of national legislations, international guidelines of best practices.
- ✓ Identity health and safety requirements of local community within the project catchment area that need to be safeguarded in line with requirements and provisions of national legislations, international guidelines of best practices.
- ✓ Identity health and safety requirements of visitors to the project site that need to be safeguarded in line with requirements and provisions of national legislations, international guidelines of best practices.

- ✓ Identity health and safety requirements of all other stakeholders that need to be safeguarded in line with requirements and provisions of national legislations, international guidelines of best practices.
- ✓ Identify ways and means of safeguarding health and safety of employees, local community, visitors to the project site and all other stakeholders.
- ✓ Identify safety measures that need to be put in place for all machines and equipment to be used.
- ✓ Identify required appropriate safety and rescue equipment to be availed in all work places within the project site.
- ✓ Document an elaborate emergency procedures and actions.
- ✓ Identify ways of ensure risk is eliminated and or minimized within the project site
- ✓ Document required training needs in safety.

11.1.3 Stakeholder engagement and involvement policy

The project proponent will develop and document a comprehensive stakeholder engagement and involvement policy that will ensure that the project proponent develops and maintains sound relations with all stakeholders. The policy will identify all the project stakeholders including those who have an interest in the project and those that are affected by the project. In additions the policy will provide a broad framework on how each of the stakeholders will be engaged and involved in the project. The policy will highlight the following, among others:-

- ✓ Identify all project stakeholders and potential stakeholders.
- ✓ Identify the stake/interest/role of each of the identified stakeholder
- ✓ Outline how management will address each stakeholder needs/requirements/interests
- ✓ Document how project management will engage and involve each of the stakeholders
- ✓ Document how the stakeholders will interact among themselves and with the project

11.1.4 Training and development policy

The project proponent will develop and document a comprehensive training and development policy to meet project environmental protection and sustainability needs, project occupational safety and health needs, community health and safety safeguards, and other training and development needs that will be necessitated by project activities. The training and development policy will be aligned to applicable national legislations, international guidelines and best practices. The policy will highlight the following among other issues: -

- ✓ In-house training and capacity development for project workforce to address and meet required project environmental protection and sustainability threshold.
- ✓ In-house training and capacity development for project workforce to address and meet required project occupational safety and health threshold.
- ✓ In-house training and capacity development for project workforce to address and meet required community health and safety safeguard threshold.

11.1.5 Risk Management policy

The project proponent will develop and document a comprehensive risk management policy to address all potential risks that are likely to be associated with the project. The policy will document guidelines of addressing each potential risk with the aim of preventing the risk from occurring while spelling out measures to be taken to address the risk should it occur. The risk management policy will cover project related environmental risks, project related social risks, and project related occupational risks among other risks. The risk management policy will highlight the following among others:-

- ✓ Identify all project related risks to the natural environmental and social environment.
- ✓ Spell out measures to be taken to prevent identified project risks.
- ✓ Spell out remedial measures that will be taken should the risk occur.

11.2 Environmental management action plan

The Environmental Management Plan prepared covers identified issues of concern of construction phase namely loss of vegetation, noise disturbance, fugitive dust, injuries and accidents and waste generation. Identified issues and concern of operational phase namely lime dust, greenhouse gases, noise and vibration, waste and occupational safety and health concerns. Identified issues and concern of decommissioning phase namely noise and vibration, injuries and accidents, dust pollution and waste generation. The EMP also covers environmental monitoring and auditing requirements, training and capacity building, institutional arrangements for safeguards implementation and reporting obligations.

Table 11: Environmental Management plan

ISSUE/CONCERN	POTENTIAL NEGATIVE IMPACT	PROPOSED MITIGATION MEASURES	TIMEFRAME	RESPONSIBLE ACTOR	MONITORING	COST ESTIMATE
CONSTRUCTION PHASE						
Loss of vegetation	Direct loss of local vegetation Diminishing of local carbon sink Reduced area capacity of carbon sequestration reduction of ecological derived from the lost floral species Reduced foliage for local fauna species	Limit vegetation removal to actual proposed project site only Plant trees around periphery of lime plant and in open spaces in the compound of the plant MCL to support planting of trees in public areas such as schools, Chief Camp, local dispensaries within the project catchment	During the construction phase and to be sustained throughout the lifecycle of the proposed project	Plant Manager Environmental Health & Safety (EHS) for MCL	Physical checking of number of trees planted around the plant area Physical checking of number of trees planted in open public places within the project catchment area	1, 000,000 p.a
Noise disturbance	Impaired oral communication among the staff involved in the construction	Comprehensive noise and vibration conservation programme including monitoring, use of noise attenuators, training and	During the construction phase and to be sustained throughout the	Plant Manager Environmental EHS for MCL Section Heads Individual	Periodic Monitoring noise levels	500, 000 pa

ISSUE/CONCERN	POTENTIAL NEGATIVE IMPACT	PROPOSED MITIGATION MEASURES	TIMEFRAME	RESPONSIBLE ACTOR	MONITORING	COST ESTIMATE
	Reduced concentration for workers Annoyance to neighbours Noise induced hearing loss	use of PPEs Prompt servicing & maintenance of equipment	lifecycle of the proposed project	employees		
Fugitive dust	Throat irritation Skin irritation Coughing Sneezing	Regular sprinkle water on opened up dusty areas Secure construction site with dust screens Provide construction workers with PPEs Fugitive dust monitoring	During the construction phase and to be sustained throughout the lifecycle of the proposed project	Plant Manager Contractor Environmental EHS for MCL Section Heads Individual employees	Physical observations of fugitive dust Monitoring of fugitive dust	500, 000
Injuries and accidents	Injuries to workers Loss of productive workforce Loss of man-hours. Reduced productivity. Delays in project implementation	Only skilled and experienced workers to be involved in the construction Use only suitable, appropriate, well serviced and maintained equipment	During the construction phase and to be sustained throughout the lifecycle of the proposed project	Plant Manager Contractor Environmental EHS for MCL Section Heads Individual employees	Log of accidents Log of injuries	500, 000

ISSUE/CONCERN	POTENTIAL NEGATIVE IMPACT	PROPOSED MITIGATION MEASURES	TIMEFRAME	RESPONSIBLE ACTOR	MONITORING	COST ESTIMATE
	Litigations	Workers working at height and in confined areas to be provided with appropriate PPEs Equipped first aid station to be on site with trained and experienced first aiders				
Waste generation	Poor housekeeping due to littering and untidiness Pollution from oil spills Flooding due to blocked drains	Reduce generation of waste from cement bags by using bulk cement delivered in bulk tankers as opposed to bagged cement Collect and recycle all empty cement bags by sending used cement bags to recyclers Provide waste receptacles for waste segregation	During the construction phase and to be sustained throughout the lifecycle of the proposed project	Plant Manager Contractor Environmental EHS for MCL Section Heads Individual employees	Duly completed waste tracking documents	1,000,00 pa
PRODUCTION PHASE						

ISSUE/CONCERN	POTENTIAL NEGATIVE IMPACT	PROPOSED MITIGATION MEASURES	TIMEFRAME	RESPONSIBLE ACTOR	MONITORING	COST ESTIMATE
Lime dust generation	Lung infection resulting from inhaling of lime dust Skin irritation Itching of the skin Irritation of the eyes Chronic cough Reduced visibility Choking of plants	Water sprinkling Use of bag filters Deployment of electrostatic precipitators	During the construction phase and to be sustained throughout the lifecycle of the proposed project	Plant Manager Contractor Environmental EHS for MCL Section Heads Individual employees	Physically checking level of dust settlement on plant leaves Measurement of dust level Feedback from neighbors Feedback from employees	10, 000,000 pa
Increase in greenhouse gasses emission (carbon dioxide, carbon monoxide, nitrogen oxides, sulfur dioxide, and ammonia)	Carbon monoxide (CO) can cause harmful health effects by reducing oxygen delivery to the body's organs and tissues, as well as adverse effects on the	Carbon Capture and Utilization (CCU): Carbon capture technologies can be applied to capture CO_2 emissions from lime production. Captured CO_2 can then be utilized in various ways, such as in the production	Proposed mitigation measures to be put in place during construction phase and to be fully operationalized	Project Directors Plant Manager Contractor Environmental EHS for MCL Section Heads Individual employees	Quarterly monitoring of greenhouse gas emissions and concentration against the baseline values.	1, 000, 000 p.a

ISSUE/CONCERN	POTENTIAL NEGATIVE IMPACT	PROPOSED MITIGATION MEASURES	TIMEFRAME	RESPONSIBLE ACTOR	MONITORING	COST ESTIMATE
	cardiovascular and central nervous systems. CO contributes to the formation of smog (ground-level ozone), which can cause respiratory problems Nitrogen oxide (NOx) can cause or contribute to a variety of health problems and adverse environmental impacts, such as ground-level ozone, acid rain, global warming, water	of synthetic fuels, and chemicals, or as a component in building materials Improved thermal efficiency, improved electrical efficiency, raw material substitution and mineralizers can mitigate CO_2 emission SO_2 emission can be mitigated by inherent scrubbing, oxygen control (increase), fuel substitution (lower total sulfur), raw material substitution (lower sulfide sulfur) and raw material alkali/sulfur balance NOX emission can be	during production phase throughout the lifecycle of the lime plant.			

ISSUE/CONCERN	POTENTIAL NEGATIVE IMPACT	PROPOSED MITIGATION MEASURES	TIMEFRAME	RESPONSIBLE ACTOR	MONITORING	COST ESTIMATE
	quality deterioration, and visual impairment. Sulfur dioxide (SO_2) in high concentrations can affect breathing and may aggravate existing respiratory and cardiovascular disease. SO_2 is also a primary contributor to acid deposition, or acid rain.	mitigated by oxygen control (decrease), indirect firing, low-NOX burner, mid-kiln firing, process improvements, process control improvements, low-NOX calciner, staged combustion, semi-direct firing and mixing air fan. CO emission can be mitigated by good combustion practice, excess air (increase), raw material substitution, pyroprocessing system design and mixing air fan. Raw material substitution and tailpipe scrubber technologies can mitigate potential NH_3 emissions				

ISSUE/CONCERN	POTENTIAL NEGATIVE IMPACT	PROPOSED MITIGATION MEASURES	TIMEFRAME	RESPONSIBLE ACTOR	MONITORING	COST ESTIMATE
Noise & vibration	Noise induced hearing loss Damage to the worker's hearing mechanism Reduction of productivity and efficiency Upset the sense of balance and cause blood vessels to constrict Fatigue, headache, nervousness, irritability and high pretension Stress and reduced concentration.	The use of silencers Room enclosures for mill operators. Noise barriers/ attenuators. Installing suitable mufflers on compressor components. Installing acoustic barriers Installing vibration isolation for mechanical equipment Provision of personal hearing protection such as ear plugs and ear mufflers Use of acoustic insulating materials, isolation of the noise source, and other engineering controls should be investigated and implemented, where feasible. Periodic medical hearing checks Record and respond to complaints	Proposed mitigation measures to be put in place during construction phase and to be fully operationalized during production phase throughout the lifecycle of the lime plant.	Project Directors Plant Manager Contractor Environmental EHS for MCL Section Heads Individual employees	Measurement of noise levels periodically	500, 000.00

ISSUE/CONCERN	POTENTIAL NEGATIVE IMPACT	PROPOSED MITIGATION MEASURES	TIMEFRAME	RESPONSIBLE ACTOR	MONITORING	COST ESTIMATE
Waste generation	Air pollution especially from lime dust Skin irritation when in contact dust Water pollution Production loss Irritation of eyes Chocking of plants Odor from decomposing food leftovers from the canteen Blockage of drainage system by scrap and other non-decomposing solid wastes.	Adoption of water conservation opportunities for facility cooling systems Use of heat recovery methods or other cooling methods to reduce the temperature of heated water prior to discharge Segregation of wastewater streams to ensure compatibility with selected treatment option Segregation and pretreatment of oil and grease containing effluents Segregation and pretreatment of oil and grease containing effluents Sewage from the industrial	Proposed mitigation measures to be put in place during construction phase and to be fully operationalized during production phase throughout the lifecycle of the lime plant.	Project Directors Plant Manager Contractor Environmental EHS for MCL Section Heads Individual employees	Duly completed Waste generation, segregation and disposal tracking documents	2,000, 000

ISSUE/CONCERN	POTENTIAL NEGATIVE IMPACT	PROPOSED MITIGATION MEASURES	TIMEFRAME	RESPONSIBLE ACTOR	MONITORING	COST ESTIMATE
	Some electronic office waste such as used toner cartridges and absolute office electronic equipment contain hazardous substances.	facility is to be discharged to an appropriate sewage treatment plant system Storm water should be separated from process and sanitary wastewater streams in order to reduce the volume of wastewater to be treated prior to discharge.				
Safety & health hazards	Dust exposure Heat exposure Physical hazards Radiation exposure Chemical hazards Industrial hygiene issues Falling / impact with objects Hot surface burns Transportation	Good housekeeping Use of air–conditioned, closed cabins Use of dust extraction and recycling systems Use of air ventilation (suction) in lime-bagging areas Use of PPE, as appropriate to address residual	Proposed mitigation measures to be put in place during construction phase and to be fully operationalized during production	Project Directors Plant Manager Contractor Environmental EHS for MCL Section Heads Individual employees	Log of incidents Log of accidents Records of health and safety training	500.000 p.a

ISSUE/CONCERN	POTENTIAL NEGATIVE IMPACT	PROPOSED MITIGATION MEASURES	TIMEFRAME	RESPONSIBLE ACTOR	MONITORING	COST ESTIMATE
	Contact with allergic substances	exposures Engineering controls Shielding surfaces where workers' proximity and close contact with hot equipment Minimizing the work time required in high temperature environments by implementing shorter shifts When working on equipment with moving parts, ensure the equipment is de-energized, isolated and locked/tagged out Use fall protection such as belts	phase throughout the lifecycle of the lime plant.			
DECOMMISSIONING PHASE						

ISSUE/CONCERN	POTENTIAL NEGATIVE IMPACT	PROPOSED MITIGATION MEASURES	TIMEFRAME	RESPONSIBLE ACTOR	MONITORING	COST ESTIMATE
Noise and vibration	Interfere with conversation and communication at the workplace Negate general work performance, thought and concentration. Negate relaxation. Causes annoyance. Induces hearing loss if exposure is continuous for a long time	Develop and implement a comprehensive noise conservation programme Ensure the decommissioning site is secured by appropriate noise attenuators. Provide all decommissioning staff with appropriate PPEs such as ear plugs and ear mufflers. Enforce proper use of the provided noise protective PPEs by all workers. Ensure equipment used is well maintained and serviceable	Throughout the decommissioning period	Contractor Environmental EHS for MCL Section Heads Individual employees	Measurement of noise level Feedback from workers Feedback from neighbor	2, 000, 000
Injuries & accidents	Loss of life Loss of productive time	Ensure all decommissioning workers are given appropriate	Throughout the decommissioning period	Contractor Environmental EHS for MCL	Log of accidents Log of injuries	1, 000,000 p.a

ISSUE/CONCERN	POTENTIAL NEGATIVE IMPACT	PROPOSED MITIGATION MEASURES	TIMEFRAME	RESPONSIBLE ACTOR	MONITORING	COST ESTIMATE
	Reduced productive Litigation	PPEs. Ensure all decommissioning workers are trained on the appropriate use of the PPEs before use. Ensure each decommissioning worker and visitors to the decommissioning site also use the provided PPEs. Ensure that tools and equipment provided for use at the decommissioning site are well serviced and maintained. Ensure that the decommissioning site is		Section Heads Individual employees	Feedback from workers	

ISSUE/CONCERN	POTENTIAL NEGATIVE IMPACT	PROPOSED MITIGATION MEASURES	TIMEFRAME	RESPONSIBLE ACTOR	MONITORING	COST ESTIMATE
		free of hazards. Ensure that among the decommissioning workers at least one is a trained first aider. Ensure there is a fully equipped first aid station at the decommissioning site. Ensure appropriate measures are put in place to minimize fugitive dust by regularly sprinkling water on dusty ground				
Dust pollution	Lung infection resulting from inhaling of lime dust Skin irritation Itching of the skin	Secure the entire site with appropriate dust screens Sprinkle water Provide all decommissioning staff with PPEs such as dust	Throughout the decommissioning period	Contractor Environmental EHS for MCL Section Heads Individual employees	Physically checking level of dust settlement on plant leaves Measurement of dust level	1, 000, 000

ISSUE/CONCERN	POTENTIAL NEGATIVE IMPACT	PROPOSED MITIGATION MEASURES	TIMEFRAME	RESPONSIBLE ACTOR	MONITORING	COST ESTIMATE
	Irritation of the eyes Chronic cough Reduced visibility Choking of plants	masks, overalls, helmet, dust coats, safety boots and goggles. Ensure all workers make proper use of PPEs provided			Feedback from neighbors Feedback from employees	
Waste generation	✓ Blockage of drainage ✓ Poor housekeeping	Minimize waste generation through re-use and recycling Provide appropriate receptacles for dropping waste Only NEMA licensed vehicles to collect waste from the site being decommissioned for disposal at licensed disposal site	Throughout the decommissioning period	Contractor Environmental EHS for MCL Section Heads Individual employees	Duely completed waste tracking documents	2, 000, 000

11.3 Environmental Monitoring
11.3.1 Greenhouse gasses monitoring

Monitoring of greenhouse gasses concentration will be quarterly i.e. every three months. The following greenhouse gases will be monitored sulphur dioxide (SO_2); oxides of nitrogen (NO_x) (which includes nitric oxide (NO) and nitrogen dioxide (NO_2)); carbon monoxide (CO); carbon dioxide (CO_2); Total Volatile organic compounds, (TVOCs) and Ammonia (NH_3). The results of the monitoring will be compared against the baseline monitoring values that were established before the construction and operation of the lime plant and are annexed in this report and the provisions of the fourth schedule of the Environmental Management and Coordination (Air Quality) Regulations 2014 that stipulates limit values of greenhouse gases as shown in Table 14.

Table 14 Ambient Air Quality Tolerance Limits greenhouse gases to guide monitoring

Greenhouse gas polutant	Time weighted Average	Industrial area	Residential, Rural & Other area	Controlled areas***
Sulphur dioxide	Instant Peak		500 µg/m^3	-
	Instant peak (10min)		0.191 ppm	-
Non-methane hydrocarbons	instant Peak	700ppb	-	-
Total VOC	24 hours**	600 µg/m^3	-	-
Oxides of Nitrogen	24 hours	100 µg/m^3	0.1 PPM	-
	Instant peak		0.5 PPM	-
Nitrogen dioxide	One hour		0.2 ppm	-
	Instant peak		0.5 ppm	-
Carbon monoxide / carbon dioxide	One Hour	10 mg/m^3	4.0 mg/m^3	10 mg/m^3
Ozone	1-Hour	200 µg/m3	0.12 PPM	-

Extract from the Ambient EMC Air Quality regulations, 2014 (Tolerance Limits)

11.3.2 Noise and excessive vibrations monitoring

The noise levels will be monitored quarterly to ensure they are in line with the provisions of the Environmental Management and Coordination (Noise and Excessive Vibration Pollution) (Control) Regulations, 2009 as shown in the table 15.

Table 15 Maximum permissible noise levels for constructions sites (Measurement taken within the facility).

Facility		Maximum Noise Level Permitted (Leq) in dB(A)	
		Day	Night
i.	Health facilities, educational institutions, homes for disabled etc.	60	35
ii.	Residential	60	35
iii.	Areas other than those prescribed in (i) and (ii)	75	65

Timeframe: Day; 6:01am-6:00pm & Night; 6:01pm-6:00am

Source: Second schedule of the Environmental Management and Coordination (Noise and Excessive Vibration Pollution) (Control) Regulations, 2009.

11.3.3 Air Quality Monitoring

Monitoring of particulate matter to ensure that the project activities adhere to the Ambient Air Quality requirements at Property Boundary for General Pollutants. Part (b) of the First Schedule of the Environmental Management and Coordination (Air Quality) Regulations, 2014 require that the particulate matter for at a property boundary should not exceed 70µg/m^3. The proponent will be monitoring particulate matter from the project site during construction phase to ensure they are within the legal limits.

11.3.4 Solid waste disposal monitoring

Waste generated and disposed from the lime mill will be managed and disposed as provided for in the Sustainable Waste Management Act, 2022 and the Environmental Management and Coordination (Waste Management) Regulations, 2006. To ensure that the provisions of the regulation and Act are adhered to, the proponent will monitor the type of solid waste generated, quantity of solid waste generated, frequency of collection and disposal, where the waste is disposed and proof of waste tracking documents in the format provided in FORM III schedule one of the Environmental Management and Co-ordination (Waste Management) Regulations 2006. This monitoring is to be done monthly.

11.4 Training and capacity building

The following training and capacity building is proposed: -

- Sensitization of the Proponent, and Contractor who will undertake the implementation of the proposed project on the importance of the EMP, its contents, how it is applied and who is responsible for the implementation of each part of the EMP.
- Training and capacity building for contractor and the construction labour on the importance and proper use of PPEs.
- Training and capacity building for Contractor and construction labour on acceptable waste management practices.
- Training and capacity building of the construction site occupational safety and health committee on construction site occupational safety and health requirements and individual safety obligations.
- Training and capacity building of construction site first aiders.
- Training and capacity building on construction site fire safety team
- Sensitization on HIV and AIDS and other communicable diseases to site construction workforce.

11.5 Institutional arrangements for safeguard implementation and reporting

11.5.1 Institutional arrangement

The responsibility of implementation of the safeguards proposed in this EMP is vested on the project proponent who is Mombasa Cement Limited. The National Environment Management Authority (NEMA) and other relevant lead agencies will enforce compliance. There will be periodic site visits by NEMA and relevant lead agencies to assess and enforce compliance. During the construction phase, the contractor will be required to prepare monthly progress reports and submit the progress reports to the proponent on the contractor’s contractual obligations on safeguards implementation responsibilities specified in the EMP. The contractor will be supervised on the ground directly by the proponent or proponent representative as will be determined by the proponent. The proponent will be required to promptly respond to improvement orders issued by NEMA and other lead agencies by compiling a report on the issues raised in the orders. The proponent will be required to prepare periodic monitoring reports and annual environmental audit reports and submit these reports to NEMA and other relevant lead agencies.

11.5.2 Reporting obligations

The following reports will be prepared:

- ✓ Monthly progress reports by the contractor on the implementation status of every obligation of the contractor on safeguards implementation specified in the EMP. These monthly reports will be submitted by the contractor to the Proponent.
- ✓ Periodic monitoring reports to be prepared by the proponent and submitted to NEMA on the status of:-

i) Greenhouse gas emission as prescribed in the Environmental Management and Coordination (Air Quality) Regulations, 2014

ii) Particulate matter (dust) emission as prescribed in the Environmental Management and Coordination (Air Quality) Regulations, 2014.

iii) Noise and excessive vibration as prescribed in the Environmental Management and Coordination (Noise and Excessive Vibration Pollution) (Control) Regulations, 2009.

iv) Waste management as prescribed in the Sustainable Waste Management Act 2022 and the Environmental Management and Coordination (Waste Management) Regulation, 2006.

- ✓ Initial Environmental Audit report to be prepared by the proponent and submitted to NEMA in the first year of operation of the project to check the efficacy and adequacy of the EMP.
- ✓ Self-environmental audit report to be prepared annually by the proponent and submitted to NEMA to report on the progress of implementation of the EMP.
- ✓ Reports responding to NEMA improvement orders to be prepared by the proponent and submitted to NEMA as and when such improvement orders are issued.

11.6 Environmental auditing

The project proponent will carryout an initial environmental audit and Annual Environmental Audit for the project activities as provided for in the Environmental (Impact Assessment and Audit) Regulations 2003. The Audits will serve to confirm the efficacy and adequacy of the proposed Environmental Management Plan.

11.7 Decommissioning

Decommissioning of the project will involve terminating project operations, dismantling of the lime plant, all project equipment and allied infrastructure and rehabilitating the site to the original status. Before decommissioning will be done, the Project Management will communicate in writing to the National Environment Management Authority stating their intension to decommission and provide a detailed decommissioning plan for approval.

12 FINDINGS, CONCLUSION AND RECOMMENDATIONS

12.1 Key findings

The following are the main findings:

- ✓ The proposed project is a lime plant that is to be constructed to manufacture lime from limestone.
- ✓ The proposed lime plant will consist of limestone preparation & dosing unit, pet coke grinding, parallel flow regenerative (PFR) kiln for quicklime production, quick lime handling unit, hydrated lime production and handling unit, packing plant for hydrated lime and quality control unit.
- ✓ The proponent of the proposed project is Mombasa Cement Limited, private company incorporated in Kenya with Limited liability.
- ✓ The proposed lime plant will be constructed on sections of land parcel MN/III/291/2 and MN/III/4391.
- ✓ While the stakeholders consulted supports the proposed project, most stakeholders had concerns on potential dust pollution from proposed lime production.
- ✓ The main raw material that will be used will be limestone which will be sourced from existing and licensed quarries while the main product will be hydrated lime and quick lime.
- ✓ Identified potential positive impacts during include employment opportunities for the local community, support to existing local businesses, on job training opportunities for local people.
- ✓ Potential negative impacts during will include loss of vegetation, noise disturbance, fugitive dust, injuries and accidents and waste generation
- ✓ Suitable mitigation measures have been identified to mitigate potential negative impacts

12.2 Conclusions

The predicted potential positive impacts can be maximized to reap maximum benefits by implementing proposed measures of enhancing each positive impacts. Likewise, fully implementation of identified mitigation measures of each potential negative impact can ensure minimization of potential negative effects to acceptable levels.

12.3 Recommendations

- ✓ To ensure environmental sustainability, the proposed environmental management plan to be fully implemented once the proposed project is approved and licensed for implementation. The project proponent to provide an adequate budget for the full implementation of the proposed environmental management plan.

- ✓ The implementation of the proposed project to adhere to all legal provisions.
- ✓ Issues, concerns and suggestion raised during the stakeholder consultation to be addressed.
- ✓ Waste generated during the cycle of the project to be strictly handled as stipulated in the Environmental Management and Coordination (Waste Management) Regulations, 2006. and the Sustainable Waste Management Act 2023.
- ✓ Management of potential emissions from the proposed project to adhere to the provisions of the provisions of Environmental Management and Coordination (Air Quality) Regulations, 2014.
- ✓ Noise and vibrations to be within the limits stipulated in the Environmental Management and Coordination (Noise and Excessive Vibration) (Pollution Control) Regulations, 2009.
- ✓ Proposed measures to mitigate on potential climate change effects to be implemented.
- ✓ All occupation and safety issues to be addressed and managed as provided for in the Occupational Safety and health Act, 2007.

APPENDICES

Appendix 1 Land documents

Appendix 2 Proponent's PIN certificate and certificates of incorporation

Appendix 3 ToR approval

Appendix 4 Practicing licenses of the firm of experts and Lead Expert

Appendix 5 Environmental baseline for ambient green-house gases monitoring

Appendix 6 Environmental baseline study report for ambient particulate matter monitoring

Appendix 7 Site layout plan of the proposed project

Appendix 8 Process flow

Appendix 9 Bills of quantities

Appendix 10 Questionnaire survey response

Appendix 11Attendance list and Minutes of the First Baraza

Appendix 12 Attendance list and Minutes of the second baraza

Appendix 13 Attendance list and Minutes of the third baraza